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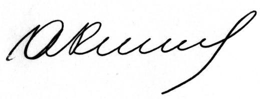
Eessõna

Tartu Observatoorium tähistas 2014. aasta septembris oma 50-ndat aastapäeva Tõraveres. Toreda kokkusattumisena lõpetasime just sellel aastal viimased tegevused peahoone renoveerimise ja juurdeehituse projektis. Saime avada oma ruumid külalistele ja korraldada mitmeid suuri üritusi.

Teadusnädala ”’Kosmos ühendab” raames toimus kosmosetehnoloogia tudengite töötuba, rahvusvaheline kosmoseteaduse ja -tehnoloogia konverents, Euroopa Kosmoseagentuuri programme tutvustav seminar ettevõtjatele ning avalik vaatlusõhtu kõigile huvilistele. Korraldasime Tõraveres järjekordsed kaugseirepäevad, kuhu kogunes ligi 100 selle valdkonna spetsialisti üle Eesti, et tutvustada kolleegidele oma teadustöö tulemusi, keskenduda kaugseire andmete laiematele kasutusvõimalustele majanduses ja aidata kaasa koostööle Euroopa Kosmoseagentuuriga.

Kõige suurema tähelepanu pälvisime Rahvusvahelise Astronoomia Ühingu sümpoosioni ”Zeldovichi maailm 100” korraldamisega Tallinnas, kus käsitleti tervele Eestile kuulsust toonud Universumi struktuuri ja tumeaine temaatikat. Kohal oli enamik valdkonna teadlaste absoluutsest paremikust maailmas, nende seas kuus maineka Gruberi teaduspreemia laureaati, kelle hulka alates sellest aastast kuulub ka meie akadeemik Jaan Einasto. Seda, et meie kosmoloogid on oma uuringutega maailma tipus, näitas ka ajakirja Nature esikaanelugu – tutvustus selle kohta paluti koostada valdkonna väljapaistval eksperdil, mullu presidendilt noore teadlase preemia pälvinud Elmo Tempelil.

Raamatus ”Tartu Observatoorium Tõraveres 50”, on kirjas peaaegu 600 siin töötanud inimese nimed. Nende töö on toonud Eesti riigile ja rahvale palju kasu ning tunnustust. On uhke selles nimekirjas olla!



Anu Reinart
Direktor

Tõraveres
veebruar 2015

Foreword

This year Tartu Observatory celebrated the 50th anniversary of its activities in Tõravere. As a wonderful sign for adoption of the new coming challenges, we finished the renovation and extension work of the main building. This allowed us to open our new facilities to guests and organize various big events.

We celebrated the anniversary during the science week "United by Space!", that included student workshop, international conference on space science and technology, seminar for entrepreneurs in European Space Agency programmes and open observations to public. We organized the traditional Estonian remote sensing days in Tõravere, where about 100 specialists all over Estonia participated to introduce the results of their research work to colleagues, to focus on the broader usage of the Earth observation data in economy and contribute to the cooperation with ESA.

The biggest international attention was given to the International Astronomical Union symposium 308: Zeldovich Universe – Genesis and Growth of the Cosmic Web. The conference was organized in Tallinn to discuss the latest achievements and results in the field of large-scale structure of the Universe and the dark matter, that have brought fame to our observatory and Estonia as a whole. Most of the top scientists in the field were among the participants, including six Gruber prize winners together with our Jaan Einasto - the laureate of 2014!

The front-page cover story of the journal Nature confirmed the fact that our cosmologists are among the top scientists of the world according to their results in cosmology – the introduction to the main article was asked to draw up by the outstanding expert of the field, the last year Young Scientist Award winner Elmo Tempel.

There were many interesting and challenging moments last year, most of them gathered in this Annual Report 2014. Take your time and have a look at that wonderful year!

There are about 600 persons who have been working in the observatory at various times. They are all listed in the history book "Tartu Observatory – 50 years in Tõravere", which we published this year. Their work has brought a world-wide recognition to Estonia. It's glorious to be one on this list!

Anu Reinart
Director

Tõravere
February 2015

1 Ülevaade

1.1 Tähtsündmused

- **Rahvusvahelise Astronoomia Uniooni sümpoosion 308: Zeldovichi maailm 100**

Tartu Observatooriumi teadlased võõrustasid 23.-28. juunini 2014 Tallinnas 181 osalejaga esinduslikku rahvusvahelist astronoomiakonverentsi IAU Symposium 308: "Zeldovichi Universum – kosmilise võrgustiku areng ja kasv". Konverents oli pühendatud väljapaistva kosmoloogi Yakov Zeldovichi 100. sünniaastapäevale ning seal käsitleti Universumi struktuuri ja tumeaine temaatikat, mis on tervele Eestile kuulsust toonud. Kohal oli enamik valdkonna teadlaste absoluutsest paremikust maailmas, nende seas kuus maineka Gruberi teaduspreemia laureaati ja ka selle aasta preemia saajad – akadeemik Jaan Einasto ja Brent Tully, kelle pikaajalised uurimustööd Universumi mõistmisel on viinud tumeaine ja kosmilise võrgustiku avastamisele. Konverentsi teaduskomiteed juhtisid Rien van de Weijgaert Gröningeni Ülikoolist Hollandist ja Sergei Shandarin Kansase Ülikoolist USA-s.

Sümpoosionist osavõtjad.

- **Laniakea, meie suurim kodu**

Tugev tunnustus Tartu Observatooriumis teostatavatele Universumi suuremastaabilise struktuuri uuringutele saabus 2014. aastal ajakirjalt Nature. See väljapaistev teadusajakiri palus kosmoloogia osakonna teaduril Elmo Tempelil kirjutada tutvustav tekst 2014. aasta septembrikuu esikaaneloole, mis asetas meie kodugalaktika täiesti uude perspektiivi. Nimelt analüüsisid Brent Tully ja kaasautorid Nature veergudel värsket detailset andmestikku meie Linnuteed ümbritsevate galaktikate paigutuse ja liikumiste kohta ning leidsid, et Linnutee on osaks ühest hiigelsuurest seniavastamata galaktikasüsteemist, millele anti nimeks Laniakea superparv. Asjaolu, et ajakirja Nature toimetus peab mullu noore teadlase preemia pälvinud Elmo Tempelit valdkonna väljapaistvaks eksperdiks näitab, et Tartu Observatooriumi kosmoloogid on õigel teel.

- **Teadusnädal ”Kosmos ühendab!”**

Raamatu saab selle koostaja Tõnu Viik.

2014. aastal täitus Tartu Observatooriumil 50. tegevusaasta Tõraveres. Sel puhul andis Tartu Observatoorium koostöös kirjastusega Aasta Raamat välja raamatu "Tartu Observatoorium Tõraveres 50", mille koostajaks on Tõnu Viik, materjali aitas kokku panna ja fotosid valida Mare Ruusalepp. Teose kaasautoriteks on ligi poolsada Tartu Observatooriumi teadlast. Väljaande valmimisele aitasid kaasa kirjastaja Indrek Ilomets, toimetaja Mart Orav, kujundaja Kalle Toompere, eesti keele toimetaja Leelo Jago. Tekstid vahendasid inglise keelde Krista Kallis ja Tiina Ann Kirss. Raamatu esitlus toimus Tartu Observatooriumi peahoones Tõraveres 25. septembril 2014 koos sünnipäevapeoga observatooriumi endistele ja praegustele töötajatele.

Olulist sündmust tähistati 22.–26. septembrini 2014 toimunud teadusnädalaga ”Kosmos ühendab!”, mille raames toimus tudengite töötuba, teaduskonverents, Euroopa Kosmoseagentuuri programme tutvustav seminar ettevõtjatele, raamatu esitlus ning avalik vaatlusõhtu kõigile huvilistele Teadlaste ÖÖ 2014 raames.

- **Eesti kaugseirepäevad**

21.–22. oktoobril 2014 korraldasid Tartu Observatooriumi kaugseire teadlased Tõraveres järjekordsed kaugseirepäevad, kuhu kogunes ligi 100 selle valdkonna spetsialisti üle Eesti, et jagada kogemusi ja tutvustada kolleegidele oma teadustöö tulemusi. Kahepäevane üritus keskendus kaugseire andmete laiematele kasutusvõimalustele majanduses ning koostööle Euroopa Kosmoseagentuuriga.

Tiit Nilson, üks Eesti kaugseire rajaja.

Esimese päeva peaesinejaks oli Gordon Campbell Euroopa Kosmoseagentuuri (ESA) teaduse, rakenduste ja tuleviku tehnoloogiate osakonnast ja kaugseire programmide direktoraadist. Päev lõppes aruteluga Eesti ettevõtjate tegevusvõimalustest kaugseire valdkonnas ESA programmides. Seminari teisel päeval keskenduti kaugseire rakendustele Eestis. Kaugseire päevadeks ilmus Keskkonnagentuuri väljaandel trükist artiklite kogumik ”Eesti kaugseire 2014”, mis oli järjeks 2008. aastal ilmunud kogumikule ”Kaugseire Eestis”.

- **Rahvusvaheline Tartu kosmoseteaduse ja -tehnoloogia konverents**

22.–24. septembrini 2014 toimus Tartu Observatooriumis rahvusvaheline kosmoseteaduse ja tehnoloogia konverents, kus tutvustati viimaseid tehnoloogia saavutusi nanosatelliitide vallas. Tartu konverents oli kolmas rahvusvahelise Balti rakendusliku astroinformaatika ja kosmoseandmete töötlemise teaduskonverentside sarjas (Baltic Applied Astroinformatics and Space Data Processing, BAASP). Kaks varasemat toimusid Lätis Ventspilsi Ülikoolis. Jätkates BAASP traditsiooni, tõi Tartu kosmoseteaduse- ja tehnoloogia konverents kokku mainekad teadlased ja entusiastlikud tudengid. Konverentsil käsitleti nanosatelliitide tehnoloogia arengut, tulevikumissioone ja -eksperimente, suurte andmekoguste analüüsi meetodeid ning arutleti kosmosetehnoloogia haridusprogrammide ja rahvusvaheliste uurimisvõrgustike arendamise teemadel.

- **Eesti kosmoseteadust ja -tehnoloogiat tutvustav infopäev Eesti alalises esinduses Brüsselis**

9. detsembril 2014 tutvustasid Eesti Kosmosebüroo juht Madis Võõras ja Tartu Observatooriumi direktor Anu Reinart Brüsselis toimunud infopäeval Euroopa teaduspoliitika kujundajatele Eesti kosmoseteaduse- ja tehnoloogia saavutusi ning Tartu Observatooriumi tegevust. Peter Breger Euroopa Komisjonist andis ülevaate Copernicuse programmi võimalustest väikeriikidele ning Leueni Ülikooli noor astrofüüsik Mihkel Kama käsitles Eesti väljavaateid osalemiseks suurtes kosmoseprojektides.

Vasakult paremale: Andreas Veispak, Madis Võõras, Anu Reinart, Peter Breger ja Mihkel Kama.

Paneeldiskussioonis osalesid kõik esinejad ja Euroopa Komisjoni Kasvu peadirektoraadi juhi nõunik Andreas Veispak. Mõttevahetust juhatas Euroopa Komisjoni Galileo teenuste sektori juhataja Hillar Tork. Eesti lähituleviku kõrgeimaks prioriteediks kosmosevaldkonnas on Maa seire meetodite ja kosmoses kasutatava tehnoloogia - seadmete, nanosatelliitide - ning teenuste arendamine tihedas koostöös digitaalse Eesti kontseptsiooni eestvedajatega. Avaldati veendumust, et Eesti suudab saavutada need kõrged eesmärgid, kui keskendume oma teadustöös esmatähtsatele küsimustele, teadlasvahetusele, mis tugevdab isiklike kontaktide kaudu asutuste vahelist koostööd ning osaleme tugevates rahvusvahelistes tehnoloogia konsortsiumites. Infopäeva viis läbi Tartu Observatoorium koostöös Eesti Teadusagentuuri Brüsseli bürooga.

1.2 Tunnustused

- **Anu Reinartit autasustati Valgetähe IV klassi teenetemärgiga**

Anu Reinart pärast autasu kättesaamist koos Eesti Vabariigi Presidendi T.H. Ilvesega

Eesti Vabariigi President Toomas Hendrik Ilves autasustas Valgetähe IV klassi teenetemärgiga Tartu Observatooriumi direktorit kui teaduse populariseerijat ja tudengisatelliidi ESTCube projekti üht eestvedajat. Autasud anti üle 20. veebruaril 2014 Pärnus toimunud tseremoonial. ”See on ühtlasi tunnustus kogu observatooriumi perele, nii meie tugeva teadustöö kui rahvale suunatud teadust tutvustava tegevuse eest”, jagas Anu Reinart heameelt tunnustuse üle.

- **Tõnu Viik valiti Eesti Looduseuurijate Seltsi auliikmeks**

30. oktoobril 2014 valiti Tartu Observatooriumi vanemteadur Tõnu Viik Eesti Looduseuurijate Seltsi 111. auliikmeks. Eesti Looduseuurijate Seltsi auliikmeks valitakse isikuid alates 50. eluaastast, kellel on erilisi teeneid loodusteaduste arendamisel või kes oma kauaaegse viljaka tegevusega Eesti Looduseuurijate Seltsis on osutanud sellele suuri teeneid. Tõnu Viik oli aastatel 2008–2014 Eesti Looduseuurijate Seltsi president. Tartu Observatooriumi teadlastest on seltsi auliikmeks veel akadeemik Jaan Einasto.

- **Olga Tihhonova** (Tartu Ülikool) sai diplomi konkursitöö ”Galaktikate stellaardünaamika modelleerimine Andromeeda näitel” eest Eesti Teadusagentuuri poolt korraldatud üliõpilaste teadustööde konkursil loodusteaduste ja -tehnika valdkonnas.

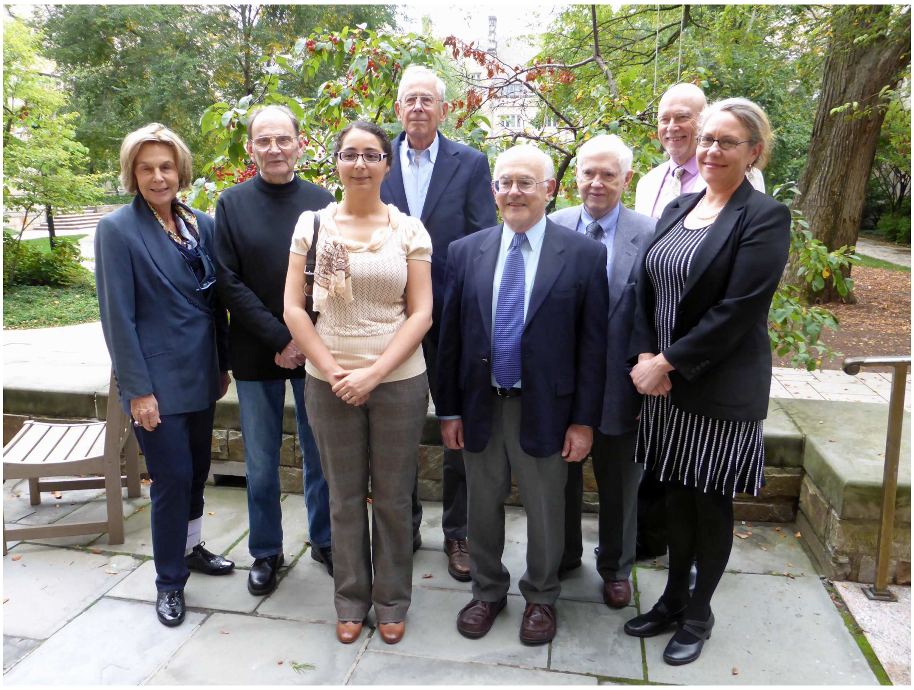
- Tallinna Ülikool nimetas **Uno Veismanni** oma silmapaistvaks vilistlaseks ja andis tunnustuskirja loodusteaduste pikaajalise populariseerimise eest.

- **Gruberi preemia akadeemik Jaan Einastole**

Tartu Observatooriumi vanemteadur Jaan Einastole omistati Gruberi Sihtasutuse mainekas rahvusvaheline kosmoloogiapreemia lähikosmose uurimise eest.

Gruberi rahvusvahelise preemiaga tunnustatakse kosmoloogia, geneetika ja neuroteaduste alade teadlasi, kelle põhjapanevad uurimused ja avastused muudavad paradigmasid meie teadmistes ja kultuuris. Jaan Einasto jagas preemiat Kenneth Freemani, R. Brent Tully ja Sidney van den Berghiga.

Preemia anti laureaatidele üle pidulikul tseremoonial 1. oktoobril Yale'i ülikoolis.

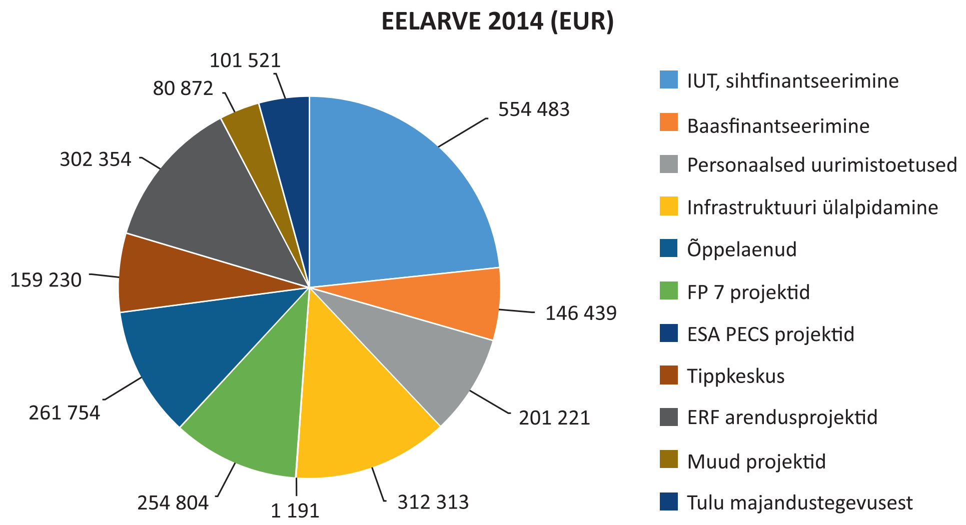


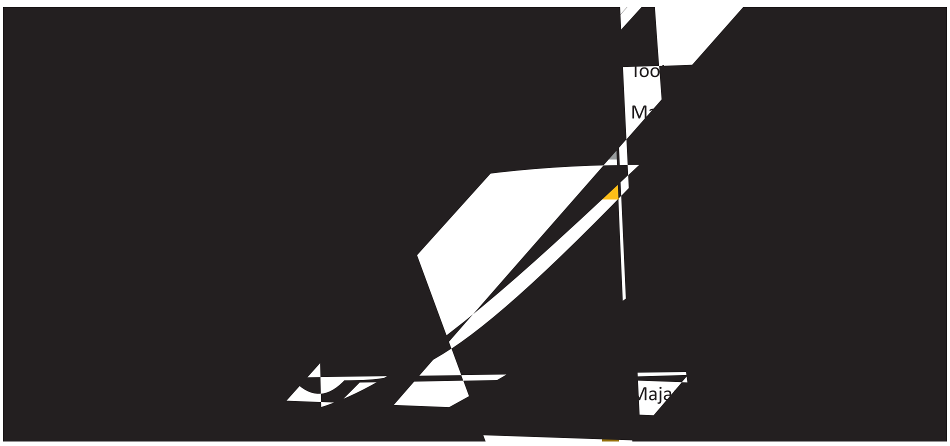
Fotol vasakult paremale: Gruberi Sihtasutuse üks rajajaid Patricia Gruber, Jaan Einasto, Gruberi Sihtasutuse Noore astronoomi stipendiumi saaja Djazia Ladjal Alžeeriast, Gruberi preemia laureaat 2000. aastal J. Peebles Princetoni Ülikoolist, Kenneth Freeman (Austraalia), preemiakomitee liige Owen Gingerich Harvardist, Brent Tully Havai Ülikoolist ja Sarah Hreha Gruberi Sihtasutusest.

1.3 Eelarve

Tartu Observatooriumi kogu eelarve 2014. aastal oli 2 376 181,32 EUR, millest 1 215 647,16 EUR laekus riigieelarvest sihtotstarbeliselt teadus-arendustegevuseks ja sellega seotud projektide läbiviimiseks (sisaldab ka jääki 2013. aastast 96 051,25 EUR), lisaks laekus 1 160 534,16 EUR ERF toetusi, FP7 projektide, ESA projektide ja muude lepingute kaudu.

Tulud ja kulud jagunesid järgnevalt:





1.4 Uurimisteemad ja grandid

1.4.1 Sihtfinantseeritavad teadusteemad

2014. aastal jätkus Tartu Observatooriumis ühe sihtfinantseeritava teadusteema täitmine ja alustati tööd uue institutsionaalse uurimistoetuse raames.

- Taimkatte kvantitatiivne kaugseire (teema juht A. Kuusk) – 80 150 EUR.
- IUT26-2: Galaktikate areng hierarhilises Universumis (teema juht E. Saar) – 288 000 EUR.

1.4.2 Eesti Teadusagentuuri grandid

Eesti Teadusagentuuri kaudu rahastati kolme Eesti Teadusfondi granti, kahte personaalset uurimistoetust ja ühte järeldoktori toetust:

- Grant 8906: L. Leedjärv – Täheassotsiatsioonide heledaimate tähtede muutlikkuse uuring (01.01.2011–31.12.2014) – 11 040 EUR.
- Grant 8970: J. Kuusk – Optiliste kaugseiremõõtmiste täpsust mõjutavad metroloogilised faktorid (01.01.2011–31.12.2014) – 7 200 EUR.
- Grant 9428: A. Tamm – Galaktiliste ketaste ja sferoidide osakaal Universumis (01.01.2012–31.12.2015) – 8 496 EUR.
- Personaalne uurimistoetus PUT232: J. Pisek – Metsa aluspinna struktuur ja hooajaline dünaamika mitme vaatesuuna kaugseirest (01.01.2013–31.12.2016) – 46 480 EUR.
- Personaalne uurimistoetus PUT246: J. Nevalainen – Kuhu küll pool barüonidest jäi? (01.01.2013–31.12.2016) – 66 720 EUR.
- Personaalne järeldoktori toetus PUTJD5: T. Tuvikene – Automaatne tähespektrite eraldamine digitaliseeritud fotoplaatidelt: meetodid ja rakendus (01.05.2014–30.04.2016) – 69 920 EUR (toetuse kogumaht).

1.4.3 Euroopa Liidu teaduskoostöö projektid

- EL 7. raamprogrammi projekt GA 251527 WaterS – Strateegiline partnerlus täiustatud vee kvaliteedi parameetrite määramiseks optilisest signatuurist (01.06.2010–31.05.2014): TO on konsortsiumi koordinaator, vastutav täitja A. Reinart – 1 954 453 EUR (TO kogumaksumus).
- EL 7. raamprogrammi projekt GA 311970 FORMIT – Metsade majandamisvõimalused Euroopas kliimamuutuste mõju leevendusvõimekuse tõstmiseks (01.10.2012–30.09.2016): TO on partner, vastutav täitja M. Lang – 67 680 EUR (TO kogumaksumus).
- EL 7. raamprogrammi projekt GA 313256 GLaSS – Sentinel satelliitide teenused järvede uuringuteks (01.03.2012–28.02.2016): TO on partner, vastutav täitja A. Reinart – 190 400 EUR (TO kogumaksumus).

- EL 7. raamprogrammi projekt GA 313116 NANOSAT – Nanosatelliitide potentsiaali kasutamine Euroopa kosmosepoliitika ja innovatsiooni toetuseks (01.01.2013–31.12.2014), TO on partner, vastutav täitja M. Noorma – 96 700 EUR (TO kogumaksumus).
- COST Action ES1309: Uudsed optilised meetodid ökofüsioloogiliste protsesside seireks (25.04.2014–24.04.2018) MC liikmed: L. Hallik, J. Kuusk.
- COST Action FA1306: Vastupidavate sortide otsingud – fenotüpiseerimine kogu taime ja raku tasandil (22.05.0214– 21.05.2018), MC liige: L. Hallik.
- Euroopa metroloogia teadusprogrammi (EMPIR) koostööprojekt MetEOC2 – Metroloogia tugi Maa ja kliima kaugseire uuringutele. Koostööpartner. (01.06.2014–31.07.2017), TO koordinaator: R. Vendt.

1.4.4 Euroopa Kosmoseagentuuri Euroopa koostööriikide programmi projektid ja Euroopa Kosmoseagentuuri tellimused

- Projekt AGE – Algoritmid galaktiliste struktuuride kaardistamiseks Gaia ja Euclidi abil (20.01.2014– 31.03.2016): A. Tamm – 181 148 EUR (TO kogumaksumus).
- Projekt QUALITY – Vee ruumhajumise mõõtja (20.01.2014–30.04.2016): A. Reinart – 110 000 EUR (TO kogumaksumus).
- Projekt MVT – MERIS valideerimine ja algoritmide 4. taastöötlus - MERIS valideerimise töörühm (MVT) (01.07.2014–30.11.2016): R. Vendt – 45 000 EUR (TO kogumaksumus).
- Optikaseadmed Euroopa tudengisatelliidile. Koostööprojekt ALMASpace ja Euroopa Kosmoseagentuuriga (2014): M. Noorma.

1.4.5 Euroopa Liidu struktuuritoetused

- Teadus- ja arendusasutuste ning kõrgkoolide õppe- ja töökeskkonna infrastruktuuri kaasajastamise projekt (3.2.0201.10-0013) "Tartu Observatooriumi infrastruktuuri arendusprojekt" (01.06.2008–31.12.2014): A. Reinart – 4 151 232 EUR (TO kogumaksumus).
- Teaduse tippkeskuste arendamise projekt (3.2.0101.11–0031) "Dark Matter in (Astro)particle Physics and Cosmology" (01.01.2011–31.12.2015): juhtpartner KBFI, TO koordinaator E. Saar, projektijuht A. Tamm – 730 262 EUR.
- Riikliku tähtsusega teaduse infrastruktuuri kaasajastamise projekt (3.2.0304.11-0395) "Eesti Keskkonnaobservatoorium" (01.01.2012–31.12.2015): juhtpartner Tartu Ülikool, TO projektijuht A. Kuusk – 103 321 EUR.

- Keskkonnakaitse ja -tehnoloogia teadus- ja arendustegevuse programmi (KESTA) projekt (3.2.0802.11-0043) Eesti veekeskkonna observatoorium (VeeOBS) (01.01.2012–31.12.2014): juhtpartner Eesti Maaülikool, TO koordinaator A. Reinart, projektijuht K. Uudeberg – 161 400 EUR.
- Keskkonnakaitse ja -tehnoloogia teadus- ja arendustegevus (KESTA) projekt (3.2.0802.11-0043) "Eesti Keskkonnaobservatooriumi biosfääri ja atmosfääri alane teadus- ja arendustegevus (BioAtmos)" (01.01.2012–31.12.2014): juhtpartner Tartu Ülikool, TO koordinaator A. Reinart, projektijuht J. Kuusk – 160 792 EUR.
- Keskkonnakaitse ja -tehnoloogia teadus- ja arendustegevus (KESTA) projekt (3.2.0801.12-0044) "Polaaralade kliima- ja keskkonnamuutused seotuna globaalsete muutustega ning nende mõju Põhja-Euroopa kliima kõikumistele" (01.04.2012–31.08.2015): juhtpartner Tartu Ülikool, TO projektijuht E. Jakobson – 36 105 EUR.
- Keskkonnatehnoloogia teadus- ja arendustegevuse toetuse (KESTA) projekt (3.2.0801.11-0012) "Aeglaselt kulgevate nähtuste tuvastamise kaugseiremeetodite täiustamine"(23.03.2012–31.12.2014): TO koordinaator U. Peterson – 83 684 EUR.
- Keskkonnatehnoloogia teadus- ja arendustegevuse toetuse (KESTA) projekt (3.2.0801.11-0041) "Eesti kiirguskliima" (23.03.2012–31.08.2015): juhtpartner Tartu Ülikool, TO koordinaator K. Eerme – 170 550 EUR.
- Teadus- ja arendusasutuste teadusaparatuuri ja seadmete kaasajastamise projekt (3.2.0302.12-0427) TAP37-1 "Kaugseireaparatuuri testimiskompleks" (01.11.2011–17.01.2014): M. Noorma – 152 000 EUR.
- Teadus- ja arendusasutuste teadusaparatuuri ja seadmete kaasajastamise projekt (3.2.0302.12-0428) TAP37-2 "Astronoomiliste vaatluste efektiivsuse tõstmine" (01.11.2011–17.01.2014): K. Annuk – 119 300 EUR.
- Teadusasutuste teadusaparatuuri kaasajastamise projekt (3.2.0302.13-0548) TAP53-1 "Kaugseire testimiskompleks 2" (01.04.2013–25.08.2015): M. Noorma – 87 200 EUR.
- Teadusasutuste teadusaparatuuri kaasajastamise projekt (3.2.0302.13-0549) TAP53-2 "Elektromagnetkiirguse mõõtesüsteem" (01.04.2013–25.08.2015): R. Vendt – 87 300 EUR.
- Programmi "Teaduse rahvusvahelistumine" algatus (3.2.0601.11-0001) "Eesti osalus Euroopa Kosmoseagentuuris – Kosmoseteaduse ja -tehnoloogia koostöövõrgustik GEOKOSMOS" (01.08.2010–31.08.2015): A. Reinart – 143 380 EUR.
- Programmi "Teaduse rahvusvahelistumine" algatus (3.2.0601.11-0001) Eesti kosmosetehnoloogia ja -rakenduste programmi integreerimine Euroopa teadusruumiga COSMOTECH (01.09.2013–31.08.2015): A. Reinart – 46 500 EUR.

1.4.6 Muud projektid ja lepingud

- Eesti maastike muutuste uuringud ja kaugseire. Riikliku keskkonnaseire programmi allprogramm, Keskkonnaministeerium: U. Peterson – 10 000 EUR.
- Deklareeritud põllupindade kontroll kaugseirevahenditega. Teadus- ja arendusleping Põllumajanduse Registrite ja Informatsiooni Ametiga (PRIA): U. Peterson – 4 095 EUR.
- Kosmoseteaduse ja -tehnoloogia populariseerimise programm (Haridus- ja Teadusministeerium) (07.05.2013-30.04.2014): M. Ruusalepp – 14 000 EUR.
- Keskkonnainvesteeringute Keskuse keskkonnateadlikkuse programmi projekt 4916: Innovatiivsete aktiivõppeprogrammide loomine Tartu Observatooriumis õpilaste keskkonnateadlikkuse tõstmiseks ja uurimusliku maailmanägemuse kujundamiseks (KIK'i projekt) (01.02.2013-30.11.2014): H. Lätt – 46 882 EUR.

1.5 Teadusnõukogu töö

Tartu Observatooriumi teadusnõukogu töötas alates 25. aprillist 2012 järgmises koosseisus:

Anu Reinart – Tartu Observatooriumi direktor, teadusnõukogu esimees,
Gert Hütsi – järeldoktor, teadustöötajate valitud liige,
Rein Kaarli – Haridus- ja Teadusministeeriumi teadusosakonna nõunik,
Marco Kirm – Tartu Ülikooli teadusprorektor,
Andres Kuusk – vanemteadur, teadustöötajate valitud liige,
Laurits Leedjärv – vanemteadur, teadustöötajate valitud liige,
Mart Noorma – vanemteadur, teadustöötajate valitud liige,
Tiina Nõges – Eesti Maaülikooli põllumajandus- ja keskkonnainstituudi uurija-professor,
Martti Raidal – Keemilise ja Bioloogilise Füüsika Instituudi uurija-professor,
Enn Saar – juhtivteadur, teadustöötajate valitud liige,
Antti Tamm – teadur, teadustöötajate valitud liige,
Elmo Tempel – teadur, teadustöötajate valitud liige,
Peeter Tenjes – vanemteadur, teadustöötajate valitud liige.

Teadusnõukogu pidas 9 koosolekut.

20. jaanuari koosolekul arutati Tartu Observatooriumi uue arengukava (2014-2020) koostamise piirjooni. Uue arengukavaga soovitakse kutsuda esile muudatusi asutuse senises arengus.

10. veebruari koosolekul kinnitati esitatavate IUT taotluste nimekiri. Toimus ka arengukava arutelu.

17. veebruari koosolekul toimus veelkord arengukava arutelu ja arutati strateegiapäeva läbiviimist.

17. märtsi koosolekul toimus elektrooniline hääletus arengukava kinnitamiseks.

09. juuni koosolekul anti ülevaade sellel aastal toimuvatest konverentsidest ning pidulikust üritusest *Tartu Observatoorium 50*. Samuti teatati, et nimelistele stipendiumitele kandideerimiseks on dokumentide esitamise tähtaeg 15. september.

18. augusti koosolekul toimus IUT 2015 tulemuste analüüs ning arutati astrofüüsika teadussuuna jätkusuutlikkust. Samuti toimus arutelu teadustöötajate töölepingute tähtajatuks muutmise üle, nii nagu nõuab ministeerium.

20. oktoobri koosolekul moodustati L. Leedjärve juhtimisel töögrupp, mis hakkab välja töötama ametinõudeid erinevatele ametikohtadele ning avaliku konkursi ja atesteerimise läbiviimise korda.
Nimeliste stipendiumite taotlejad esinesid ettekannetega:
Kristiina Verro: Nova 1901 struktuur ja kinemaatika (E.J. Öpiku nimelise stipendiumi taotleja),
Eero Vaher: Programmi SMART võimalused ja kasutamine reaalsete tähespektrite analüüsimisel (E.J. Öpiku nimelise stipendiumi taotleja),
Anni Sisas: CUDA (Copernicus Urban Development Analyses) – Tallinna ja Tartu lähiümbruse hoonestuse laienemine (J. Rossi nimelise stipendiumi taotleja).
Villem Voormansik: Maapinna ja majade vertikaalliikumise mõõtmine Tartus. PSIn Sar meetodi rakendused ja testimine (J. Rossi nimelise stipendiumi taotleja).
Andris Slavinskis: ESTCube-1 attitude determination and control (Ch. Villmanni nimelise stipendiumi taotleja).
Pika arutelu tulemusena said stipendiumid Kristiina Verro, Anni Sisas ja Andris Slavinskis.

10. novembri koosolekul toimus ettevalmistatud dokumentide, ”Tartu Observatooriumi teadustöötajate valimise kord"ja ”Tartu Observatooriumi teadustöötajate ametinõuded eri ametikohtadele"põhjalik arutelu. Arutleti ka aastaraamatu formaati ning otsustati jätkata juba traditsiooniks kujunenud formaadis.

15. detsembril toimunud koosolekul otsustati esitada E. Tempel ja A. Hektori kandidatuur Eesti Vabariigi teaduspreemiale täppisteaduste erialal. Kinnitati eelmisel koosolekul arutelu all olnud alusdokumendid. Kuulutati välja konkurss direktori ametikohale.

1.6 Külastuskeskuse tegevus

Tartu Observatooriumi külastuskeskuse jaoks oli 2014. aasta töörohke. 2013. aastal komplekteeritud ja koolidele mõeldud rändnäitus "Kosmosetehnoloogia meie igapäevaelus!" ringles ka 2014. aastal 17 koolis üle Eesti. Aasta jooksul korraldati kolm õpetajate koolitust, kus kokku osales 70 õpetajat erinevate piirkondade koolidest, sh Hiiumaalt. Observatooriumi külastas kolme erineva aktiivõppeprogrammi (kaugseire, kosmosetehnoloogia ja satelliidid) raames kokku 21 õpilasgruppi, ligi 630 õpilasega. Külastajaid oli Harjumaalt, Ida-Virumaalt, Virumaalt, Tartumaalt, Põlva- ja Võrumaalt. 14. veebruaril toimus Tartu Observatooriumis õpilasteadlaste konverents "Kosmosel on tulevikku!", kus osales 91 õpilast. Õpilased tulid kokku Viimsist, Põlvast, Rakverest, Jõgevalt ja Tartust. Renoveeritud peahoone on täienenud uute eksponaatidega. Aatriumi laes ripub automaatjaama Proba-V makett (suuruses 1:1), mille originaal lennutati kosmosesse koos ESTCube-1-ga. Sisustati satelliidi juhtimiskeskuse ruum, kus saab jälgida ESTCube-1 või mõne teise satelliidi ülelendu Eestist. Aatriumi seintel on nüüd postrid, tutvustamaks kaugseire, kosmosetehnoloogia ja astronoomia valdkondi. Külastuskeskuse trepihallis on kanderakett Ariane 5 vähendatud makett koos selgitatavate tekstidega.

Vaade Stellaariumi uuele ekspositsioonile.

Kevadel lõppes Stellaariumi remont ja ekspositsiooni uuendamine. Juba traditsioonilised astronoomia põhialuseid tutvustavad posterid said uue sisu ja kujunduse. Valmistati planeet Marsi kanjoni makett, uue kujunduse sai

Orioni tähtkuju tekkimist selgitav installatsioon. Täiesti uus on Tartu Observatooriumis kunagi kasutusel olnud arvutustehnika ekspositsioon. Vaatamata aasta alguse seisakule külastas 2014. aastal Stellaariumi 223 gruppi 4800 huvilisega. Eriti palju oli külastajaid oktoobris, kui Tõraveres käis 66 gruppi 1432 huvilisega. Aktiivselt võtsime osa Teadlaste ÖÖ üritusest koos teaduskeskusega AHHAA. Peahoones räägiti kaugseirest ja kosmosetehnoloogiast, K. Voormansik esines loenguga "Linnastumise jälgimine kosmosest ja seosed inimeste tervisega". Suure teleskoobi tornis näidati teleskoobiga planeete, toimusid vestlused astronoomidega, sai uudistada ekspositsiooni ja kuulata/vaadata taevaseid objekte virtuaalplanetaariumi programmiga Starry Night. Kokku käis sellel õhtul Tõraveres 250 inimest. Tartu Observatooriumi külastuskeskuse töötajad on käinud mitmetel üritustel tutvustamas potentsiaalsetele külastajatele meie maja täienenud külastusvõimalusi.

2014. aasta olümpiaaditsüklil korraldasid TÜ Teaduskooli egiidi all toimuvat Lahtist Astronoomia Võistlust T. Sepp, T. Eenmäe (mõlemad osalesid ka koondise juhtidena ülemaailmsel Astronoomiaolümpiaadil) ja R. Kipper. Kokku osales lahtisel võistlusel 22 õpilast. Lahtise võistluse tulemuste alusel valiti 10 koondise kandidaati. Valituks osutusid: Carel Kuusk, Taavet Kalda, Jonathan Kalmus, Paul Kerner, Joonas Kalda gümnaasiumiastmes ning Fedor Stomakhin, Airon Johannes Oravas, Carmel Kuusk, Pearu Pung, Gamithra Marga põhikooliastmes. Neile korraldati viiepäevane treeninglaager kus valiti kuus Eesti koondislast üleilmsele olümpiaadile. Eesti koondislastele korraldati Tartu Observatooriumis ka teine 4-päevane treeninglaager. Lisaks eespoolmainitutele õpetasid treeninglaagrites lapsi ka J. Laur, E. Vaher, T. Kuutma ja T. Liimets. 12.–21. oktoobril toimus XIX üleilmne Astronoomiaolümpiaad Bishkekis ja Chopton Atas Kõrgõzstanis. Eesti koondislaste tulemused olid rõõmustavad, sest saadi neli pronksmedalit ja kaks diplomit. Vanemas astmes said medali kõik kolm koondislast: Carel Kuusk Tallinna Reaalkoolist, Taavet Kalda Gustav Adolfi Gümnaasiumist ja Jonatan Kalmus Hugo Treffneri Gümnaasiumist. Nooremas astmes oli parim pronkmedalist Airon Johannes Oravas ning diplomi pälvisid Pearu Pung ja Gamithra Marga (kõik Tallinna Prantsuse Lütseumist).

Eesti võistkondade osalemist rahvusvahelistel võistlustel rahastab HTM ja nende lähetamist koordineerib TÜ Teaduskool.

3. juulil 2014 külastasid Tartu Observatooriumi VII Eesti aukonsulite konverentsi raames ligi 40 Eesti aukonsulit ning nende saatjat. Aukülalisi tervitas observatooriumi direktor A. Reinart. Paljudele aukonsulitele juba tuttavast Eesti tudengisatelliidi projekti missioonist ESTCube-1 kõneles projekti eestvedaja kosmosetehnoloogia osakonna juhataja M. Noorma. Aukonsulid lõid kaasa ESTCube-1 kaameraga tehtud piltide põhisel viktoriinil. Tudengisatelliidi meeskonna liikmed juhatasid külalised observatooriumi huvitavaimatesse paikadesse: laboritesse ja katuse-

le mõõteriistadega tutvuma. Järgnes suure teleskoobi vaatamine ja Stellaariumi väljapanekuga tutvumine. Tee peal näitas Eesti Lennuakadeemia lõpetanud Toivo Värbu oma lõputööd – kompaktset ja kiiresti püstitatavat mobiilset satelliidi maajaama. Külaskäik lõppes ühise lõunaga.

Aukonsulid ringkäigul Tõraveres.

7. oktoobril 2014 külastas Eestis kahepäevasel ametlikul visiidil viibiv Norra kaitseväe juhataja admiral Haakon Bruun-Hanssen Tartu Observatooriumi.

Kõrgeid külalisi võttis vastu observatooriumi direktor A. Reinart. Teadur K. Voormansik andis ülevaate observatooriumi teadlaste kompetentsist radarkaugseire valdkonnas ning võimalustest militaar- ja tsiviilvaldkonna koostööks. Kosmosetehnoloogia osakonna juhataja M. Noorma kõneles eesti esimesest satelliidist ning toimivast koostööst Eesti kaitseväega tudengite ettevalmistamisel. Juhtivinsener V. Allik näitas külalistele satelliidi maajaama, M. Noorma mõõteseadmeid tornis ning R. Vendt tutvustas katse- ja kalibreerimislaborite võimalusi. Eesti kaitseväe juhataja kindralmajor Riho Terras ja admiral Haakon Bruun-Hanssen jätsid tänusõnad sooja ja väga huvitava vastuvõtu ning pilgu eest tulevikku observatooriumi külalisteraamatusse.

Toimus ka 30 laboriekskursiooni teadlastele, õpilastele, õpetajatele, üliõpilastele, ettevõtetele, koostööpartneritele.

Ilmus Tähetorni Kalender 2015 (91. aastakäik) ja juba traditsiooniline Tähistaeva Kalender 2015. Mõlema kalendri kalendaariumi osa arvutused tegi A. Puss.

Observatooriumi teadlaste arvukad populaarteaduslikud kirjutised on üksikasjaliselt ära toodud lk. 104, avalikud loengud ja intervjuud lk. 124.

1.7 Tänuavaldused

Meie teadlased on saanud rahalist või muud toetust paljudelt asutustelt üle maailma. Oleme tänulikud kõigile toetajatele, nende nimed leiate ingliskeelsest osast leheküljel 40.

2 Summary

2.1 Key events

- **International Astronomical Union symposium 308: Zeldovich Universe – Genesis and Growth of the Cosmic Web**

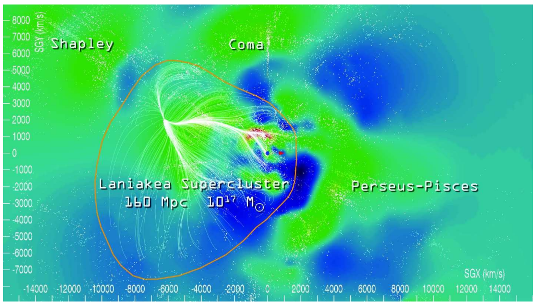
From left: Enn Saar, Rien van de Weijgaert, Sergei Shandarin.

In 2014 fill the renowned scientist Yakov Zeldovich would have been 100 years of age. His seminal work paved the way towards a theoretical understanding of the complex weblike patterns that have been observed in our Universe. The conference was dedicated to that event.

The symposium brought together nearly 200 leading cosmologists and astronomers to discuss the latest achievements and results in the field of large-scale structure of the Universe. Most of the top scientists in the field were among the participants, including six Gruber prize winners.

The symposium focused on the subject of the structure, constituents, properties, dynamics and analysis of the cosmic web in the large-scale cosmic matter and galaxy distribution. The symposium synthesized the insights obtained from many different observational and theoretical studies and set out the lines for the major upcoming scientific programmes that will not only extend our view over a far larger fraction of the visible Universe but also allow the systematic investigation of the evolution of cosmic structure. Rien van de Weijgaert from University of Gröningen, the Netherlands and Sergei Shandarin from University of Kansas, USA, led the Symposium Scientific Committee.

- **Laniakea, our largest home**



In 2014, our research of the large scale structure of the Universe received strong recognition by the Nature journal. This outstanding science magazine asked Elmo Tempel, the research fellow of the department of cosmology, to write an introduction to the cover story of the September 2014 issue that puts our home galaxy into a completely new perspective. In that paper, Brent Tully and colleagues analysed a fresh and detailed dataset about the positions and motions of galaxies around our Milky Way. The authors found that our home galaxy is a part of a huge, previously unknown galaxy system, which they named the Laniakea supercluster. The fact that the Nature considers Elmo Tempel a distinguished expert of the field indicates that the cosmologists of Tartu Observatory are on the right track. Elmo Tempel was also the winner of the last year's Estonian Young Scientist Award.

- **Scientific Week "United by Space!"**

Tartu Observatory researchers have studied space related issues in Tõravere already 50 years. In September, 22–26 Tartu Observatory celebrated an important milestone with the science week. Observatory issued an interesting history book "Tartu Observatory – 50 years in Tõravere" in cooperation with publishing house "Aasta Raamat". The Editor-in-Chief of the book was Tõnu Viik, Mare Ruusalepp selected the photos. The texts in the book are written by *ca* 50 researchers in the observatory.

The publisher of the book was Indrek Ilomets, Mart Orav edited it and the designer was Kalle Toompere, Leelo Jago edited the text in Estonian. Krista Kallis and Tiina Ann Kirss translated the text into English.

The public presentation of the book was on September 25, 2014 in Tõravere together with previous and present colleagues.

The programme of the scientific week included student workshop ”How to develop a successful CubeSat mission?”, Tartu Conference on Space Science and Technology, workshop on ESA Science & Technology Programmes for entrepreneurs and cooperation partners and open observations in Stellaarium in the framework of Researchers' Night 2014.

- **Tartu Conference on Space Science and Technology**

Participants of the conference.

Honouring the latest achievements regarding technology of nanosatellites, Tartu Conference on Space Science and Technology was organized on September 23–24, 2014 in Tõravere in conjunction with the International Scientific Conference ”Baltic Applied Astroinformatics and Space Data Processing” (BAASP) that has been held twice already at the Ventspils University College, Latvia. Continuing the tradition of BAASP, the Tartu conference brought together experienced scientists and enthusiastic students.

The key topics of the conference included technology of nanosatellites, innovative and future missions and experiments for nanosatellites, methods for analysis of Big Data amounts. An educational programme in space technology and development of international research networks were also discussed during the event. Pre-conference workshop gave the international student team unique opportunity to share experiences and get to know the secrets how to develop successful CubeSat missions.

- **Estonian Remote Sensing Days**

On October 21–22, 2014, about one hundred remote sensing scientists from various organizations from Estonia and abroad gathered to exchange new ideas, hold panels and discussions during Estonian Remote Sensing Days.

The conference focused on various hot topics and new technologies on Earth observation on a local and on a global scale. Special focus was on ESA Earth Observation Programmes as optional programmes for new member states and the cooperation between ESA and Estonian entities.

Keynote speaker Mr Gordon Campbell from ESA Directorate of Earth Observation Programmes, Science, Applications and Future Technologies Department gave an overview from ESA perspective. On the second day, the Estonian Earth Observation issues were discussed.

The Estonian Environmental Protection Agency issued a publication ”Remote sensing in Estonia 2014” on this special occasion.

- **The Estonian Space Research and Technology Capacities Introduced in Brussels**

On Dec 9th 2014 Tartu Observatory and the Estonian Liason Office for Research and Innovation organized a joint seminar to introduce the Estonian space research and technology capacities to the policy makers in Brussels.

Head of the Estonian Space Office, Madis Võõras and Director of Tartu Observatory, A. Reinart introduced the current developments of the Estonian Space policy, our relations to ESA and EU, the cutting-edge research capacity of Tartu Observatory. Skilled people and modern infrastructure in space sector are ready to work out value-added chain from fundamental science to public services in close cooperation with other research institutions, universities, and enterprises in EU and worldwide.

Head of Unit of Copernicus Services from DG Enterprise and Industry (DG Growth) Peter Breger opened up the real benefits and opportunities for small countries to participate in the EU Earth Observation and monitoring programme Copernicus. Young astrophysist Mihkel Kama from Leuen University shared his thoughts about small countries in large astrophysics projects.

Head of Galileo Service Provision sector, DG Enterprise (DG Growth) Hillar Tork asked all participants in the roundtable to point out the main issues that support Estonia from its' current position on the highway to space. Andreas Veispak, Advisor of Director General of DG Enterprise (DG Growth) added valuable comments on SME Instrument in Horizon 2020 as useful tool to work out the research based services, and for positioning Estonia in the larger context of European and international development.

The Estonia's highest priorities in space activities today lay in the development of Earth Observation methods and specific technology usable in space – instruments, nanosatellites and services, in close cooperation with the conception of digital Estonia. These high goals are achievable through focusing our research priorities, exchange of researchers, and participation in strong international technology consortia. The seminar was organized in the rooms of Permanent Representation of Estonia to the EU.

2.2 Awards

- **Anu Reinart was awarded the order of White Star, class IV**

In 2014 the President of the Republic of Estonia Toomas Hendrik Ilves decorated the talented Estonian scientists. The Director of Tartu Observatory, Anu Reinart was awarded the order of the White Star, IV class for popularization of science and as one of the leaders of the ESTCube student satellite Project.

- **Jaan Einasto – Gruber Cosmology Prize winner 2014**

On June 10, 2014 The Gruber Foundation announced the 2014 Gruber Cosmology Prize laureates.

The 2014 Gruber Foundation Cosmology Prize recognized Jaan Einasto, Kenneth Freeman, Richard Brent Tully, and Sidney van den Bergh for their individual roles in the development of Near Field Cosmology for their pioneering contributions to the understanding of the structure and composition of the nearby universe. By establishing a connection between observations of the nearby universe with the universe on the whole, they pioneered an area of study that helped establish both that the distribution of galaxies is not random but has a definite structure, and that dark matter played a key role in the evolution of that structure.

The Prize was presented to Einasto, Freeman, Tully, and van den Bergh in a ceremony at Yale University on October 1, 2014.

- **Tõnu Viik was elected an Honorary Member of the Estonian Naturalists' Society**

On October 30th 2014, Senior Research Fellow of Tartu Observatory, Tõnu Viik was elected an Honorary Member of the Estonian Naturalists' Society. During 2008–2014, Tõnu Viik was a president of the Estonian Naturalists' Society. He has promoted the natural sciences through articles, public lectures, excursions, instruction of students, writing books, administrative work for

decades. In 2014 he was the Editor-in-Chief of the book ”Tartu Observatory 50 years in Tõravere”.

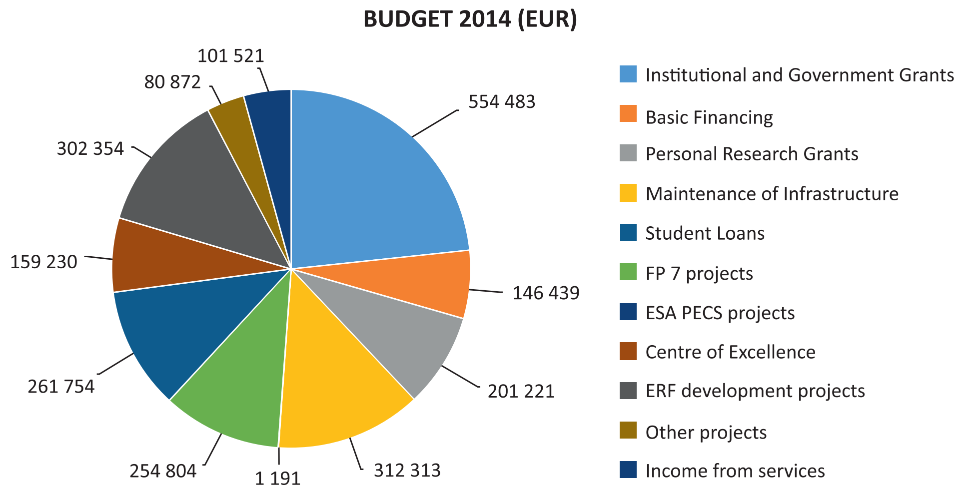
Only persons over 50 years of age, who have distinguished services in the development of natural sciences or who, through their long-time and productive activities have provided great services to the Estonian Naturalists’ Society, can be elected honorary members. Another Honorary member of ENS from Tartu Observatory is Jaan Einasto.

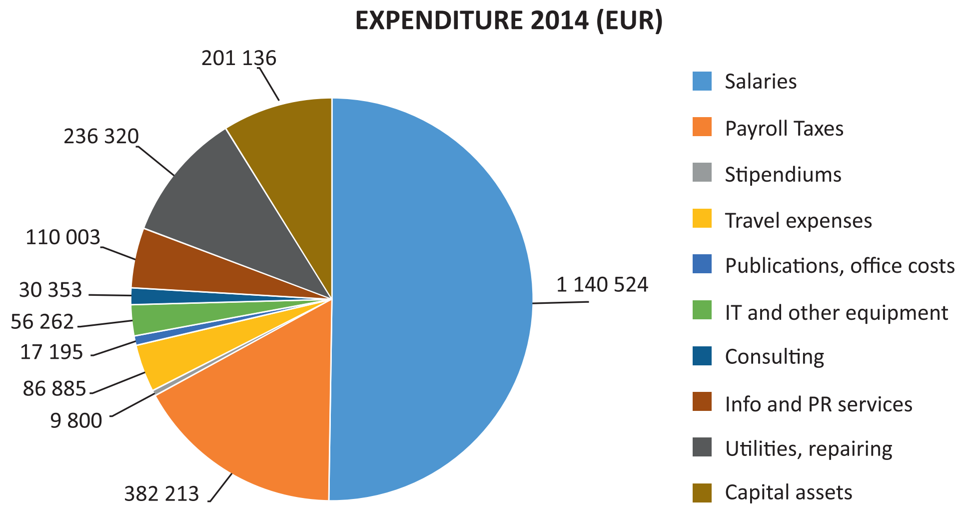
- **Olga Tihhonova** (University of Tartu) was awarded a diploma for the entry ”Modelling Galaxy Stellar Dynamics on the Base of Andromeda” in the competition of student research on sciences and technology. The competition was organized by the Estonian Research Council.

- The University of Tallinn named **Uno Veismann** their outstanding alumnus and issued a letter of acknowledgement for long-time popularization.

2.3 Budget

Total budget of Tartu Observatory in 2014 was 2 376 181, 32 EUR, where 1 215 647,16 EUR are from governmental funding for the research and related projects (includes also 96 051,25 EUR from year 2013), additionally 1 160 534,16 EUR are from European Regional Funds, FP7, ESA and other projects.





The mean salary of researchers was approximately 1402 EUR by the end of 2014.

2.4 Research projects and grants

In 2014, the research in the framework of one target financed project was continued and was commenced in the frame of new institutional research grant.

- Quantitative remote sensing of vegetation covers (principal investigator A. Kuusk) – 80 150 EUR.
- Galaxy evolution in the hierarchical Universe (principal investigator E. Saar) – 288 000 EUR

2.4.1 Estonian Research Council grants

The Estonian Research Council financed three research grants, two personal research grants and one postdoctoral research grant:

- Grant 8906: L. Leedjärv – Time-resolved survey of the most luminous stars in stellar associations (01.01.2011–31.12.2014) – 11 040 EUR.
- Grant 8970: J. Kuusk – Study of metrological factors limiting complex optical measurements in remote sensing and atmospheric research (01.01.2011–31.12.2014) – 7 200 EUR.
- Grant 9428: A. Tamm – Share of galactic discs and spheroids in the Universe (01.01.2012–31.12.2015) – 8 496 EUR.
- Personal research grant PUT232: J. Pisek – ForESt undersTory StructurE and sEasonal Dynamics by multi-angle remote Sensing (EST SEEDS) (01.01.2013–31.12.2016) – 46 480 EUR.
- Personal research grant PUT246: J. Nevalainen – Where have half the baryons gone? (01.01.2013–31.12.2016) – 66 720 EUR.
- Personal postdoctoral research grant PUTJD 5: T. Tuvikene – Automated extraction of stellar spectra from digitised photographic plates: methods and application (01.05.2014–30.04.2016) – 69 920 EUR (full amount).

2.4.2 The European Union Research Projects

- FP7 project GA 251527 WaterS – Strategic partnership for improved basin-scale Water quality parameter retrieval from optical Signatures (01.06.2010–31.05.2014), TO is consortium coordinator, PI: A. Reinart – Full cost for TO 1 954 453 EUR.
- FP 7 project GA 311970 FORMIT – FORest management stategies to enhance the MITigation potentials of European forests (01.10.2012–30.09.2016), TO is partner, PI: M. Lang – Full cost for TO 67 680 EUR.
- FP 7 project GA 313256 GLaSS – Global Lakes Sentinel Services (01.03.2012–28.02.2016), TO is partner, PI: A. Reinart – Full cost for TO 190 400 EUR.

- FP7 project GA 313116 NANOSAT – Utilizing the potential of NANO-SATellites for the implementation of European Space Policy and space innovation (01.01.2013–31.12.2014), TO is partner, PI: M. Noorma – Full cost for TO 96 700 EUR.
- COST Action ES1309: Innovative optical tools for proximal sensing of ecophysiological processes (OPTIMISE) (25.04.2014–24.04.2018), MC members: L. Hallik, J.Kuusk.
- COST Action FA1306: The quest for tolerant varieties: Phenotyping at plant and cellular level (22.05.0214–21.05.2018), MC member: L. Hallik.
- EMRP JRP: MetEOC2 Metrology for Earth observation and climate (01.06.2014–31.07.2017), TO coordinator: R. Vendt.

2.4.3 European Space Agency projects

- Project AGE – Algorithms for mapping galactic structures with Gaia and Euclid (20.01.2014–31.03.2016), A. Tamm – Full cost for TO 181 148 EUR.
- Project QUALITY – Instrument for the volume scattering function of water (20.01.2014–30.04.2016), A. Reinart – Full cost for TO 110 000 EUR.
- MERIS Validation and Algorithm 4th reprocessing – MERIS Validation Team (MVT) (01.07.2014–30.11.2016), R. Vendt – Full cost for TO 45 000 EUR.
- Optical payload for European Student Earth Orbiter (ESEO, in cooperation with ALMASpace and ESA) – M. Noorma.

2.4.4 EU Structural Funds Projects

- Project (3.2.0210.10-0013) Renovation and development of Tartu Observatory infrastructure (01.06.2008–31.12.2014): PI A. Reinart – 4 151 232 EUR.
- Programme for Centres of Excellence in Research project (3.2.0101.11-0031) Dark Matter in (Astro)particle Physics and Cosmology (01.01.2011–31.12.2015): leading partner KBFI, TO coordinator E. Saar, PI A. Tamm – 730 626 EUR.
- Estonian Research Infrastructures Roadmap project (3.2.0304.11-0395) Estonian Environmental Observatory (01.01.2012–31.12.2015): Leading partner University of Tartu, TO PI A. Kuusk – 103 321 EUR.
- Environmental Conservation and Environmental Technology R&D (KESTA) project (3.2.0802.11-0043) ”Estonian observatory of water environment (VeeOBS)” (01.01.2012–31.12.2014): Leading partner Estonian University of Life Sciences, TO PI A. Reinart, project leader K. Uudeberg – 161 400 EUR.

- Environmental Conservation and Environmental Technology R&D (KESTA) project (3.2.0802.11-0043) Biosphere and atmosphere related R&D in the Estonian Environmental Observatory (BioAtmos) (01.01.2012–31.12.2014): Leading partner University of Tartu, TO PI A. Reinart, project leader J. Kuusk – 160 792 EUR.
- Environmental Conservation and Environmental Technology R&D (KESTA) project (3.2.0802.11-0044) "Climate and environment changes in polar regions and their relations to global changes and climate variability in Northern Europe" (01.04.2012–31.08.2015): Leading partner University of Tartu, TO PI E. Jakobson 36 105 EUR.
- Environmental Conservation and Environmental Technology R&D (KESTA) project (3.2.0801.11-0012) "Improving methods for remote sensing of slowly proceeding phenomena" (23.03.2012–31.12.2014): TO PI U. Peterson – 83 684 EUR.
- Environmental Conservation and Environmental Technology R&D (KESTA) project (3.2.0801.11-0041) Estonian radiation climate (23.03.2012–31.08.2015): Leading partner University of Tartu, TO PI K. Eerme – 170 550 EUR.
- Research equipment and facilities project (3.2.0302.12-0427) TAP 37-1 Test facilities for remote sensing equipment (01.11.2011–17.01.2014): M. Noorma – 152 000 EUR.
- Research equipment and facilities project (3.2.0302.12-0428) TAP37-2 "Increasing effectiveness of astronomical observations" (01.11.2011–17.01.2014): K. Annuk – 119 300 EUR.
- Research equipment and facilities project (3.2.0302.13-0548) "Test facilities for remote sensing equipment 2" (01.04.2013–25.08.2015): M. Noorma – 87 200 EUR.
- Research equipment and facilities project (3.2.0302.13-0549) "Measurement system for electromagnetic emission" (01.04.2013–25.08.2015): R. Vendt – 87 300 EUR.
- Internationalization of research initiative (3.2.0601.11-0001) "Participation of Estonia in the European Space Agency – network for space science and technology GEOKOSMOS" (01.08.2011–31.08.2015): A. Reinart – 143 380 EUR.
- Internationalization of research initiative (3.2.0601.11-0001) "Integration of the Estonian Space Science and Technology Applications into the European Research Area COSMOTECH" (01.09.2013–31.08.2015): A. Reinart – 46 500 EUR.

2.4.5 Other projects and contracts

- Review of declared agricultural parcels with remote sensing methods: U. Peterson – 4 095 EUR.

- National programme of environmental monitoring, subprogramme ”Studies on change of Estonian landscapes and remote sensing”, Ministry of the Environment: U. Peterson – 10 000 EUR.
- A programme for popularization of space science and technology (Ministry of Education and Research; 07.05.2013-30.04.2014): M. Ruusalepp – 14 000 EUR.
- Creation of innovative active study programmes for enhancing the awareness of pupils in environment and for formation the exploratory world vision (Environment Investment Centre Project nr 4916) (01.02.2013–30.11.2014): H. Lätt – 46 882 EUR.

2.5 Scientific Council

The members of the Tartu Observatory Scientific Council in 2014 were:

Anu Reinart – director, Chair of the Council,
Gert Hütsi – postdoc, elected by researchers,
Rein Kaarli – adviser in the Ministry of Education and Research,
Marco Kirm – vice-rector of the University of Tartu
Andres Kuusk – senior research associate, elected by researchers,
Laurits Leedjärv – senior research associate, elected by researchers,
Mart Noorma – senior research associate, elected by researchers,
Tiina Nõges – Estonian University of Life Sciences, research professor,
Martti Raidal – senior research associate of the National Institute of Chemical Physics and Biophysics,
Enn Saar – leading research associate, elected by researchers,
Antti Tamm – research associate, elected by researchers,
Elmo Tempel – research associate, elected by researchers,
Peeter Tenjes – senior research associate, elected by researchers.

The Research Council of Tartu Observatory held nine meetings.

On January 20, the council discussed the outlines of the new Development Plan of Tartu Observatory for the period of 2014 – 2020.

On February 10, the council confirmed the list of institutional research grant (IUT) applications submitted to the call for IUT 2015 and discussed again the draft of the Development Plan.

On February 17, the council discussed once more the draft of the Development Plan and agenda of the strategy day to discuss the development plan issues with all staff and students.

On March 17, the Council accepted the Development Plan of Tartu Observatory for the period of 2014 – 2020 by electronic voting.

On June 9, the organizers gave an overview of the scientific conferences planned in 2014 and introduced the plans for celebration of the 50 years of Tartu Observatory in Tõravere in September. On the same meeting, the council announced the call for Tartu Observatory 2014 scholarships.

On August 18, the council analyzed the results of IUT 2015 call and discussed the future of the astrophysics research field in the observatory. The council discussed also the new procedure of the employment contracts of the researchers starting from the January 1st, 2015 according to the changes in the Research and Development Organization Act.

On October 20, the council appointed a working group, led by Laurits Leedjärv, to work out the job requirements for the research staff, regulations for selection of the research staff and rules for evaluation of the researchers. The Tartu Observatory 2014 Scholarship candidates presented their research work.

Kristiina Verro: The structure and kinematics of Nova 1901 (applied for the E.J. Öpik Scholarship),

Eero Vaher: The possibilities of the programme SMART (applied for the E.J. Öpik Scholarship),

Anni Sisas: CUDA (Copernicus Urban Development Analyses) (applied for the J. Ross Scholarship),

Villem Voormansik: Application and testing of PSIn Sar method (applied for the J. Ross Scholarship),

Andris Slavinskis: ESTCube-1 attitude determination and control (applied for the Ch. Villmann Scholarship).

On November 10, the council discussed thoroughly the job requirements for the research staff and regulations for the selection of the research staff. They discussed also the format of the Annual Report and decided to issue the 2014 Annual Report in the traditional format.

On December 15, the council decided to nominate Elmo Tempel and Andi Hektor as the candidates of the Estonian Science Prize in the exact sciences candidates, approved the Job Requirements for the Research Staff and The Procedure for Selecting or Nominating the Research Staff, and promulgated the competition for the position of the Director of Tartu Observatory.

2.6 Visitor centre

In 2014, the Tartu Observatory Visitor Centre opened the renewed exposition of our research fields: astronomy, remote sensing and space technology to the public and welcomed about 250 groups of students, teachers, scientists and partners in Tartu Observatory. The travelling exhibition for schools ”The Space Technology in Our Everyday Life”, that got ready in 2013, was demonstrated in 17 schools all over Estonia in 2014. The Visitor Centre organized three teacher training events to introduce the active learning programmes and methods in remote sensing, space technology and satellites, where 70 natural science teachers all over the country participated. Twenty-one groups of about 630 pupils passed the active learning programmes in the Tartu Observatory Visitor Centre last year. They were from Harju, Ida-Virumaa, Virumaa, Tartu, Põlva and Võru Counties. On February 14th, the Visitor Centre organized a conference of student researchers ”Space has Future!” with 91 participants from Viimsi, Põlva, Rakvere, Jõgeva and Tartu.

Satellite ground station.

The new exposition of the Visitor Centre in the main building of the observatory on the space technology and Earth observation, including various very interesting showpieces was opened. A sample of the automatic station Proba V, which was launched into the space together with the student satellite

ESTCube-1 is suspended from the ceiling of the atrium. The satellite control station was equipped with apparatuses where visitors can follow the overflight of the ESTCube-1 and other satellites. The glass posters on the walls of the atrium introduce the research fields of the observatory: astronomy, remote sensing and space technology. There is also a reduced size model of the booster Ariane 5 with explanations on the stairways to the conference hall. The Visitor Centre also completed the renovation of the exhibition hall and Stellarium. The visitors can now admire a model of Mars canyon, the 3D projection of the Orion constellation and the variety of old computers, used by the researchers in Tõravere at various times. There were 223 groups with 4800 visitors attending the guided tours in Stellarium in 2014. The people were especially active in October, where 66 groups with 1432 participants visited the new exhibition. Last, but not least, in 2014 over 30 laboratory tours were conducted to scientists, pupils, teachers, students, companies and partners, introducing the new laboratory facilities and the research work done there. The Visitor Centre participated in the activities of Researchers' Night 2014 in cooperation with the science centre AHHAA. The staff of the Visitor centre introduced the renewed possibilities for the visitors during various events.

On July 3, 2014 Tartu Observatory had the honour of hosting about 40 Honorary Consuls of Estonia in the course of the VII Conference of the Honorary Consuls of Estonia. The director of the observatory, Anu Reinart gave a brief overview of the observatory and its history. Mart Noorma, initiator of the Estonian Student Satellite project ESTCube and head of the department of space technology in Tartu Observatory, gave our visitors an update on ESTCube-1. Honorary consuls participated in a quiz based on images taken by ESTCube-1. Members of the ESTCube team guided guests to the most interesting attractions in the building: the labs, the radio lab and the rooftop. Next, they took a walk towards the telescope building in the beautiful weather. On the way, recent Estonian Aviation Academy graduate Toivo Värbu demonstrated the mobile ground station developed especially for the ESTCube project as the subject of his thesis. The visit ended with a lunch and warm farewells.

On October 7th 2014, Chiefs of the Defence Forces of Norway Admiral Haakon Bruun-Hanssen and General Major Riho Terras of Estonian Defence Forces visited Tartu Observatory in Tõravere. Director Anu Reinart welcomed the high guests and gave an overview of the institute. Research fellow Kaupo Voormansik told about the possibilities of Tartu Observatory to support the defence forces. Mart Noorma introduced nanosatellites and ESTCube as well as collaboration experiences with defence forces through education of engineers and military technology. The Leading Engineer Viljo Allik showed the satellite ground station to the Admiral and delegation. Mart Noorma introduced the antennas and measurement facilities on the roof and Dr Riho Vendt demonstrated the testing and calibration laboratories. General

Major Riho Terras and Admiral Haakon Bruun-Hanssen signed in the guestbook expressing their thanks for very interesting introduction into the research and work done in the observatory. The guests were awarded with the newly issued books "Tartu Observatory in Tõravere" for memorizing the visit to the observatory.

The researchers of Tartu Observatory Tiit Sepp, Tõnis Eenmäe and Rain Kipper coached the Estonian national team for the XIX International Astronomy Olympiad for schoolchildren. There was an open competition organized in Estonia to select the members for the national team, and 10 participants out of 22 was chosen as a candidates for national team. Training camps were held twice in Tartu Observatory, where Jaan Laur, Eero Vaher, Teet Kuutma and Tiina Liimets in addition to the above-mentioned coaches contributed to the preparation of the national team. The Olympiad was held from October 12th to 21st 2014 in Bishkek, Kyrgyzstan. The students competed in 2 age groups, whose age limit correspond approximately to age limit of comprehensive school and gymnasium. All participants in the younger group where from Tallinn French School: Airon Johannes Oravas won bronze medal, Pearu Pung won diploma and Gamithra Marga won diploma and special award for the best problem illustration. All participants in the elder age group: Carel Kuusk from Tallinn Secondary Science School, Taavet Kalda from Gustav Adolf Gymnasium and Jonatan Kalmus Hugo Treffner Gymnasium, won bronze medals. The participation of the Estonian teams in the international competition is funded by the Ministry of Education and Research and coordinated by the Gifted and Talented Development Centre of the University of Tartu.

Chief of the Defence of Norway and Chief of the Defence of Estonia in Tartu Observatory.

On October 22nd, the former president Arnold Rüütel planted an oak tree nearby the main building of the observatory during the visit to observatory. In 2014 Tartu Observatory issued the 90th edition of the "Calendar of the Tartu Observatory" for the year 2014 and "Calendar of the Starry Sky 2014".

The calendar calculations for both calendars were made by Alar Puss.

The numerous science fiction articles published by the researchers of Tartu Observatory are listed on page 104, public lectures, presentations and interviews are listed on page 124.

2.7 Acknowledgements

Many associates were supported by various institutions throughout the world. Herewith we cordially thank:

- Archimedes Foundation
- ASTRONET (EC FP6/FP7 project)
- Astronomical Institute of the Academy of Sciences of the Czech Republic
- Astronomical Institute of the Slovak Academy of Sciences
- Astrophysikalisches Institut Potsdam
- CWT Estonia AS
- Enterprise Estonia
- Estonian Academy of Sciences
- Estonian Ministry of Education and Research
- Estonian Ministry of Environment
- Estonian Ministry of Finance
- Estonian Research Council
- Enterprise Estonia
- Euro–Asian Astronomical Society
- European Astronomical Society
- European Commission
- European Space Agency
- DoRa Programme
- Foundation Lindau Nobelprizewinners Meeting at Lake Constance
- Helsinki University
- Instituto de Astrofisica de Canarias
- International Astronomical Union
- Institute of Physics, University of Tartu
- National Astronomical Observatories, China
- Nordic Forest Research Co-operation Committee (SNS)
- Nordic Optical Telescope
- Observatori Astronomic, Universitat de València
- Ondřejov Observatory
- Pakker Avio
- Tartu Ülikooli Sihtasutus
- Tuorla Observatory, University of Turku
- University of Tartu

3 Galaxy evolution in the hierarchical Universe
Galaktikate areng hierarhilises Universumis

Nagu alati, hõlmasid meie kosmoloogide tööd nii Universumi üldiseid omadusi, selle suuremastaabilist struktuuri, ja galaktikate jaotust Universumis kõikides mastaapides, galaktikate superparvedest kuni vaeste galaktikagruppideni. Galaktikate ruumiline jaotus Universumis on keerukas galaktika gruppide, filamentide ja superparvede võrgustik, mis sisaldab endas ka väiksemaid ja suuremaid kosmilisi tühikuid. Selle heaks näiteks on 2014. a. ilmunud Hawaii ja Prantsuse astronoomide uurimus, mis kaardistas meie koduse galaktikate superparve – Laniakea, mida näete aruande kaanepildil. Muidugi uurisime ka galaktikate omadusi kaugetest galaktikatest kuni meie kodugalaktikani.

G. Hütsi koostöös kolleegidega Max Plancki Astrofüüsikainstituudist uuris röntgentaeva fluktuatsioone Chandra röntgenteleskoobi poolt teostatud XBoötes'e ülevaadet kasutades. Uuringutes keskenduti nõrgale, punktallikateks lahutamatule komponendile, mille jaoks mõõdeti fluktuatsioonide ruumiline võimsusspekter. Selgus, et spektrit saab hästi seletada peamiselt kahe komponendiga: 1) supermassiivsete mustade aukude kiirgus aktiivsete galaktikatuumade näol, 2) galaktikagruppide ja -parvede difuusne röntgenkiirgus. Pehmemas röntgenspektri otsas lisandub neile ka meie Galaktika panus. Antud uurimused on heaks harjutusülesandeks tõstmaks valmisolekut tegelemaks tulevase eROSITA röntgentaeva ülevaatega.

E. Saar töötas välja uue meetodi galaktikate ruumtiheduste hindamiseks mahukates galaktikakataloogides. See meetod on adaptiivne, kiire ja leiab lokaalse tiheduse kõrval ka selle lapikuse ja lokaalse tihedusellipsoidi orientatsiooni. Need omadused lubavad klassifitseerida galaktikate lokaalse jaotuse geomeetriat (parved, filamendid, tasandid).

Koos kolleegidega Valencia Ülikooli Observatooriumist töötas E. Saar ALHAMBRA galaktikaülevaate interpreteerimisel, püüdes kasutada selle tulemusi halo mudeli täpsustamiseks. ALHAMBRA on sügav fotomeetriline ülevaade ja võimaldab mõõta palju väiksemaid galaktikatevahelisi kaugusi taevasfääril kui spektraalsed ülevaated, nt Sloani ülevaade. See info lubab palju paremini uurida halode keskosi, mis on olulised tumeaine olemuse otsingul.

Üheskoos Jaapani kolleegidega Hiroshima ja Nagoya ülikoolidest uuris G. Hütsi heledate punaste galaktikate ruumjaotust Sloan'i taevaülevaadet kasutades. Töö fookuses oli galaktikate ruumiline paiknemine punanihkeruumis, väikestel, tumeaine halodele vastavatel skaaladel. Töös mõõdetud kõrgemat järku multipoolspektrid on tundlikud tumeaine halode sisestele juhuslikele liikumistele, võimaldades leida efektiivset gravitatsioonikonstanti galaktika gruppidele/parvedele vastaval skaalal, seeläbi avades tee gravitatsiooniteooria testimiseks neil mastaapidel. Tulemused osutusid kooskõlaliseks üldrelatiivsusteoorial põhineva standardse kosmoloogilise ΛCDM mudeli ennustustega. Arvestades tulevaste taevaülevaadete poolt pakutavate suurema ruumtihedusega galaktikavalimitega, on antud mõõtmisi võimalik oluliselt täpsustada.

M. Einasto, E. Tago, J. Einasto ja H. Lietzen (Tenerife) uurisid koos kolleegidega Tuorla observatooriumist ja Lõuna-Korea Süvauuringute Instituudist, kas kvasarite andmeid on võimalik kasutada kosmilise võrgustiku uurimisel suurtel punanihetel. Nad kasutasid Sloani Digitaalse taevaülevaate kvasarite kataloogi. Kvasarite ruumtihedus on väga väike, seetõttu võrdlesid nad kvasarite ruumjaotust juhusliku jaotusega, et aru saada, kas kvasarite jaotus üldse erineb juhuslikust. Nad rakendasid klasteranalüüsi ning uurisid selle abil süsteeme erinevatel naabrusraadiustel ning perkoleeruva (ruumi täitva) süsteemi teket. Nad leidsid, et suurimad, kogu ruumi täitvad süsteemid moodustuvad kvasarite korral väiksematel naabrusraadiustel kui juhuslike valimite korral, mis näitab, et väga suurtel skaaladel on kvasarite jaotus juhuslikust erinev. Selles töös genereeritud kvasarisüsteemide kataloogid on astronoomilisele üldsusele kättesaadavaks tehtud ning võivad olla aluseks kosmilise võrgustiku uurimisel suurtel punanihetel. See on esimene töö üldse, kus on kosmilist võrgustikku uuritud suures taevaalas suurtel punanihetel.

M. Einasto, H. Lietzen ja J. Einasto koos paljude kaasautoritega jätkasid galaktikate superparvede morfoloogia ja galaktilise koostise vahelise seose uurimist, kasutades Sloani Digitaalse taevaülevaate andmete põhjal koostatud galaktikate ja superparvede katalooge. Superparvede morfoloogiline tüüp määrati Minkowski funktsionaalide abil. Leiti, et superparved saab nende ehituse järgi jagada kahte põhitüüpi. Filament-tüüpi superparvedes on suure tihedusega piirkonnad ühendatud vähese arvu galaktikakettidega. Ämblik-tüüpi superparvedes ühendab suure tihedusega piirkondi suur hulk galaktikakette.

Erineva ehitusega superparvede galaktilist koostist võrreldes leiti, et filament-tüüpi superparvedes on võrreldes ämblik-tüüpi superparvedega suhteliselt rohkem punaseid, varast tüüpi, suurema tähelise massi ja aktiivse tähetekketa galaktikaid. Ühesuguse rikkusega galaktikagruppides on suhteliselt rohkem punaseid, suure tähelise massiga, varast tüüpi galaktikaid, kui nad asuvad filament-tüüpi superparvedes. See töö näitab, et nii galaktikate lokaalsel kui ka suureskaalalisel ümbrusel on oluline roll galaktikate tekkel ja evolutsioonil. Erinevused superparvede siseehituses viivad erinevusteni galaktikate ning gruppide arengus galaktikate superparvedes.

Analüüsides galaktikate jaotust piki galaktikate ahelaid ehk filamente, leidsid Tartu Observatooriumi astronoomid E. Tempeli eestvedamisel, et galaktikate filamendid on nagu taevased pärlikeed, kus galaktikagrupid paiknevad piki filamenti teatud regulaarsusega. Eelistatud vahekaugus galaktikate ja parvede vahel on umbes 10 Mpc. Natukene nõrgem regulaarsus ilmeb 6 Mpc juures. Galaktikate ja parvede paiknemise uurimine piki filamendi telge näitas, et iga parve ümber on piirkond, kus asub keskmiselt palju vähem galaktikaid. Galaktikate jaotuse regulaarsus piki filamendi telge on uus tulemus, mis võib aidata mõista universumi struktuuride kujunemist ning ta võib anda olulist infot, et mõista tumeenergia rolli Universumi arengus.

J. Nevalainen juhib projekti galaktikatevahelise kuuma gaasi otsimiseks. See gaas moodustab pea poole barüonidest Universumis, kuid on siiani väga raskesti vaadeldav. Koos Juhan Liivamäe ja Elmo Tempeliga leidsid nad supergalaktilised struktuurid Skulptori superparve suunas, kus on jälgi otsitavast gaasist siiski leitud. Koos kolleegidega Rooma ja Bologna ülikoolidest kalibreerisid nad kosmoloogiliste simulatsioonide põhjal seose galaktikate ruumtiheduse ja kuuma gaasi tiheduse vahel. Jukka Nevalainen kasutas koos kolleegidega Alabama Ülikoolist ja Hollandi Kosmoseinstituudist ka röntgen- ja ultraviolettpiirkonna andmeid ühe huvitava blasari kohta, mille neeldumisspektris võib leida galaktikatevahelise kuuma gaasi jälgi.

J. Liivamägi analüüsis seoses galaktikatevahelise gaasi otsingu projektiga suuremastaabilist struktuuri vaatesihilises projektsioonis. Analüüs põhines SDSS DR8 galaktikate kataloogil. Leidmaks sobivaid taevapiirkondi gaasi vaatlemiseks, arvutas ta projektsioonid galaktikate heledustiheduse- ning galaktika filamentide tõenäosusväljast. Saadud projektsioonidest eraldati struktuurid, kusjuures vaatesihid valiti nii, et nad kataksid ühtlaselt kogu taeva. Pärast struktuuride eraldamist saab arvutada mitmesuguseid suuruseid – näiteks struktuuride arvu ja kogupikkuse igal vaatesihil. Tulemusi on juba kasutatud vaatlusprogrammide koostamisel, et hinnata vajalikke vaatlustingimusi ja õnnestumise tõenäosuseid.

B. Deshev uuris alles tekkivat galaktikaparve A520 koos Peeter Tenjese ja Alexis Finoguenoviga (Helsinki Ülikool). Ta mõõtis selle parve 520 galaktika spektrid, kasutades 6.5m teleskoopi Arizonas (USA). Andmed on töödeldud, uurimine jätkub koostöös Viini Observatooriumi astronoomidega. B. Deshev jätkab ka galaktika M33 uurimist, kasutades La Palma observatooriumis saadud uusi andmeid.

M. Einasto ja J. Vennik uurisid koos Seth Coheni, Ryan Hickoxi ja Gary Wegneriga Dartmouthist (USA) tähetekkega galaktikate jaotust ühe- ja mitmemodaalsetes galaktikaparvedes. Selles töös kasutati Sloani Digitaalse taevaülevaate galaktikate põhjal leitud 109 rikka galaktikaparve andmeid, mida Maret Einasto oli varasemates töödes analüüsinud. Näidati, et mitmekomponendilistes parvedes on suhteliselt rohkem tähetekkega galaktikaid kui ühekomponendilistes parvedes. Nii ühe- kui mitmekomponendilistes galaktikaparvedes kasvab tähetekkega galaktikate osakaal parvede ja komponentide äärealadel, ning kahaneb galaktikate tiheduse kasvades. See näitab, et galaktikaparvede liitumine mõjutab täheteket galaktikates.

A. Tamm ja T. Kuutma uurisid galaktikate sisestruktuuride omaduste sõltuvust galaktikate keskkonnast ja punanihkest. Uurimisel on lähedaste galaktikate valim Sloani Taevaülevaate andmetest. Eesmärk on võrrelda lähedasi ja kaugemaid valimeid, et leida kuidas galaktikate struktuurid Universumi arengu jooksul muutuvad. Projekti käigus katsetasid nad ka meetodeid suure valimi galaktikate fotomeetriliseks modelleerimiseks, mida saaks kasutada käesoleva töö jaoks ja ka edaspidi.

J. Vennik uuris lähedastes gruppides olevate satelliitgalaktikate omadusi. Koos kolleegidega leidsid nad, et need sõltuvad oluliselt galaktikate kaugusest grupi keskmest – mida lähemal galaktika sellele on, seda punasem see on. Nad leidsid ka erinevusi eri tüüpi galaktikate kiiruste vahel.

R.Kipper, P. Tenjes, E. Tempel ja A. Tamm uurisid elliptiliste galaktikate fundamentaaltasandit – seost, mis ühendab galaktikate raadiused, tsentraalsed kiiruste dispersioonid ning tsentraalsed pindheledused. Uuringu eesmärk oli teada saada, kas see seos sõltub ka suuremastaabilisest keskkonnast, kus galaktikad asuvad. Sõltuvuse olemasolu viitaks põrkumiste mõjule galaktikale. Suuremastaabilist strukuuri sai hinnatud filamentides olemisega ning heledustihedusega, mis on silutud üle 8 Mpc/h skaala. Leiti küll väike erinevus, kuid see jäi statistiliselt vigade piiresse.

Koos Stefano Berta ja Ivan Delvecchioga uuris ülalnimetatud grupp erinevatel kaugustel olevate galaktikate gaasiketaste paksust. Peamiselt toimus modelleerimine isotroopseid Jeansi võrrandeid kasutades, mis seovad massi jaotuse galaktikas kinemaatiliste suurustega: pöörlemisköveraga ning kiiruse dispersiooniga. Kasutatud mudel koosnes neljast komponendist: täheketas, gaasiketas, mõhn ning tumeaine halo. Mudelite ja vaatluste võrdlemisest leiti, et lähedaste galaktikate gaaskettad on õhemad, mille põhjuseks võib olla interaktsioonide vähenemine galaktikate vahel.

U. Haud jätkas meie Galaktika gaaskomponendi uurimist, täpsustades Parkese ülevaate andmeid. Ta leidis sealt hulga süstemaatilisi efekte ja töötas välja meetodid nende arvestamiseks. Teise tulemusena kinnitas ta oma ja Bonni kolleegide varasemat väidet, et suurematel kaugustel Galaktika keskmest selle gaasketas pakseneb, vastuolus üldkasutatavate galaktikamudelitega.

Sel aastal alustati uuesti galaktikate vaatlusi Tõraveres, kus vaatlustingimused (kujutise kvaliteet, taeva heledus) pole selleks üldiselt soodsad. Kasutades uut 0.4-meetrilist robotteleskoopi said Antti Tamm, Tõnis Eenmäe ja Ann Alice Ehala 30-tunnise kogusäriajaga kaardi supernoova SN2014G kodugalaktika kohta. See on parem kui olemasolev kaart Sloani ülevatest. Näha on selgeid jälgi hiljutisest põrkest teise galaktikaga.

3.1 Large-scale structure in the Universe

3.1.1 Statistical studies of the structure in the Universe

G. Hütsi continued collaboration with MPA (Garching, Germany) High Energy Astrophysics group members (Marat Gilfanov, Alexander Kolodzig and Rashid Sunyaev) in order to build tools and increase readiness to confront the challenges of the upcoming eROSITA all-sky X-ray survey. They analyzed the data from the XBoötes, which is an X-ray survey covering the 9.3 deg^2 Boötes field of the NOAO Deep Wide-Field optical and near-infrared imaging survey. The XBoötes survey was performed by the Chandra X-ray Observatory covering the energy range $0.5-7$ keV and reaching limiting fluxes for point-source detection $F_{\rm lim} \sim 5 \times 10^{-15}$ erg cm^{-2} s^{-1}. GH together with MPA colleagues analyzed the statistical properties of the XBoötes fluctuation field below the point-source detection limit, i.e., an unresolved part of the XBoötes. In particular, they performed a power spectrum analysis dividing the full $0.5-7$ keV energy band into three sub-bands. In the softest sub-band, as one might expect, they found significant contribution from the diffuse X-ray emitting gas of our Galaxy. For the harder X-ray bands the signal is dominated by the contribution from the AGN, which make up most of the clustering spectrum at large multipoles. However, at somewhat lower multipoles one can clearly detect an excess clustering signal beyond the one expected from the AGN, which turns out to be compatible of arising from the X-ray emitting gas inside galaxy groups and clusters. As the analysis of the X-ray data from XBoötes field is quite involved, due to the complex instrumental responses and the non-uniformity of the exposure across the survey footprint, there are still several consistency checks needed to be done before the results can be finally released.

E. Saar developed a new method to estimate the spatial density of galaxies for big galaxy catalogues. The method is adaptive and fast and finds, besides the local density, the flatness and orientation of the local density ellipsoid. The latter properties allow to directly classify the geometry of the density distribution (clusters, filaments, sheets).

Together with colleagues from Valencia University Observatory Enn Saar worked on interpreting the ALHAMBRA galaxy survey, trying to use its results to better quantify the halo model of the galaxy distribution. ALHAMBRA is a deep photometric survey and allows to measure much smaller projected distances between galaxies than the usual spectroscopic surveys, e.g., the Sloan Survey. This information allows to study better the central parts of cluster haloes that are important in dark matter searches.

G. Hütsi in collaboration with colleagues from Japan (Hiroshima University, Nagoya University) used LRG data from the SDSS DR7 to measure higher order galaxy clustering multipole power spectra (hexadecapole – P_4, tetra-hexadecapole – P_6) in redshift-space. In this analysis wavenumbers in the range $0.3 \leq k/\mathrm{h\,Mpc}^{-1} \leq 0.6$ were used, i.e., wavenumbers where the one-halo clustering term gives significant contribution. Since these measurements were sensitive on halo-scale redshift-space clustering they probed the random motions of galaxies inside dark matter halos, which allowed to measure the effective gravitational constant G_{eff} on these scales. The results turned out to be in agreement with the concordance cosmological ΛCDM model, which assumes the validity of General Relativity (GR) on cosmological scales. However, the modified gravity models typically predict values for G_{eff} different from the GR value, and so in principle with higher accuracy measurements, available from the future large redshift surveys, the investigated methodology can be used to test modified gravity theories on galaxy group/cluster scales. The measurement of P_4 and P_6 on halo scales is complementary to the usual method of testing gravity by targeting the linear growth rate on very large scales.

3.1.2 Tracing the high-redshift Universe with quasar systems

M. Einasto, E. Tago, H. Lietzen (Tenerife) and their colleagues from Tuorla Observatory (Finland), and Korea Institute of Advanced Studies analysed the possibility to trace the high-redshift cosmic web at redshifts $1.0 \leq z \leq 1.8$ with quasar systems using quasar (QSO) data from the SDSS DR7 QSO catalogue. Systems of quasars were determined by the friend-of-friend algorithm in the quasar and random catalogues at a series of linking lengths. They analysed percolation properties of quasar systems, as well as the richness and sizes of systems. The results of this study show that at the linking lengths $l \leq 30h^{-1}$Mpc the number of quasar systems is larger than the number of systems detected in random catalogues, and the systems themselves have smaller diameters than random systems. The diameters of quasar systems are comparable to the sizes of poor galaxy superclusters in the local Universe. The richest quasar systems have four members. The mean spatial density of quasar systems at these linking lengths is close to the mean spatial density of local rich superclusters. At intermediate linking lengths ($40 \leq l \leq 70h^{-1}$Mpc), the richnesses and lengths of quasar systems are similar to those derived from random catalogues. Quasar system diameters are comparable to the sizes of rich superclusters and supercluster chains in the local Universe. The percolating system, which penetrates the whole sample volume, appears in a quasar sample at a smaller linking length than in random samples (85 h^{-1}Mpc). Quasar luminosities in systems are not correlated with the system richness. This is the first study to show the high-redshift cosmic web in a large area of sky.

The quasar system catalogues in Tartu Observatory web pages and at the Strasbourg Astronomical Data Center (CDS) can serve as a database for searching superclusters of galaxies and for tracing the cosmic web at high redshifts.

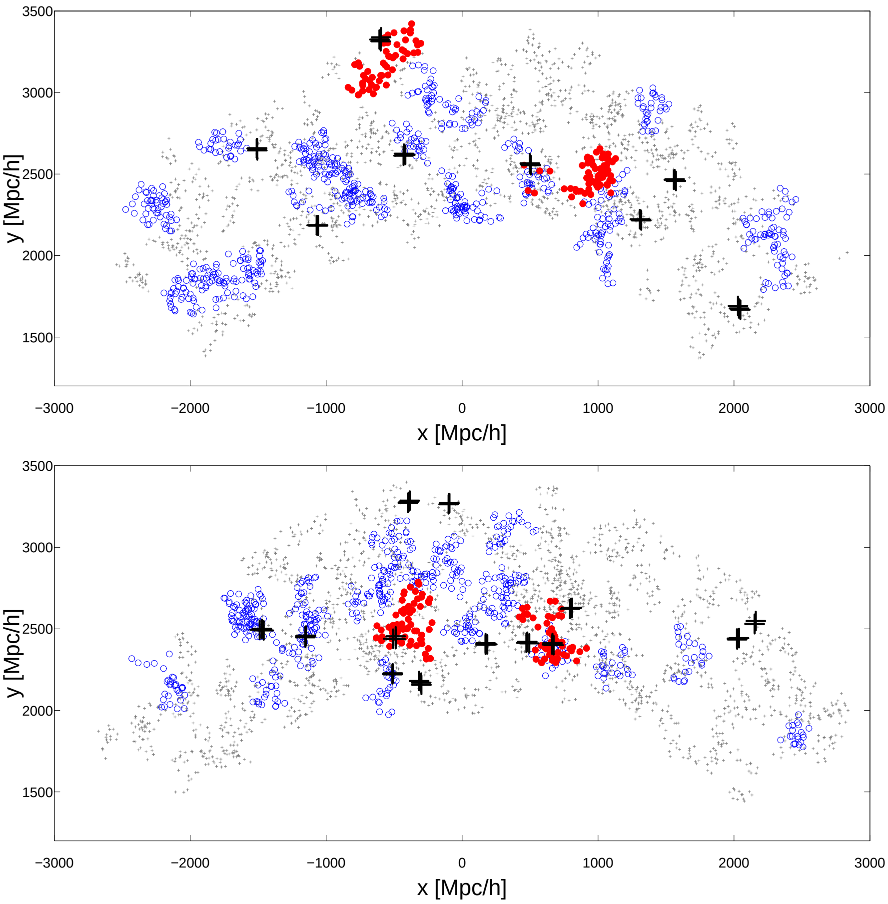


Figure 3.1 Distribution of QSO systems at the linking length 70 h^{-1}Mpc in the x and y coordinates in two slices by the z coordinate (upper panel: $z < 0$, lower panel: $z > 0$). Grey dots denote quasars in systems with $10 \leq N_{QSO} \leq 24$, blue circles denote quasars in systems with $25 \leq N_{QSO} \leq 49$, and red filled circles denote quasars in systems with $N_{QSO} \geq 50$. Black crosses denote quasar triplets at a linking length 20 h^{-1}Mpc. Naabrusraadiusel 70 h^{-1}Mpc leitud kvasarisüsteemide jaotus x, y koordinaatides kahes koordinaadikihis ($z < 0$ ja $z > 0$, vastavalt ülemine ja alumine paneel). Hallid punktid märgivad kvasareid süsteemides, kus on 10–24 liiget, sinised ringid - 25–49 liikmega süsteemides, ja punased ringid kvasareid vähemalt 50 liikmega süsteemides. Mustad ristid tähistavad kvasareid kolme liikmega süsteemides, mis saadud naabrusraadiusel 20 h^{-1}Mpc (sel naabrusraadusel rikkaimad süsteemid).

3.2 Superclusters of galaxies

3.2.1 Morphology and galaxy content of SDSS galaxy superclusters.

M. Einasto, J. Einasto and H. Lietzen together with many other collaborators studied the morphology and galaxy content of SDSS DR8 superclusters. The morphological types of superclusters were determined using Minkowski functionals and visual inspection. Superclusters can be divided into two main morphological types: filaments with a relatively simple inner structure, in which a few high-density cores are connected by a small number of galaxy chains, and spiders with a complicated structure with high-density cores connected by a large number of galaxy chains. Comparing the galaxy and group content of superclusters of different morphology they found that the fraction of red, early type, low SFR galaxies in superclusters of filament type is higher than in superclusters of spider type. In superclusters of spider morphology red, high SFR galaxies have higher stellar masses than in filament type superclusters. Groups of equal richness host galaxies with larger stellar masses, and they have a larger fraction of early type and red galaxies, and a higher fraction of low SFR galaxies, if they are located in superclusters of filament morphology. The peculiar velocities of the main galaxies in groups from superclusters of filament morphology are larger than in those of spider morphology. Groups with larger peculiar velocities of their main galaxies in filament type superclusters are located in higher density environments than those with small peculiar velocities. There are significant differences between galaxy populations of individual richest superclusters.

They concluded that both the local (group) and global (supercluster) environments and even supercluster morphology play an important role in the formation and evolution of galaxies. Differences in the inner structure of superclusters of filament and spider morphology and the dynamical state of galaxy groups in them may lead to the differences found in our study.

M. Einasto, J. Einasto and their colleagues searched for shell-like structures in the distribution of nearby rich clusters of galaxies drawn from the SDSS DR8). They found the maxima in the distribution of distances from rich galaxy clusters to other groups and clusters at a distance of about 120 h^{-1}Mpc, suggesting a density enhancement at these distances from rich clusters, and possible indication of shell-like structures. The rich cluster A1795, the central cluster of the Bootes supercluster, has the highest maximum in the distance distribution of other groups and clusters around them at a distance of about 120 h^{-1}Mpc among our rich cluster sample, and another maximum at a distance of about 240 h^{-1}Mpc. However, the radius of the possible shell is larger than expected for a BAO shell ($\approx 109\ h^{-1}$Mpc).

3.2.2 Galaxy filaments

Using the Bisous model (marked point process with interactions) E. Tempel and colleagues extracted the galaxy filaments from the SDSS spectroscopic galaxy survey. The diameter of the extracted filaments is roughly 1 h^{-1}Mpc. Using the galaxies and groups in filaments (with a distance from the filament axis less than 0.5 h^{-1}Mpc) they studied how the galaxies/groups are distributed along the filament axis. They found that the galaxy and group distributions along filaments show a regular pattern with a preferred scale around 7 h^{-1}Mpc. A weaker regularity is also visible at a scale of 4 h^{-1}Mpc. The regularity of the distribution of galaxies along filaments is a new result that might help to understand structure formation in the Universe. The pair correlation functions of galaxies and groups along filaments show that around each group, there is a region where the number density of galaxies/groups is smaller than on average. They also found that galaxy groups in the Universe are more uniformly distributed along filaments than in the Poisson case.

The clustering pattern of galaxies and groups along filaments tells us that galaxy filaments are like pearl necklaces, where the pearls are galaxy groups that are distributed along the filaments in some regular pattern.

They suggested that the measured regularity of the galaxy distribution along filaments could be used as a cosmological probe to discriminate between various dark energy and dark matter cosmological models. Additionally, it can be used to probe environmental effects in the formation and evolution of galaxies. They plan to test these hypothesis in our following analysis using N-body simulations and deep redshift surveys like the Galaxy And Mass Assembly and the VIMOS Public Extragalactic Survey.

The Figure shows the Z-squared statistic for all galaxies closer than 0.5 h^{-1}Mpc (upper panel) and 0.25 h^{-1}Mpc (lower panel) to the filament axis. The Z-squared statistic based on galaxies is shown with red lines, where the shaded region shows the 95% confidence limits. The blue line shows the statistic for the null hypothesis using Monte Carlo simulation for a Poisson sample. The shaded region shows the 95% confidence limits for this case. For Monte Carlo simulation, the filaments and numbers of galaxies per filament are the same as for the real sample, but galaxies are Poisson distributed.

3.2.3 Search for warm-hot intergalactic gas

In our PUT246 project ”Where have half the baryons gone”, headed by J. Nevalainen, we have been developing our methodology for finding and characterising the missing baryons in the form of Warm Hot Intergalactic Medium WHIM. Using our galaxy filament finding algorithm on the 2dF data we have detected structures in Sculptor supercluster in a line-of-sight towards a blazar

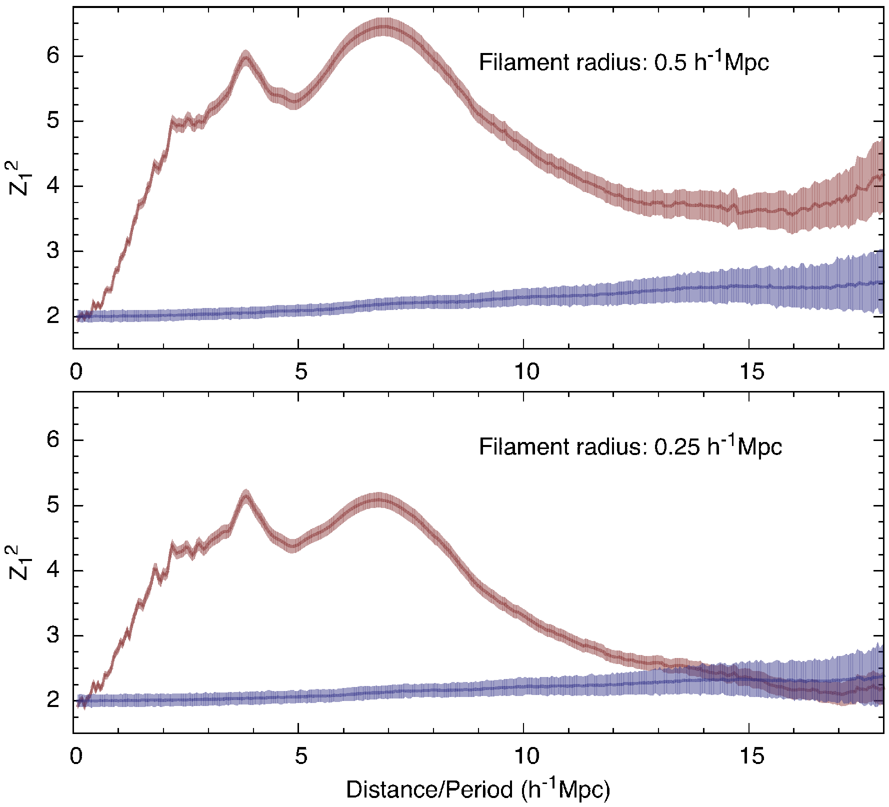


Figure 3.2 The Z-squared statistic for filaments of two radii, respectively. The blue region shows the random signal for the case of no periodicity. Z-ruudus statistika kahe raadiusega filamentide jaoks. Sinine piirkond tähistab juhuslikku signaali, kui perioodilisus puudub.

H2356-309 (Fig.3.3), where several significant WHIM X-ray absorption lines have been reported. We quantified the luminosity density field around these structures, using a method developed by J. Liivamagi, and the luminosity density profile towards H2356-309.

In order to relate the galaxy luminosity and WHIM density in galaxy filaments, we analysed cosmological large scale simulations designed to follow the formation of the baryonic structures. This work enables us now to estimate the WHIM density in a given observational galaxy structure (Fig. 3.4). We do this in collaboration with colleagues from University of Rome and Bologna, Italy. We reported preliminary results on this in the IAU 308 symposium in Tallinn. Our estimate for the WHIM hydrogen column density in the Sculptor Wall structure, $\log N_H = 21.0 \pm 0.2$ (Fig. 3.3), agrees with the X-ray absorption value.

For a line-of-sight to another interesting blazar, PKS 2155-304, we have analysed the FUV data from HST and FUSE, and additionally the XMM-Newton X-ray data, in collaboration with University of Alabama, USA and Netherlands Institute for Space Research SRON. These preliminary results, combined with our WHIM density estimates, yield good constraints for the WHIM structures.

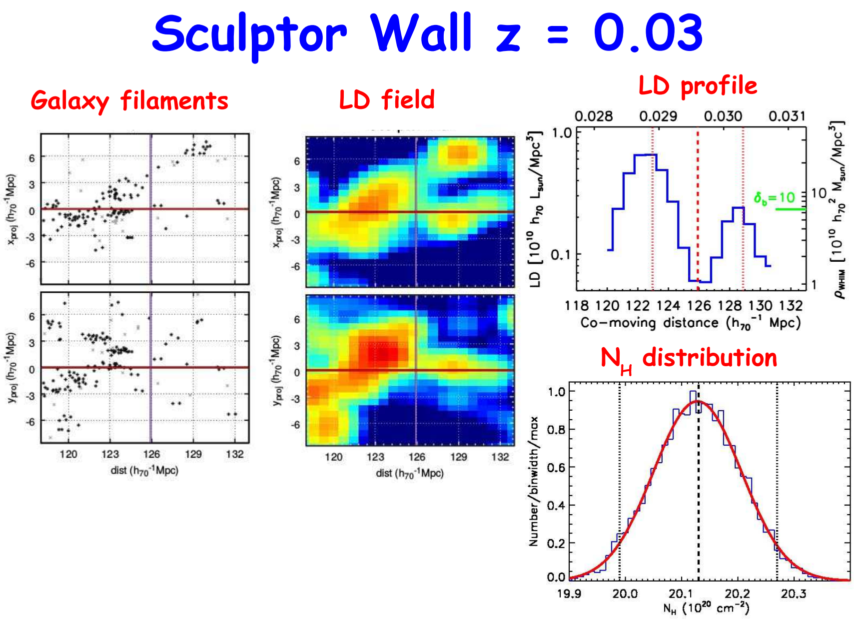


Figure 3.3 Results for the Sculptor Wall structure, based on the 2dF data. The galaxy distributions and the luminosity density field are shown for two projections (two left panels). The luminosity density profile towards H2356-309 (upper right panel) is used to derive the WHIM N_H distribution (lower right panel). Skulptori Seina superparv, mis põhineb 2dF andmetel. Galaktikate jaotus ja heledustiheduse väli on antud kahes projektsioonis (vasakpoolsed paneelid). Heledustihedusjaotus H2356-309 suunas (ülemine parempoolne paneel) on aluseks WHIM N_H jaotuse leidmiseks (alumine parempoolne paneel).

For the same project, J. Liivamägi conducted a preliminary analysis of line-of-sight projections of the large-scale structure to estimate the abundance and locations of the potentially WHIM-containing structures. The analysis is based on the SDSS DR8 main galaxy catalogue. To delineate the suitable observing locations he calculated projections of the galaxy luminosity density field and the filament probability field. From the projected fields, structures along the lines-of-sight were extracted using a set of various parameters. The lines-of-sight were chosen to uniformly cover the sky. After that we can calculate several properties for each line-of-sight, e.g. the number of structures, the total length of the structure, column luminosity density along the line-of-

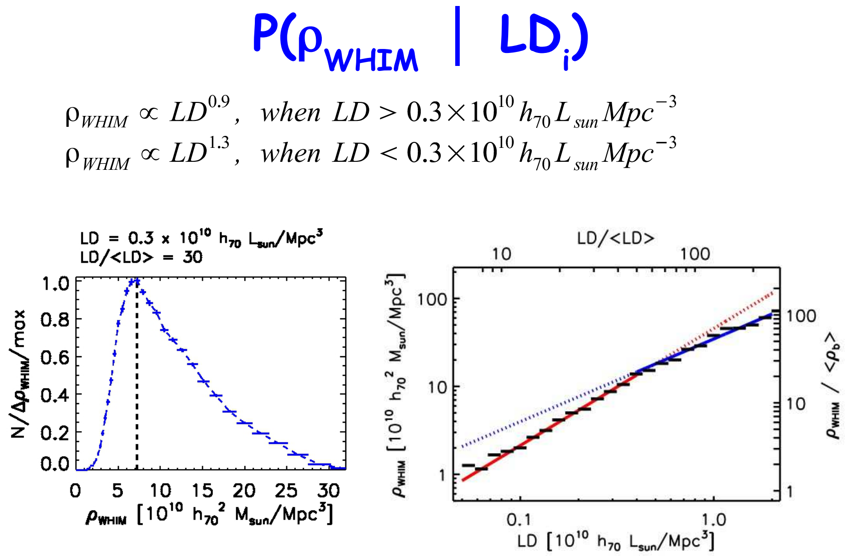


Figure 3.4 Left panel: WHIM density distribution in the simulations at a luminosity overdensity value of 30. Right panel: The LD-WHIM density relation in the LD overdensity range 5-200. Vasak paneel: WHIM tihedusjaotus simulatsioonides heledustiheduskontrasti 30 puhul. Parempoolne paneel: LD-WHIM tiheduste seos LD tiheduskontrasti vahemikus 5-200.

sight, etc. By studying simulations we are also able to get a better estimate for the parameters to delineate the structures and also to calculate the amount of gas. This allows us to find the distribution of suitable observing locations and estimate the chance for success. Figures show the number of structures for each line-of-sight on the plane of the sky.

3.3 Galaxy clusters and groups

M. Einasto and J. Vennik together with Seth Cohen, Ryan Hickox and Gary Wegner from Dartmouth College completed the study of the distribution of star-forming galaxies in galaxy clusters with substructure. They used data about 109 clusters from the Sloan Digital Sky Survey with substructure, presented by Maret Einasto and her collaborators. They showed that multi-component clusters have a higher fraction of star forming galaxies than single-component clusters. In both single- and multicomponent clusters the fraction of star-forming galaxies increases with cluster-centric and component-centric distance and decreases with local galaxy number density, being at almost all cluster-centric distances and local densities higher in mul-

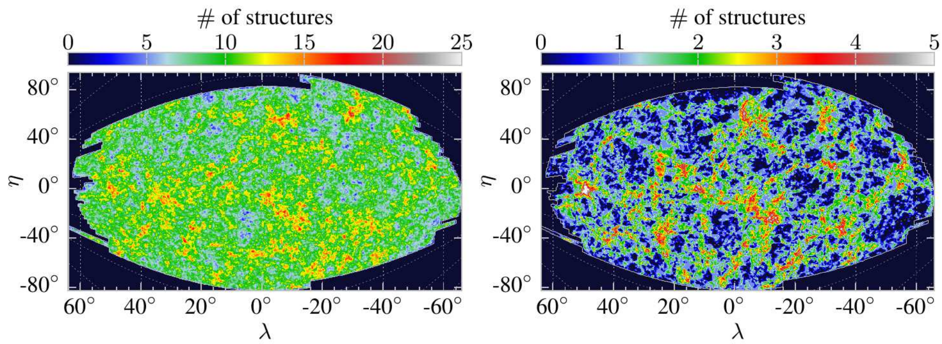


Figure 3.5 Luminosity density (left panel) and filament density (right panel) maps for the Sloan sky. Heledustiheduse (vasak panel) ja filamentide tiheduse (parempoolne paneel) kaardid Sloani ülevaate piirkonnas.

ticomponent clusters than in single-component clusters. These results show that cluster mergers affect star formation in galaxies in clusters, either by supressing star formation in galaxies in groups after they merge with clusters, or by enhancing star formation in outer parts of groups during merging.

Starting from September 1-st. 2014 B. Deshev was admitted as a Ph.D. student in Tartu University, to investigate the fate of the galaxies in a merging cluster A520 at z=0.2 under the supervision of Peeter Tenjes (Tartu University) and Alexis Finoguenov (Helsinki University, Finland). In February spectra was taken for 520 galaxies in the field of A520 with the multi-fibre spectrometer Hectospec on the 6.5m Multi-Mirror Telescope in Arizona, USA. The data were reduced by Boris Deshev with the first results of the analysis being already available. The results and future directions for this project were discussed with the collaboration during a work visit in Vienna Observatory, Austria.

During his visits to IAC, B. Deshev also continues the work on data processing and analysis of the archival and new data of M33 collected with INT+WFC at La Palma.

J. Vennik studied properties of satellite galaxies in two samples of nearby groups - in the SDSS DR10 groups and in those from the Karachentsev's list. He confirmed clear radial dependence of galaxy properties, with more massive, red and passive satellites being distributed predominantly near the center of (stacked) group. He (newly) found some evidence of velocity modulation of properties of satellite galaxies and conclude that using the kinematical data, it should be feasible to separate dynamical classes of virialized, backsplash and infalling satellite galaxies.

Five groups, which were earlier observed spectroscopically with the HET, were studied in more detail.

3.4 Galaxies

3.4.1 Evolution of galaxies

A. Tamm and T. Kuutma studied the relations between galaxies internal structures and galaxy environments and redshifts, working with a nearby sample from the SDSS. The goal is to compare nearby and distant samples to find out how the structures of galaxies change in cosmological timeframes. During the project they also tested methods to make photometric models from a large number of input data, which will be useful for this and future projects.

R. Kipper, E. Tempel, A. Tamm, P. Tenjes, Stefano Berta and Ivan Delvecchio are participating in a project to determine gas distribution in near and far galaxies in order to determine thinning of gas discs. As the major part in the velocity distribution of gas disc comes from its vertical thickness, it is possible to estimate the thickness by modelling kinematical data. Thanks to Jeans equations, with assuming isotropic velocity distribution, it is possible to determine kinematical data from mass distribution only. The mass profile is based on superposition of 4 components: stellar disc, gas disc, bulge and dark matter halo. It is easy to constrain stellar components from photometric modelling, the dark matter halo comes mostly from fitting the rotation curve, the gas mass from the correlation with dust. The radial distribution of gas is assumed to be similar to the stellar one. Therefore all parameters are constrained, which leaves the velocity dispersion distribution almost entirely for estimating the gas thickness. The widths they found vary from 0.1 kpc to 3 kpc while having a larger scatter at higher redshifts. They concluded that gas discs do settle down with time and are being less disturbed later by external processes, like minor mergers.

They examined also the fundamental plane of elliptical galaxies, which is a scaling relation that ties together the surface brightnesses, radii and velocity dispersions of galaxies. The aim was to find if the parameters of the fundamental plane depended on the large scale structure: dependence on it could indicate an increased merger rate. Environment was taken into account checking if the galaxy was in a filament or had a high luminosity density value, calculated with a smoothing kernel of 8 Mpc/h, in its location. The Bayes approach was used to model the fundamental plane parameters. They found a slight dependence on the environment, but the effect was within errorbars.

The year 2014 marks a turning point in observational galaxy physics at Tartu Observatory. In general, the poor observing conditions in Estonia have been considered to prevent any meaningful scientific use of galaxy imaging. Nevertheless, a bachelor student Ann Alice Ehala and A. Tamm started to investigate the possibilities for using the new 0.4-metre robotic telescope of Tartu Observatory for deep galaxy imaging. Throughout most of 2014, T. Eenmäe had made use of the telescope to observe the supernova SN2014G on clear nights. This dataset can be combined together, resulting in a 30-hour exposure of the host galaxy of the supernova, the galaxy NGC 3448. The aim of the new study is to check, whether the usage of such extreme exposure times allows us to probe the faint outer regions of galaxies even under the substantial light-pollution conditions of Tõravere.

The initial results are somewhat promising. Compared to the available imaging by the 2.5-metre Sloan telescope (50 second exposure), the outer regions of the galaxy are indeed clearly more pronounced (see Fig. 3.7). Interestingly, the data reveals strong signs of a recent interaction of NGC 3448 with some of its neigbours, which has probably lead to a starburst in the galaxy and eventually to the supernova explosion of one of the high mass stars formed during the starburst.

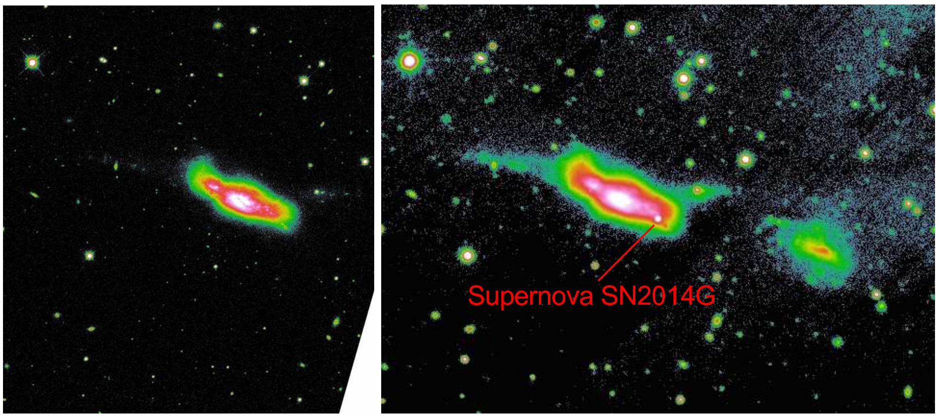


Figure 3.7 Galaxy NGC 3448, imaged by the Sloan 2.5-metre telescope (left) and the 0.4-metre robotic telescope of Tartu Observatory (right). Galaktika NGC 3448 kujutis, mis on saadud Sloani 2.5-meetrise teleskoobiga (vasakul) ja Tartu Observatooriumi 0.4-meetrise robotteleskoobiga (paremal).

The false colour scheme is selected to emphasize low luminosity regions. Although the resolution of the Sloan observation is better, a 30-hour exposure with the small robotic telescope is significantly better for studying the faint outskirts of the galaxy: for the given galaxy, clear signs of a recent interaction become apparent. The location of the supernova (not present in the Sloan image) is also indicated.

3.5 Our Galaxy

The main direction of the work by U Haud, in collaboration with P. M. W. Kalberla from the Argelander-Institut für Astronomie, Universität Bonn, was the improvement of the HI data from the Parkes Galactic all-sky survey (GASS). He used the Gaussian decomposition of the survey data and the statistical analysis of the distributions of the obtained Gaussian parameters. In this year, the main attention was devoted to the fact that a part of the GASS data, predominantly at high brightness temperatures, show stripes in scanning direction. The reason for this failure remained for quite a while a mystery. Eventually they found that such problems were correlated with channel-to-channel fluctuations that could be traced to individual scans in the telescope dump database. These problems are time dependent; hence they show up as scanning stripes in a part of the data. When searching for a measure of such failures, eventually a very simple approach was found, but the final selection of the bad dumps was a compromise between discarding affected dumps and retaining low noise in the data products. The first priority was to prevent any degradation of the generic HI features. A paper is being written to describe the results.

Another direction of the work was somewhat surprising. In the time period from 1999 to 2007 U. Haud participated in the creation of the mass distribution model of the Milky Way galaxy, based in particular on the Leiden-Argentina-Bonn (LAB) all-sky database of the 21-cm HI data. One of the predictions of this model was that the thickness of the stellar disc of our Galaxy must increase at large radial distances from the centre of the Galaxy. At these times this prediction was completely unacceptable for astronomical journals for publishing and the corresponding paper in its original form was rejected. However, in recent years some observational indications that such increase of the scale heights may indeed exist, have appeared, but the most recent mass models still assume that the stellar disk has a constant scale height, independent of the galactocentric radius. Therefore, the old model predictions were revived, the results were compared with the latest observational data and a new paper was prepared.

4 Observational and theoretical investigation of stars and their envelopes during advanced evolutionary phases Evolutsiooni hilisfaasis tähtede ja nende ümbriste vaatluslik ja teoreetiline uurimine

Tähtede füüsika uurimisteema on traditsiooniliselt seotud kohapealsete astronoomiliste vaatlustega. Tartu Observatooriumi 1.5 m teleskoobiga AZT-12 vaadeldi 2014. aastal 88 vaatlusööl. Enim vaatlusöid hõlmasid siniste ülihiidude kõrge ajalise lahutusega vaatlused ning täheassotsiatsioonide Per OB1, Gem OB1 ja Cyg OB2 suure absoluutse heledusega liikmete spektraal- ja radiaalkiiruse muutlikkuse monitoorimine. Paaril ööl tehti astromeetriasatelliidi GAIA jaoks maapealseid kalibratsioonivaatlusi.

Robotteleskoobiga vaadeldi 2014. aastal 96 vaatlusööl, paljud nendest öödest olid vaid osaliselt selged. Põhilise osa vaatlustest moodustas täheassotsiatsioonide ja -parvede heledate liikmete heledusmuutuste jälgimine, regulaarses monitooringuprogrammis olid assotsiatsioonid Cyg OB2 ja Gem OB1 ning hajusparved NGC 6913 ja NGC 7419. Tänu võimekale teleskoobile osaleti rahvusvahelistes supernoova SN 2014g ja pikaperioodilise varjutusmuutliku kaksiktähe EE Cep vaatluskampaaniates. Nimetatud supernoovat vaadeldi ka teleskoobiga Zeiss-600. Kahte noovat – Nova Cyg 2014 ja Nova Cep 2014 – õnnestus vaadelda loetud tunnid peale avastamist.

Koostöö raames Ondřejovi observatooriumiga Tšehhis jätkusid siniste ülihiidude fotomeetrilised vaatlused.

Robotteleskoobile soetati tasaväljakaadrite tegemiseks luminestsentspaneel. Observatooriumi peahoone katusel rakendati töösse öist pilvisust jälgiv ületaevakaamera.

T. Eenmäe osales SN 2014g rahvusvahelises vaatluskampaanias. Kokku vaadeldi supernoovat Tõraveres 23 vaatlusööl. Avastamisjärgselt liigitati SN 2014g galaktikas NGC 3448 klassi SN IIn, mida vahel nimetatakse ka hüpernoovadeks, kuid spektraalvaatlustega täpsustus klassifikatsioon tuuma kollapsiga SN IIL tüüpi supernoovaks.

T. Eenmäe ja TÜ üliõpilane Üllar Kivila jätkasid massiivse varjutusmuutliku tähe BD+48°1098 analüüsiga, vaatlustel osalesid ka üliõpilased Rene Voog ja Robert Matjus.

Kosmoseteleskoobi Gaia testperioodil (jaanuar kuni juuli 2014) esitati Tartu Observatooriumi poolt põhjendatud ettepanek kasutada madala spektraalse lahutusega instrumentide lainepikkuste skaala kontrollimiseks sinises spektripiirkonnas WR-tähti ja punases spektripiirkonnas M-tüüpi hiidtähti. Lisaks edastati Gaia objektide muutlikkuse tuvastamise algoritmide kontrollimiseks meie poolt kogutud vaatlusandmed ekliptika põhjapooluse piirkonnas paiknevate tähtede heledusmuutlikkuse kohta.

Täheassotsiatsioonide heledaimate tähtede muutlikkuse uuring jätkus spektraal- ja heledusvaatlustega Tõraveres ning New Mexicos (USA). Suurem tähelepanu on sihitud sinisele hüperhiiule Schulte 12 assotsiatsioonis Cyg OB2 ning ülihiidudele HD 13267, HD 14134 ja HD 225094 Per OB1 ja Cas OB5 assotsiatsioonides. Põhieesmärk on muutlikkuse erinevate ajaskaalade tuvastamine seotuna tähekoosluste ja tähtede erineva vanusega.

A. Aret uuris massiivsete tähtede pulsatsioone ja aine väljavoolu neist, keskendudes sinistele ülihiidtähtedele. Sinised ülihiiud on heledad tähed, mis on arenenud massiivsetest OB tüüpi peajada tähtedest. Senise teooria kohaselt toimub siniste ülihiidude pulsseerimine vaid gravitatsioonimoodides perioodidega 2–10 päeva, kuid hiljuti avastati oluliselt kiirem muutlikkus, mis vastab rõhumoodidele perioodidega ühest tunnist paarikümne tunnini. A. Aret osaleb aktiivselt rahvusvahelises siniste ülihiidude vaatlusprojektis koos kolleegidega Tšehhi Vabariigist, Argentinast ja Poolast. 2014. aastal keskenduti peamiselt tähele 55 Cyg, mis kuulub α Cygni tüüpi muutlike tähtede klassi.

L. Sapar, A. Sapar, R. Poolamäe ja A. Aret uurisid kaltsiumi isotoopide difusioonilist eraldumist valgusindutseeritud triivi (LID) toimel mõõdukalt kuumades keemiliselt iseäralikes HgMn tüüpi täheatmosfäärides. Üldpilt kaltsiumi isotoopide stratifikatsioonist osutus oodatult samaks kui varasematel analoogsetel arvutustel elavhõbeda kohta. Peamiseks iseärasuseks osutus see, et LID kujundab raskeima isotoobi, antud juhul ^{48}Ca, domineerimise kogu atmosfääri ulatuses. Isotoopide eraldatus suureneb väliskihtide suunas. Osutus, et arvutatud CaII infrapunase tripleti spektrijoonte profiilid on heas kooskõlas tähe HD 175640 kõrgdispersioonilise vaatlusspektriga. See näitab, et spektrijoone profiil ja selle isotoopnihe vastavad isotoobile ^{48}Ca, millest järeldub, et tehtud hüpoteesid mikroturbulentsi füüsikalise kujunemise kohta on tõepärased.

A. Sapar tegeles edukalt üldistatud ortonormeeritud analüütiliste orbitaalide ja nendel baseeruvate analüütiliste radiaalintegraalide teooria väljatöötamisega Hartree-Focki meetodi teisendamiseks analüütilistele avaldistele atomaarstruktuuride arvutamiseks. Orbitaale ja ruuminurkfunktsioone sisaldavate integraalide baasil leiti analüütilised avaldised elektronide impulsside korrelatsioonist tuleneva spetsiifilise massinihke, isotoopnihke ja ülipeenstruktuurilise lõhenemise arvutamiseks. Saadud valemite tuletamisel on eeldatud, et impulssmomentidele kehtivad Russell-Saundersi ehk LS-interaktsiooni liitmiseeskirjad.

A. Sapar uuris kosmoloogilise neutriinofooni dünaamika seaduspärasusi galaktikates, nii sfääriliste kui ka õhukeste telgsümmeetriliste galaktikaketaste korral. Sfäärilistes galaktikates kutsub radiaalne neutriinovoog esile ulatuslike konstantse sügavusega potentsiaaliaukude kujunemise. Osutus, et telgsümmeetrilise galaktika keskpiirkonnas moodustub neutriinode konstantse ruumtihedusega tuumik. Selle mõjul kujuneb ringorbiitidel liikuvate tähtede radiaalse kiirusejaotuse lineaarosa.

I. Vurm ning R. Hascoët ja A. M. Beloborodov USA-st uurisid varajast optilist ning GeV (giga-elektronvolt) kiirgust gammasähvatuses GRB 130427A. Lööklaine tekib, kui relativistlik ainevool kuumutab gammasähvatuse eellaseks olnud tähe tähetuule osakesi relativistlike energiateni, mis seejärel kiirgavad pöörd-Komptoni ja sünkrotronkiirgust vastavalt GeV ja optilises diapasoonis. Kiirguslevi ja ainevoolu dünaamika detailne modelleerimine võimaldas leida ematähe tähetuule tiheduse, mis osutus sarnaseks Wolf-Rayet tähtede omaga. Viimane annab kinnitust hüpoteesile, et Wolf-Rayet tähed võivad teatud tingimustel plahvatada gammasähvatustena.

I. Vurm ning Brian Metzger, Romain Hascoët ja Andrei M. Beloborodov uurisid ka lööklainete teket aine väljavooludes noovaplahvatustes, mille varajased heleduskõverad raadiodiapasoonis pole mõnel juhul hästi standardsete teooriatega kirjeldatavad.

4.1 Observations

Using the 1.5 m telescope AZT-12 at Tartu Observatory, observations were carried out in 88 nights. Most prominent observational programmes in 2014 were high-resolution time-resolved spectroscopy of blue supergiants and monitoring of the most luminous members of the OB associations Per OB1, Gem OB1 and Cyg OB2. In couple of nights, ground-based observations for calibration of the Gaia satellite were made.

In 2014 the telescope Zeiss 600 was used on one night to observe an extragalactic supernova SN 2014g.

The robotic telescope was used in 96 observing nights, many of those nights were only partially clear. The main observational programme was monitoring stellar clusters and OB associations Cyg OB2, NGC 6913, NGC 7419, Gem OB1 as often as possible. Thanks to the capable instrument, participation in international observational photometric campaigns of extragalactic supernova SN 2014g and a long-period eclipsing variable EE Cep was possible. Two novae were observed just hours after their discovery.

In cooperation with Ondřejov observatory, time-resolved photometric observations of blue supergiant stars continued through the year.

An electroluminescent flat field panel was ordered. On top of the observatory main building, an all-sky camera for night-sky cloud coverage observations was installed.

4.2 Hot luminous stars

T. Eenmäe participated in international observational campaign of a supernova (SN) SN 2014g. Rapidly after the discovery, SN in the galaxy NGC 3448 was classified as of type SN IIn, based on its featureless blue continuum and few narrow emission lines. SN IIn-type SNe are sometimes also called hypernovae because of their high absolute luminosity.

However, similar spectrum is observable during events called “supernova impostors”, where unlike to an ordinary core-collapse SN explosion, the progenitor may be e.g. a luminous blue variable (LBV-type) star in a giant eruption phase and progenitor will not be destroyed during the event. True nature of “supernova impostors” has remained unclear. Based on relatively short distance to the host galaxy and apparent magnitude of SN 2014g, a hypotesis of a possible SN impostor arised, and photometric observational campaign was organized by Prof. J. Martin (Illinois Springfield University).

Five weeks after the visible light maximum, new spectral observations were made with Tartu Observatory 1.5-meter telescope and 6.5-meter Multiple Mirror Telescope with spectral resolution $R \approx 1000$. Based on these spectra, SN 2014g was classified as a more common SN IIL-type supernova.

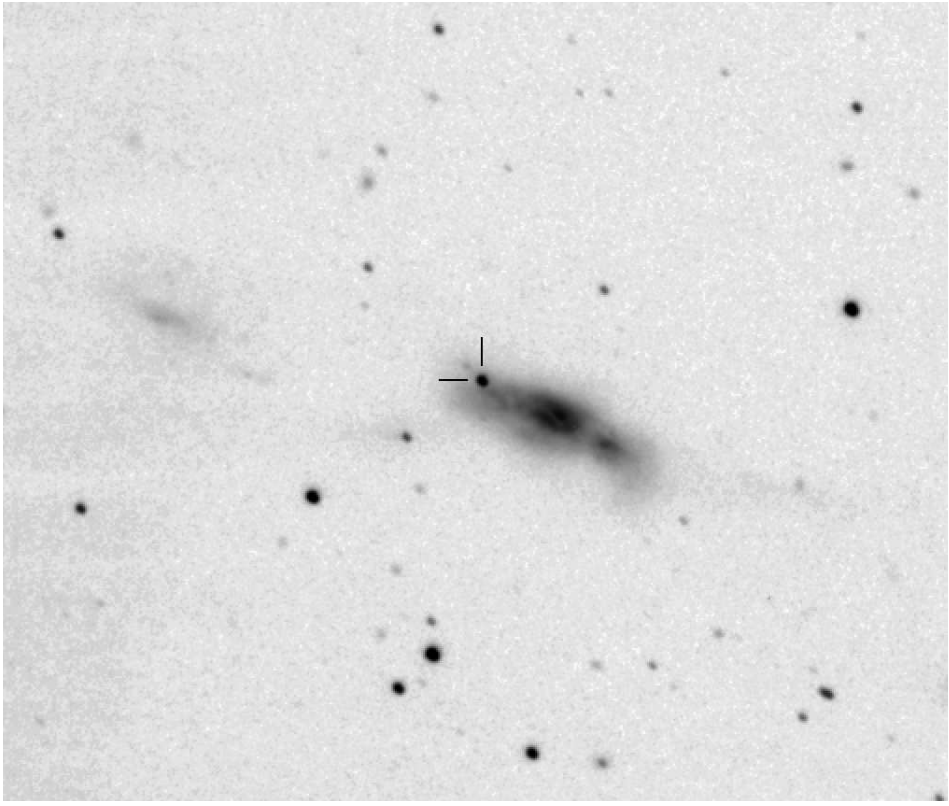


Figure 4.1: Supernova SN 2014g in the outskirts of the galaxy NGC 3448, pointed by two lines. Image in V-filter is taken with robotic telescope at Tartu Observatory, effective exposure time is 30 min. Kahe joonega on märgitud supernoova SN 2014g galaktikas NGC 3448. Foto on tehtud V-filtris Tartu Observatooriumi robotteleskoobiga.

Spectral behaviour of the SN was observed at Tartu Observatory in two additional nights (see Fig. 4.2).

Photometric observations with new robotic telescope started before the visible light brightness maximum in the second half of January and lasted till bright nights in the beginning of May, photometric observations of SN at Tõravere were made in 23 nights. The photometric light curve is also similar to a Type SN IIL supernova. From photometric light curve, the absolute magnitude of SN was determined to be -17.65, several magnitudes more luminous compared to known SN impostors.

The results of photometric observations have been presented by J. Martin at the 224th Meeting of the American Astronomical Society as a poster and at AAVSO meeting in oral presentation.

T. Eenmäe and Ü. Kivila (student of the University of Tartu) continued

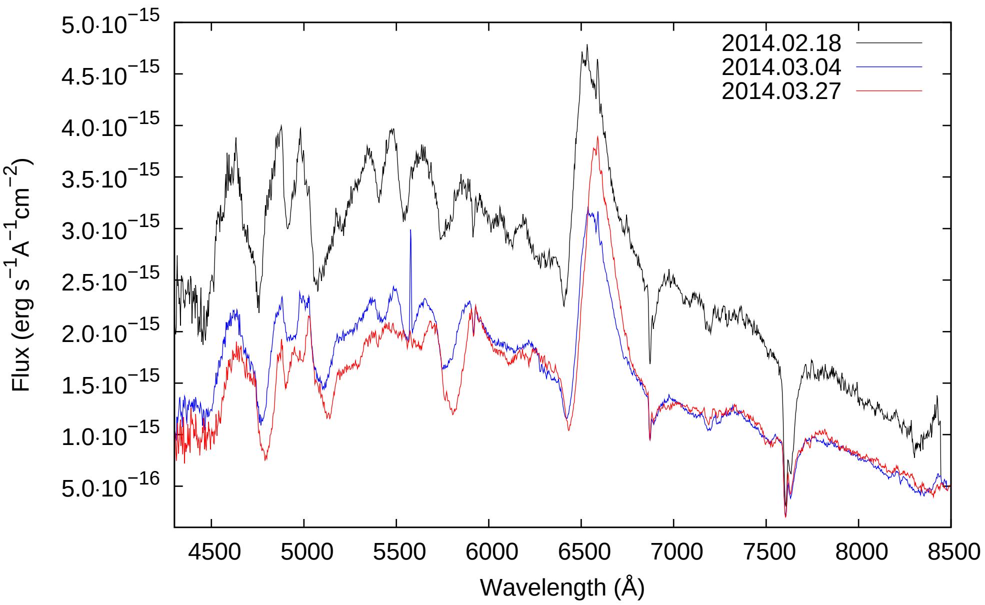


Figure 4.2: Significant changes in absolute flux and shape of the spectrum reflect the evolution of the supernova SN 2014g in 37 days. 37 päevaga on toimunud supernoova spektris märkimisväärsed muutused.

with the analysis of a massive eclipsing binary BD+48°1098, both photometric (41 nights) and spectroscopic observations (9 nights) continued in 2014 to complete the light curve in Johnson-Cousins B, V, R, and I filters, in order to determine more high-precision time of minima, and to cover radial velocity curve of the components of binary systems. Students Rene Voog and Robert Matjus significantly contributed to spectroscopic observations.

4.3 Pulsations of evolved massive stars

A. Aret has studied pulsations in evolved massive stars, particularly in the blue supergiants. Blue supergiants are luminous objects that have evolved from massive OB main-sequence stars. They loose mass via powerful line-driven winds and display strong photometric and spectroscopic variability which were suggested to be linked to stellar pulsations. Pulsational activity in massive stars is assumed to be connected with mass-loss episodes and the formation of clumps in the wind. Blue supergiants are predicted to pulsate in pure gravity modes with periods of 2–10 days. However, much shorter periodicity corresponding to the pressure modes with periods of hours to about one day have been recently discovered, emphasizing that our knowledge of the pulsational activity in blue supergiants is still incomplete.

The ability of blue supergiants to maintain stable pulsations opens a completely new perspective in studying these stars. Asteroseismology provides methods to investigate deep interior of the stars revealing important physical properties such as internal structure, rotation, and mixing. Knowledge of these parameters is of vital importance for our understanding of the post-main sequence evolution of massive stars, as these are key input parameters to modern stellar evolution calculations.

To investigate a possible interplay between pulsations and mass loss, an observational campaign was initiated to search for pulsational activity and cyclic mass-loss variability in stellar winds for a sample of bright blue supergiants collaborating with researchers from Czech Republic, Argentina and Poland. Detailed analysis of the object 55 Cyg has been carried out, work on other objects is in progress. 55 Cyg shows oscillations in pressure, gravity and strange modes. The star undergoes episodes in which the determined mass loss can vary by a factor of 1.7–2 on time scales of two or three weeks. It was concluded that there is a direct link between pulsational activity and enhanced mass loss. Furthermore, WISE (Wide-field Infrared Survey Explorer) infrared images of 55 Cyg (Fig. [55Cyg]) reveal presence of a large bow shock structure originating from the interaction of a strong mass-loss event with the interstellar matter. This strong wind phase is expected to occur during the evolution through the red supergiant stage. The obtained results suggest that 55 Cyg has already passed the red supergiant phase, crossing the Hertzsprung–Russell diagram towards the blue region, and thus belongs to the classical α Cygni variables.

4.4 Diffusional separation of Ca isotopes in stellar atmospheres

L. Sapar, A. Sapar, R. Poolamäe and A. Aret studied diffusional separation of calcium isotopes due to light-induced drift (LID) in the atmospheres of hot chemically peculiar HgMn stars. Microturbulence in the quiescent chemically peculiar (CP) stellar atmospheres is the main factor, which essentially reduces separation of isotopes. A formula has been derived for the microturbulence velocity, supposing that it is due to the acceleration generated by radiative flux. Collisions between the photons of radiative flux and atomic particles of plasma specify the mean free path of photons, which has been accepted as the characteristic length of the microturbulence. The microturbulence diffusion coefficient in CP stellar atmospheres has been determined according to usual concept as the product of the microturbulence velocity and the mean free path of photons. This quantity has been used in computations

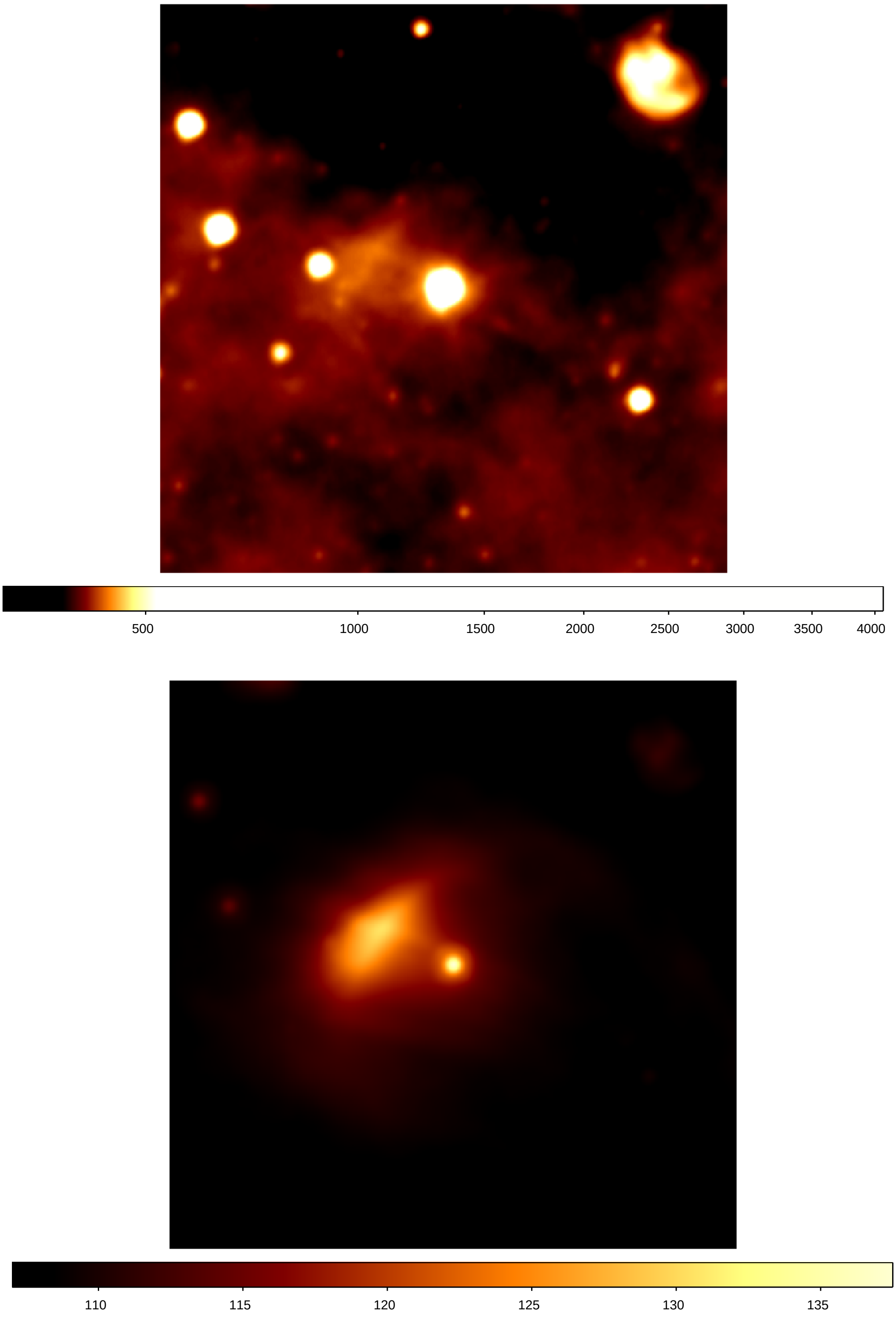


Figure 4.3: Bow shock near 55 Cyg detected by WISE. Shown are the image at 12 μm in logarithmic luminosity scale (upper) and the image at 24 μm in linear scale (lower). The size of the images is $10^\circ \times 10^\circ$. Kosmoseteleskoobi WISE $10^\circ \times 10^\circ$ nurkmõõmetega infrapuna-pildid lööklainest tähe 55 Cyg juures. Ülemisel pildil (lainepikkus 12 μm) on heledus logaritmilises skaalas, alumisel pildil (lainepikkus 24 μm) on heledus lineaarskaalas.

of isotope stratification due to LID by the software SMART, updated for these computations.

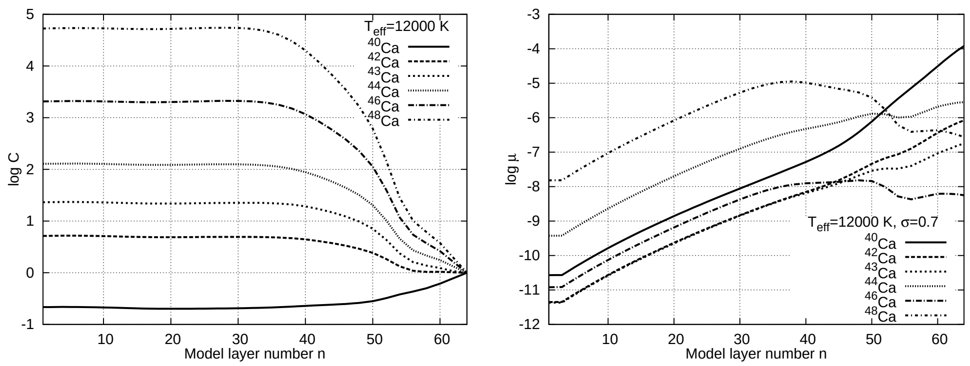


Figure 4.4: Ca isotope concentrations C relative to solar values (left) and corresponding relative densities in model atmosphere layers μ (right), both in logarithmic scale. The Ca isotope inner boundary concentrations are assumed to be the solar ones. The modelling parameters are $\log g = 4.0$, $T_{\text{eff}} = 12\ 000$ K. The mean value of accepted impact cross section is $\sigma = 0.7 \cdot 10^{-16}$ cm ^{2}.
Kaltsiumi isotoopkontsentratsioonid võrreldes standardväärtusega Päikesel (vasakul) ja vastavad suhtelised tihedused mudelatmosfääri kihtides μ (paremal), mõlemad logaritmilises skaalas. Kaltsiumi isotoopide kontsentratsioonid mudelatmosfääri sisepinnal on võetud Päikese standardväärtusteks. Modelleerimisparameetrid on $\log g = 4.0$, $T_{\text{eff}} = 12\ 000$ K. Põrkeristlõigete keskväärtuseks on võetud $\sigma = 0.7 \cdot 10^{-16}$ cm ^{2}.

The necessary input file containing the numerical values of parameters of the hyperfine and isotopic splitting of calcium spectral lines has been composed. For adequate computations of radiative transfer in blends of isotopic spectral lines, the spectral resolution has been taken extremely high, up to $R = 2.5 \cdot 10^6$. The general picture of Ca isotope stratification turned out to be similar to previous results obtained for Hg isotopes by the same authors: essential overabundance of the heaviest isotope (in the present case ^{48}Ca) is generated due to LID. The isotope separation grows outwards throughout the atmosphere.

Profiles of isotope concentrations in late B and early A spectral type stellar atmospheres have been computed, assuming that on the inner boundary surface the isotope concentrations are the solar ones. The computed CaII infrared triplet line profiles fit well to the observed line profiles in high-dispersion spectrum of HD 175640 demonstrating that line profiles and the spectral line shift correspond to predominance of isotope ^{48}Ca. It has been concluded from this circumstance that the suggestions about the physical nature of the microturbulence can have realistic physical meaning.

4.5 Luminous stars in stellar associations

In the framework of the Estonian Research Council grant 8906 ”Time resolved survey of the most luminous stars in stellar associations” the spectral and photometric monitoring of the blue hypergiant star Schulte 12 and several ordinary supergiants (HD 14134, HD 13267, HD 225094) as well as massive luminous binaries (BD +48 1098) has been continued. Two B.Sc. theses (R. Voog and Ü. Kivila) have been defended on this topic. The papers summarizing the results on variability time scales (Schulte 12), and on binary structure and its parameters (BD +48 1098) are in preparation.

4.6 Preparations for the ESA Gaia mission

The participation of Tartu Observatory in the Gaia space mission has been continued in the framework of the project "Algorithms for mapping galactic structures with Gaia and Euclid" which is financed by the ESA PECS (Plan for European Cooperating State) programme. In the framework of this project Tartu Observatory has contributed in 2014 to the tasks of Coordination Unit 3 ”Core processing” (CU3) and Coordination Unit 7 ”Variability processing” (CU7) at the Gaia Data Processing and Analysis Consortium. After the launch of Gaia on December, 19th 2013 during the period of initial in-orbit commissioning (IIOC) which ended formally on July, 18th 2014, we proposed to test the shape of the actual on-board dispersion curve (CU3 task) in the case of BP and RP spectrophotometric instruments using a selected set of M-type giant stars (RP instrument) and of WR-stars (BP instrument), respectively. The IIOC has been conducted using mainly the ecliptic-pole scanning law for Gaia enabling CU7 to test Gaia variability processing algorithms on objects around ecliptic poles. Tartu Observatory has delivered to CU7 variability data on stars in the north ecliptic pole region obtained during ground-based photometric observations in the framework of the Estonian Research Council grant 8906.

4.7 Symbiotic stars and related objects

Symbiotic stars are a class of interacting binary stars, consisting of a cool red giant and a hot companion. The latter, in most cases, is a white dwarf star that accretes matter from the copious wind of the red giant so that thermonuclear burning of hydrogen shell could start on the surface of the white dwarf. Symbiotic stars display a variety of interesting astrophysical phenomena of which some are unique to this class of stars.

AG Dra is a classical symbiotic star which has been studied quite a lot, but there are still some issues to solve. For example, physical reasons and mechanisms of its outburst activity are not yet clear. There are major (so called cool) outbursts taking place in about 12–15 years intervals, while smaller scale (hot) outbursts can be observed at about 350–370 days intervals between them, alternating with shorter or longer quiescent stages. L. Leedjärv in collaboration with L. Hric, R. Gális and E. Kundra from Slovakia has recently analysed the 120 years long photometric time series for AG Dra (MNRAS, 443, 1103, 2014). In 2014, the work was continued, with a main attention to the spectroscopic observations done at Tartu Observatory. The about 370-day periodicity can be observed in the characteristics of the spectral emission lines, possibly reflecting pulsations of the cool giant and resulting from those variability of the stellar wind. Of special interest is the Raman scattered emission line at λ 6825 Å which practically disappears during the cool outbursts. As the He II line at λ 4686 Å also weakens significantly at the same time, one can conclude that temperature of the hot component decreases in this case. However, it still remains obscure why phenomena of this type take place with about 12–15 years quasi-periodicity.

4.8 Peculiar stars

4.8.1 R Aquarii

T. Liimets, K. Verro, I. Kolka together with R. Corradi and M. Santander-Garcia continued analysing the wealth of data of the nebulosity and jet complex surrounding the symbiotic star R Aquarii. Surprisingly, some parts of the the jet are showing rather fast lateral motions which seem to refer to changing ionization beam rather than a real matter motion. The scientific paper is in preparation.

4.8.2 V838 Monocerotis

I. Kolka, T. Liimets, T. Kipper together with T. Augusteijn from Nordic Optical Telescope (NOT) continued photometric and spectroscopic monitoring of the peculiar binary star V838 Mon with the NOT. V838 Mon is still in deep minimum.

4.9 Radiative transfer

I. Vurm together with R. Hascoët and A. M. Beloborodov studied the origin of the peculiar simultaneous double GeV+optical flash in gamma-ray burst 130427A, peaking at ~ 15 seconds after the onset of the (main) MeV emission. They proposed that the flash is produced by the interaction of the relativistic jet with the stellar wind of the progenitor star, creating a shock at the interface. The shock-heated wind material gives rise to the GeV flash via inverse Compton emission, the optical flash is synchrotron emission by the same particles. The mechanism is robust and allows to place strong constraints on the progenitor wind density which was found to be typical of Wolf-Rayet stars, strengthening the connection betwen GRBs and Wolf-Rayet progenitors.

I. Vurm together with Brian Metzger, Romain Hascoët, and Andrei M. Beloborodov studied the importance of shock interactions within nova outflows, some of which show peculiar double-peaked radio light curves which are not easily explained by standard theory. The early radio peak was proposed to arise from bremsstrahlung emission from shock-heated thermal particles, although synchrotron emission from Fermi-accelerated relativistic electrons could not be ruled out. The shock hypothesis is further supported by the recent detection of novae above 100 MeV by the Fermi/LAT instrument.

4.10 Statistical methods in astronomy

In collaboration with Centre of Excellence in Research on Solar Long-term Variability and Effects (ReSoLVE, Finland) J. Pelt proceeded with development and application of different novel time series analysis methods.

In traditional observational astrophysics context he applied the so called carrier fit method to analyse different light curves of magnetically active stars. The results for a star LQ Hya are in the process of publishing.

He started also to participate in the project, which is devoted to numerical modeling of the dynamo processes. His and Nigul Olspert's role in this project is to analyse time dependent behaviour of the computed dynamo models using specially developed time series analysis methods.

In the context of geophysics J. Pelt worked on the problems of Sun-Earth connections. He studied the linear correlations between solar magnetic activity and Earth energy balance and between Sun's coronal activity and magnetic disturbances measured in Finnish observing stations.

J. Pelt took part in the statistical study of galaxy filaments too. He was helpful in proposing various time series analysis methods to analyse distributional properties of the galaxy projections.

4.11 Generalized orthonormal analytical orbitals for Hartree-Fock formalism

A. Sapar essentially succeeded in elaboration of a generalized set of orthonormal analytical radial orbitals for Hartree-Fock formalism computations of atomic structure. Different radial integrals are needed for computation of wave functions, energetic states and transition probabilities. These orbitals have been named the distorted hydrogenic orbitals. Proposing of these analytical formulae is aimed at essential time-economy, higher precision, relative simplicity of quantum mechanical computations needed in astrophysical spectroscopy, and better physical interpretation than in the case of purely numerical computations.

Distortion coefficients have been introduced in these formulae, they must be specified by a non-linear optimization method, using computations based on the variational minimization principle. The constants used enable to take into account in more detail the reciprocal electrostatic shielding effects in the filled electron subshells and in the spectroscopic terms of unfilled subshells. Analytical formulae for the necessary radial integrals of the direct and exchange Coulomb interaction between electrons have been derived.

The obtained formulae have been applied to formulae for the energy of filled electron subshells and generalized for the always filled spectroscopic terms in the unfilled valence subshells. The formulae for the specific mass shift, isotopic shifts and hyperfine structure of spectral lines in the formalism with generalized orbitals based on the quantum-mechanical perturbation theory have been derived.

The orthonormality conditions for orbitals and for angular integrals guarantee that in variational computations it is not necessary to use the Lagrange coefficients with penalty expressions to generate them.

All of the above described formulae have been obtained using the Russell-Saunders or LS-interaction for addition of quantum numbers. However, for more complicated jj-interaction of angular momenta of bound atomic electrons simpler formulae to describe the electron angular momenta by $3j$-, $6j$- and $9j$-symbols have been proposed.

4.12 Dynamics of cosmic neutrinos in galaxies

In the expanding Universe the red-shift cooling of the cosmic background particles takes place a decrease of their moments. Thus, cooling of relativistic particles is proportional to the expansion rate measured as redshift, but for the cooled, non-relativistic or classical Newton mechanics particles it is proportional to the cosmological redshift squared. As a result the non-relativistic rest-mass particles are cooling to much lower temperatures than the massless photons. Due to this circumstance the cosmic background of massive, about 1 eV rest-energy neutrinos turns out to be cooled to extremely low temperatures, reaching to almost completely degenerated state.

The Fermi velocity of the neutrinos at the present evolutionary epoch of the Universe is about 50 km/s.

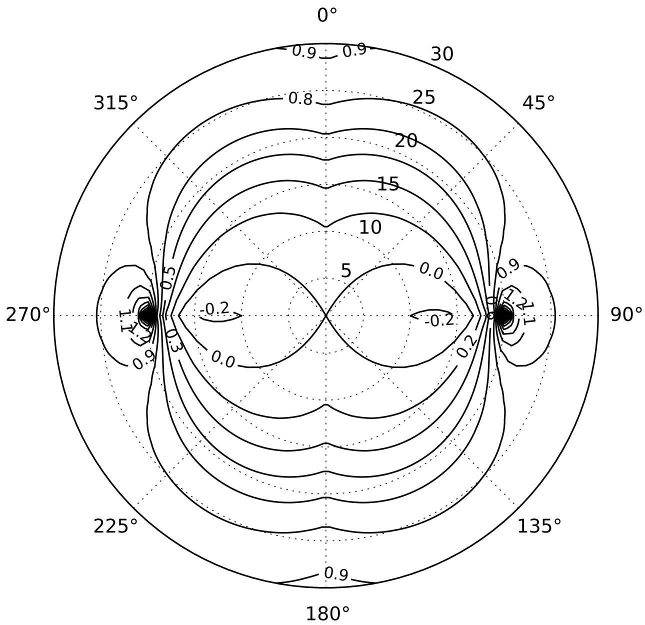


Figure 4.5: The axial section plane isolines of the ratio 'computed radial gravity of circular disk galaxy versus gravity of the mass-point in the galactic centre' both having equal masses. In the outer region the ratio is asymptotically approaching to 1.0 and its central value is zero. Numerated distances are the conventional ones. Isojooned radiaalsete raskuskiirenduste suhtele, mida tekitab telglõiketasandis ühtlase radiaaltihedusega ketasgalaktika ja sama massiga must auk galaktika tsentris. Kaugel tsentrist läheneb see suhe asümptootiliselt arvule 1 ja tsentris on ta väärtus 0. Nummerdatud kaugused on kalibreeritud ühikutes.

The formulae of dynamics for the cosmic background neutrino contribution have been derived for the spherical and axisymmetric thin circular disc galaxies. The formulae comprise gravitational potential and gravity of the uniform baryonic disc galaxies. It was possible to remove infinities in the integrand and to integrate analytically over the azimuthal angle, obtaining formulae of gravitational potential and gravity as its gradient.

The equations for the trajectories of the non-relativistic collision-free neutrinos in the axisymmetric galaxies have been derived. Formation of constant radial neutrino flux in spherical galaxies favours formation of the wide unipotential wells in them. The neutrino flux in the axisymmetric galaxies suggests to favour evolution in the direction of spherically symmetric potential. The generated unipotential wells due to both the baryonic matter and massive neutrinos in the axisymmetric galaxies are observed as plateaux in the velocity curves of circular stellar orbits.

The constant neutrino density at galactic centres gives the linear part of the velocity curves of stars in axisymmetric galaxies. The derived system of quasilinear partial differential equations for neutrinos in the axisymmetric galaxies have been reduced to the system of time-dependent first order differential equations (the Lagrange-Charpit equations). These are the coupled differential equations, specifying the local neutrino velocities and dynamics of motion along trajectories, and an additional interconnected equation of neutrino mass conservation, to be applied for determination of density of neutrino component in galaxies. Main modelling results are visualized in the Figure.

5 Remote sensing Kaugseire

Maismaa kaugseires jätkus Eesti taimkatte primaarproduktsiooni hindamine mudelarvutustega (mudelid EST-PP ja satelliidi MODIS primaarproduktsiooni mudel). Metsade kaugseire alased uuringud olid suunatud otsestele metsamajanduslikele rakendustele. Metsade tüvemahu kaardistamiseks kasutati keskmise ruumilise lahutusega Landsat 8 pilte, lennukilidari andmeid, maapeal proovitükkidel tehtud mõõtmisi ja k-lähima naabri klassifitseerimismeetodit (kNN). Alustati aerolidari andmetele tugineva metsade takseerimise metoodika väljatöötamisega. Aerolidari mõõtmisandmetest on võimalik saada statistilise hinnanguna metsa kõrgus ja võrastiku katvus, mis on omakorda hästi seotud biomassi ja puidu hulgaga. Aerolidari andmeid kasutati ka puittaimestiku kaardistamiseks põllumajanduslikel maadel. Koostöös mitmete uurimisrühmadega Prantsusmaal, Saksamaal, Hollandis ja Itaalias analüüsiti hooldusraiete mõju metsade albeedole. Senised kliimamudelid seda ei arvesta. Noorte metsade albeedot kujundab eelkõige liigiline koosseis, aga puistute vanuse kasvades muutub metsamajanduslike meetmete mõju järjest olulisemaks. See on üks mehhanism, mille kaudu inimtegevus kujundab Maa kliimat. Jätkusid tööd metsade kiirguslevi alal. Lehtede peegeldumisspektri uurimine on näidanud lähisinfrapunase spektripiirkonna olulisust klorofüllisisalduse hindamisel. Klorofüllisisaldus mõjutab lehtede peegeldumisspektrit isegi lainepikkustel üle 730 nm, mida aga senises praktikas tavaliselt arvesse ei võetud. Jätkusid puistute detailse struktuuri uuringud, mõõdeti lehtpuumetsade lehtede kaldenurkade jaotusi ning grupeerumist nii Eestis kui Itaalias ja Prantsusmaal. Koguti täiendavaid andmeid metsade alustaimestiku peegeldusomaduste kohta. Tartu Observatooriumis välja töötatud metsa kiirguslevi mudeli täiustamine parandas mudeli suutlikkust simuleerida metsade peegeldusomaduste suundolenevust. Peegeldusindikatrissi kuju täpne tundmine on vajalik mitme vaatesuunaga satelliidimõõtmisandmete interpreteerimiseks ja ainult ühes vaatesuunas mõõtmisandmetest metsade albeedo hindamiseks.

Atmosfääriuuringute osas jätkus koostöö Keskkonnaagentuuri ja Tartu Ülikooliga projektis "Eesti kiirguskliima". Valmis Eestit iseloomustav soojuskiirguse välja statistiline kirjeldus. Eesti kiirguskliima temaatikas koostati andmebaas ultravioletse kiiritustiheduse dooside integreerimiseks registreeritud spektritest päevade ja päeva osade (enne ja pärast keskpäeva, keskpäevased tunnid jne.) ulatuses. Saabuva päikesekiirguse spektreid registreeriti Järvseljal Eesti Keskkonnaobservatooriumi SMEAR-jaama lähedal ultravioletist lühilainelise infrapuna piirkonnani (290–2150 nm) kogu vegetatsiooniperioodi kestel. Täienes optikalabori suutlikkus kaliibrida ja metroloogiliselt igakülgselt uurida nii aktinomeetrilisi kui kaugseire kiirgussensoreid. Rahvusvahelise võrgustiku FP7 WaterS, mida TO veekaugseire grupp koordineeris neli aastat, raames jätkasid meil külalisteadlastena Dr. Olaf Krüger atmosfääri korrektsiooni probleemi uurimist ja doktorant Philipp Grötsch, kes lõpetas oma uuringu sinivetikate massiõitsengute määratlemise kohta. Projekti WaterS tegvuste lõpetamiseks toimus Tõraveres ka rahvusvaheline seminar "Challenges in the inland water remote sensing – future sensors, improved processing methods", nii meie partnerite kui ka mitmete teiste rahavusvaheliste tippteadlaste osavõtul. Jätkasime oma regulaarsete välitöödega Peipsil ja Võrtsjärvel, kuid seekord saadi võrdlusandmeid satelliitsensorilt Landsat 8 ja WorldView 2. Lisaks koguti koostöös partneritega andmeid veel mitmetelt Eesti väiksematelt järvedelt, mille hulka kuulus ka näiteks Ülemiste järv, et täita Euroopa Liidu veepoliitika raamdirektiivi nõudeid erinevate veetüüpide uurimise kohta. Projekti VeeOBS raames valmis andmebaas, kus lisaks Tartu Observatooriumi poolt kogutud andmetele on meie partnerite andmeid. Uuriti klorofüll-a ja fütoplanktoni neeldumiskoefitsiendi omavahelist seost ja selle põhjal valmis E. Kangro magistritöö. Tulemuseks oli Eesti järvede jaoks välja töötatud empiiriline algoritm, mida rakendati satelliitsensori MERIS tulemitele ning mille edasiarendamine Sentinel 3 jaoks toimub FP7 projekti GLaSS raames. Jätkus sinivetikaõitsengute uurimine madalates eutroofsetes järvedes. Potentsiaalselt mürgiste õitsengute tuvastamine on oluline nii puhkajate tervise kui joogivee puhastamise seisukohast. Kui traditsioonilised seiremeetodid võimaldavad anda punktipõhise hinnangu, siis satelliitkaugseire lisab ülevaate õitsengu ajalise ja ruumilise arengu kohta. Sentinel 3 stardi ootuses 2015. aastal teeme ühiseid ettevalmistusi koos teiste ESA liikmesriikidega Sentinel 3 valideerimise (S3VT) meeskonnas. Meie optikalabori poolt pakutav teenus veeseire tugimõõtmisteks ja vastavate seadmete kalibreerimine on vajalik paljudele S3VT liikemetele. ESA PECS-2 raames jätkub töö vee hajumisiskoefitsiendi mõõtmiseks vajaliku seadme loomisega koostöös Interspectrum OÜ-ga.

5.1 Remote sensing of vegetation

T. Nilson, M. Lang and M. Rennel continued the last year activity on the simulations of Estonian vegetation primary production by the EST–PP and MODIS NPP models. It was shown that for the performance analysis of these models it is reasonable to consider a so-called complex meteorological limiting factor that is calculated as the product of three limiting factors: incident photosynthetically active radiation (PAR) as well as limiting functions due to temperature and water supply. Then the yearly gross production (GPP) can be considered as the sum of daily products of the complex meteorological limiting factor and of the absorbed by vegetation fraction of PAR (fAPAR). Making use of meteorological data sets of Tartu-Tõravere meteostation the average seasonal courses of the complex meteorological limiting factor were found for the period from 2000 to 2011 and compred with those from a coastal station Sõrve. It was found that only during the spring period of year the meteorological conditions are better for plant productivity in inland while for the rest of the year and as an average over the whole year the conditions for plant growth are better at the coast. It appears that all the three factors, incident PAR, air temperature and air humidity are more favourable at the coastal area according to these models. As all the terms in the NPP model responsible for the respiration appear to be linear functions with respect to the leaf area index (LAI) and assuming a functional relation between fAPAR and LAI (fAPAR=1-exp[-K LAI]), a problem to find an optimum LAI under given meteorological conditions was formulated. Analytical formula to calculate the optimum LAI was derived. The optimum seasonal courses of LAI for different landcover classes in Estonia were calculated and compared with the LAI courses from the satellite image derived MERIS LAI products.

M. Lang ja T. Arumäe used Landsat 8 OLI images, airborne lidar data, sample plot data and k-nearest neighbors classifier to estimate standing wood volume in Laeva test site, Estonia. The results revealed systematic bias which depended on actual wood volume - in young stands wood volume was overestimated, and in old stands wood volume was underestimated. Similar results were observed in earlier tests in Kurzeme region, Latvia. According to our analysis the bias is caused by nonlinear relationships between remote sensing variables and wood volume, and by small random errors in measurements.

M. Lang and T. Arumäe started elaboration of airborne lidar based forest inventory methodology for Estonia. The inventory is based on estimates of canopy height and canopy cover obtained from airborne lidar data. T. Arumäe proposed a simple model for the estimation of tree crown length from airborne lidar data.

A method to estimate woody plant cover from airborne laser scanning data was tested by M. Mõistus and M. Lang. The validation dataset of test-sites in Tartumaa confirmed that the tested method is a simple and reliable way to compile forest fractional cover maps in agricultural fields.

In collaboration with research teams in France, Germany, Netherlands and Italy the influence of forest management onto forest albedo was analyzed (A. Kuusk). During stand establishment, summertime canopy albedo is driven by tree species. In the later stages of stand development, the effect of forest thinning increases. This is one of the mechanisms how the planet climate is influenced by economic activity.

M. Lang, A. Kodar and T. Arumäe tested a new hemispherical image processing software HSP for the estimation of canopy gap fraction by using images from Laeva test site, Estonia. The results showed that the implementation of above canopy sky reference image restoration in HSP is reliable and allows a single hemispherical camera to be used instead of the pair of plant canopy analyzers. The only drawback of HSP is significantly longer processing time compared to subjective pixel value classification (thresholding) methods. M. Mõistus used HSP to get canopy transmittance from hemispherical photos taken in the forests of Järvselja. Ground measurements and airborne laser scanning data based leaf area index map was compiled for areas near SMEAR (Station for Measuring Ecosystem-Atmosphere Relations) tower. The all lidar pulse returns based transmittance was found to be the most suitable lidar value for compiling LAI maps about dense forests.

J. Pisek collected vertical profiles of leaf angle inclination distribution for broadleaf tree species occuring at the Hesse site, France (i.e. European beech (*F. sylvatica*), horn-beam (*C. betulus*), oak (*Q. robur*), silver birch (*B. pendula*), and wild cherry (*Pr. avium*). The obtained vertical profiles were used to examine if the often assumed spherical leaf angle distribution is indeed a valid assumption for given broadleaf tree species in temperate ecoclimatic region. Next, the leaf angle inclination distributions from Hesse site will be compared with previously obtained profiles for co-occuring measured tree species (*B. pendula, P. tremula*) from Estonia in hemi-boreal ecoclimatic region to see if there might be any changes in leaf inclination angle distribution profiles with latitude.

J. Pisek obtained vertical profiles of foliage clumping by climbing the tower at Castelporziano site in Italy and taking levelled digital hemispherical photos (DHPs) along the climbed height. At each profile, several series of DHPs were acquired using a Nikon CoolPix 4500 digital camera with a Nikon FC-E8 fisheye lens under diffuse illumination conditions, following the protocol of Zhang et al. (2005). The reference DHPs were obtained above the top of the tree canopy. Gap fraction profiles will be extracted from the blue channel at view zenith angle 57° with the DHP software (v4.5; Canada Centre for Remote Sensing, Ottawa, Canada). The obtained vertical profiles of gap frac-

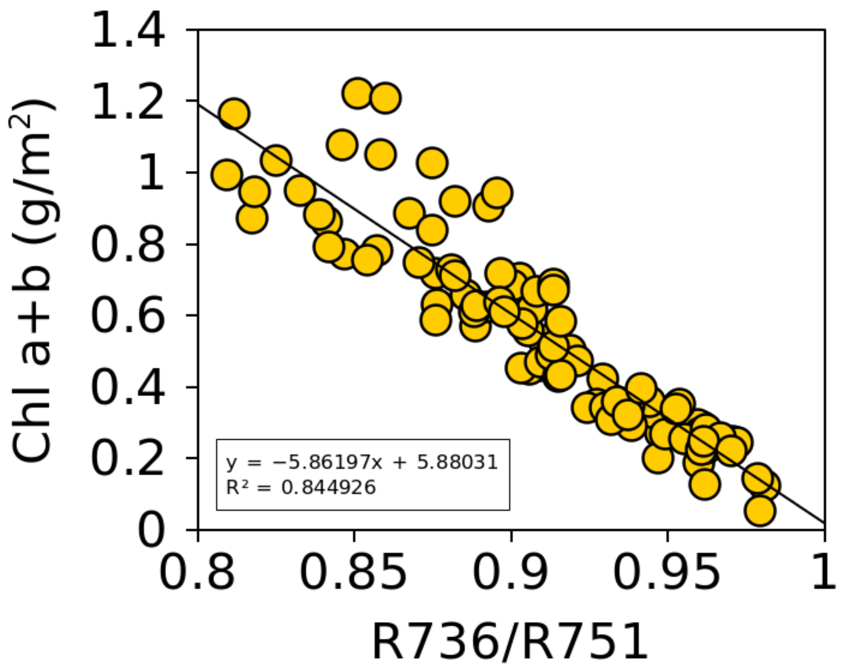


Figure 5.1: Relationship between leaf chlorophyll content and simple ratio of reflectance at 736 nm and 751 nm. Klorofüllisisalduse seos suhteindeksiga SR=R736/R751, kus R736 ja R751 on heleduskordajad lainepikkustel 736 ja 751 nm.

tion and foliage clumping for the Mediterranean evergreen ecosystem were readily used to fill existing void in the validation and comparison of existing foliage clumping products derived from remote sensing data (Pisek et al., ISPRS, in press).

Our studies show the significance of near-infrared (NIR) spectral region for estimating chlorophyll content from leaf reflectance spectra (L. Hallik). Wavelength region of 400–700 nm is called photosynthetically active radiation (PAR). Larger wavelengths beyond 700 nm are usually investigated in the context of ”red edge” position, which is known as good estimate for leaf chlorofyll content. However, leaf age can significantly influence the prediction of leaf chlorophyll content from ”red edge” position, as shown in the article published this year (Mõttus et al.). A thorough search of chlorophyll indices showed that NIR plateau deserves more detailed attention than it has received previously. The best spectral regions for chlorophyll estimation may remain outside of the wavelength range usually investigated (Fig. 5.1). It appears that chlorophyll content influences leaf reflectance even at wavelengths beyond 730 nm (Fig. 5.2) which is commonly not considered as chlorophyll sensitive spectral region.

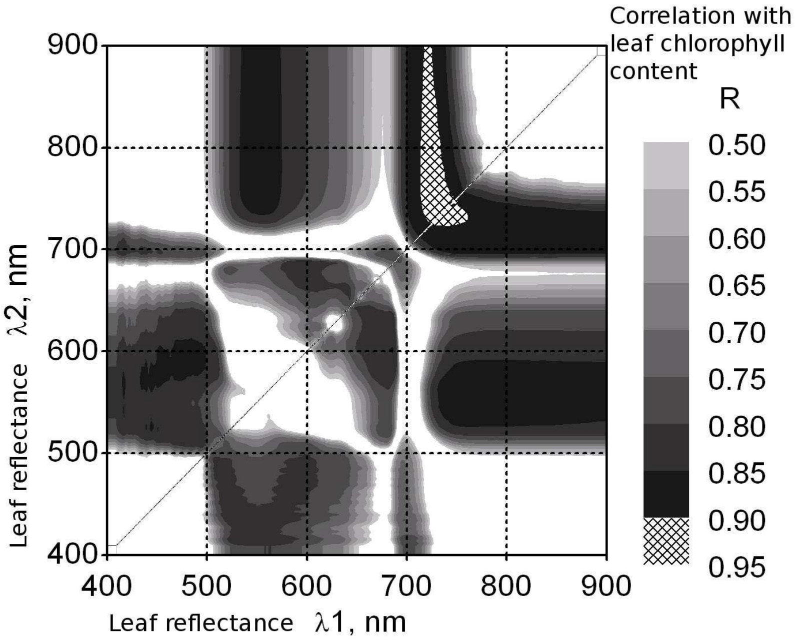


Figure 5.2: Correlation map of leaf chlorophyll content vs SR (simple ratio vegetation index = reflectance lambda 1 / reflectance lambda 2). Korrelatsioon suhteindeksi SR=R1/R2 ja klorofüllisisalduse vahel.

M. Nikopensius, K. Raabe, and J. Pisek kept tracking seasonal variation (April-September) and spectral changes occurring in understory layers of a typical European hemi-boreal forest. When compared with previous similar study carried in a boreal forest in Finland, it can be seen that it is not possible to make easy generalizations about the understory properties even for the stands with the same overstory tree species. The collected dataset would be of much use to improve and validate algorithms or models for extracting spectral properties of understory from remote sensing data. It can be also further used as a valuable input in radiative transfer simulations that are used to quantify the roles of forest tree layer and understory components in forming a seasonal reflectance course of a hemi-boreal forest, and the upcoming phases of the RAdiation Model Intercomparison (RAMI) experiment.

J. Pisek and the visiting scientist M. Rautiainen of University of Helsinki retrieved the seasonal courses of understory Normalized Difference Vegetation Index (NDVI) from MODIS BRDF data using the semi-empirical and physically-based approach. They compared the satellite-based understory NDVI series to seasonal courses of understory NDVI measured in the forests for three full growing seasons in boreal and hemiboreal sites in Northern

Europe. The results indicated both semi-empirical and physically-based approaches using MODIS BRDF data do have a potential to track seasonal changes in understory NDVI. Differences in the performance between of the two retrieval methods can be expected within the boreal zone depending on the level of forest fragmentation.

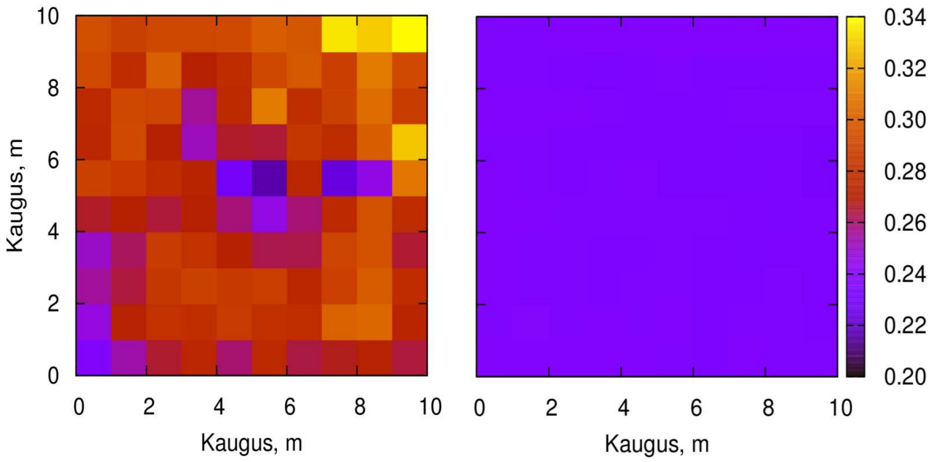


Figure 5.3: Reflectance of the Järvselja reference panel at 400 nm in summer 2013 (left) and in summer 2014 (right). Järvselja peegeldusetaloni heleduskordaja väli 2013. ja 2014. aastal.

One of the two environmental obervatory's SkySpec spectrometers measured total and diffuse irradiance at Järvselja during the whole vegetation period (April 28 - October 23, 2014). The other one was extensively studied in the optical radiometry laboratory (J. Kuusk). The investigated parameters were dark signal dependence on temperature and integration time, spectral stray light, cosine response error, radiometric sensitivity and its nonlinearity. Development of correction algorithms for these nonidealities is still in progress.

On July 29, 2013 the high spatial resolution satellite WorldView-2 measured the Järvselja region. During data processing it turned out that although the reflectance of the 10 m x 10 m reference panel was calibrated on 1m grid, the high variance of surface reflectance was problematic, Fig. 5.3. Therefore, in 2014 the surface of the reference panel was painted, which reduced the variance of reflectance about 10 times, Figs. 5.4 and 5.5.

The optical radiometry laboratory's capability of calibrating remote sensing instruments is gradually increased. J. Kuusk designed a computer interface for electronical shutter. It can be used for automation of dark signal measurement during calibration. This allows to take more frequent dark signal measurements which reduces errors caused by dark signal drift during calibration. Liquid cooling was added to the body of the shutter in order to avoid heat damage of the electromagnetic coil caused by the 1 kW calibration lamp.

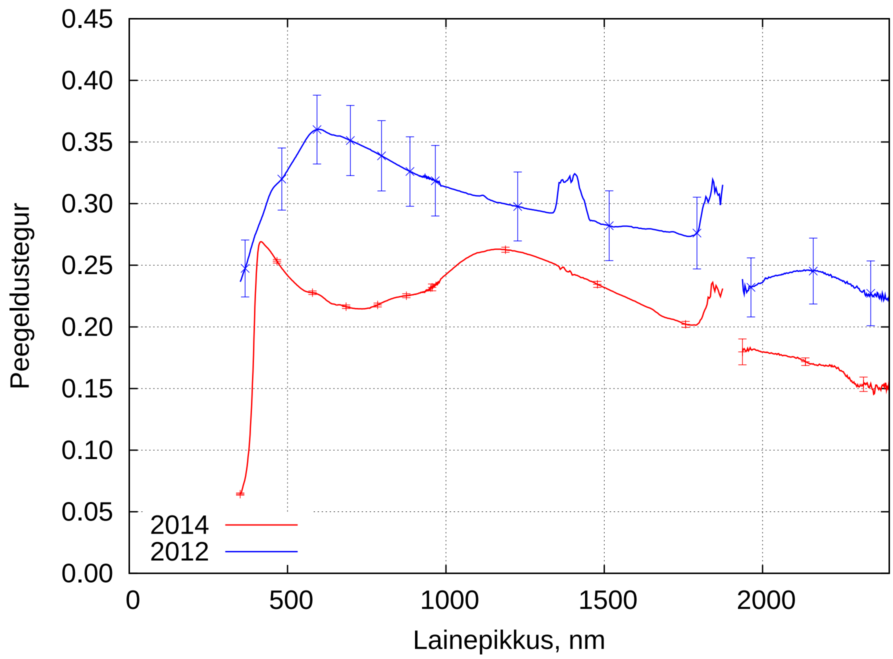


Figure 5.4: Reflectance spectrum of the Järvselja reference panel before and after painting. Järvselja peegeldusetaloni heleduskordaja enne ja pärast värvimist.

The directional multispectral hybrid type forest radiative transfer model FRT by Kuusk and Nilson (2000) was compared using directional reflectance factor of high angular resolution measured over three mature hemiboreal forest stands in Estonia. The model systematically underestimated backward scattering even in case of the best available input data, especially in coniferous stands. A. Kuusk replaced the Ross-Nilson area scattering phase function by more asymmetric Henyey-Greenstein phase function in the model. In order to better model angular dependence of gap fraction in overstorey canopy the erectophile leaf area distribution was applied in the model. These modification of the model significantly improved the agreement of model and measured angular distribution of forest directional reflectance.

5.2 Remote sensing of atmosphere

The work within project ”Estonian radiation climate” has reached the analysis of recorded ultraviolet radiation (UVR) spectra. Measurement system based on Bentham double monochromator was recalibrated using renewed laboratory facilities (I. Ansko). New producers calibrator was purchased and an additional one based on more powerful lamp was built. Also indirect checking of the instruments reliability was applied (K. Eerme, U. Veismann, M. Aun). Environmental effects of solar radiation depend strongly on its spectral composition. Variations and trends in the availability and spectral composition of UVR are causing various effects on the atmospheric chemistry, plants health, litter decomposition and carbon cycle as well as on human health. The exposure of organisms to UVR is characterized by annual and diurnal cycles of solar irradiance availability and by the variance (anomalies) of biologically-weighted irradiances within seasons. Availability of the most efficient UVB irradiance depends on the presence of direct sunshine and on solar elevation. Major contributor to variations of both UVB and UVA irradiance in Northern Europe and Estonia is cloudiness. The relatively largest daily doses are recorded at moderate cloud amounts when sunshine episodes are frequent and related to enhancement of irradiance. Both enhancement and attenuation increase the relative contribution of UVA radiation in the UVR spectrum (K. Eerme, M. Aun, M.Sc. students I. Aruoja and K. Virronen). At small amounts clouds are less frequently located close to sun and at large amounts attenuation of irradiance by clouds dominates.

Our collaboration with Estonian Environment Agency and Tartu University continued in the frames of ”Estonian radiation climate” project. V. Russak together with I. Niklus analysed the measurement data of downward and upward long-wave radiation at Tõravere. A description of infrared radiation conditions, characteristic for Estonia was prepared. Considered is the role of thermal radiation in entire radiation, also its temporal variability, as well as the diurnal and annual variability of the hourly totals of long-wave radiation and their dependence on meteorological parameters. Continuously the attention has been paid to the transfer of solar radiation in the cloudless atmosphere. A comparison of the time series of integral atmospheric transparency coefficients determined in different geographical sites in Estonia, Russia and Ukraine (Tõravere, Tiirikoja, Pavlovsk, Moscow, Feodossiya) has shown a great similarity. At the same time, the atmospheric optical thickness is systematically higher in Moscow and Feodossiya.

Tropospheric humidity and temperature datasets from Estonia (Harku) as well as Finland (Sodankylä, Jyväskylä and Jokioinen) using three types of Vaisala radiosondes have been homogenized by H. Keernik. With the intention to unite the time series by means of different sonde types, several corrections for well-known errors have been applied, which offers a possibility to estimate long-term trends up to tropopause.

The theory of Anthropogenic Global Warming claims that an increasing CO2 concentration of the atmosphere is capable to push the Earth radiation budget (ERB) out of balance. Mutual analysis of annual cycles for forcing and response in the Earth climate system does not support that claim. The analysis explains that the increase of greenhouse gas concentrations is unable to push the ERB out of balance because the latter is never balanced but its annual values oscillate around the balance by much larger amplitude than an annual influence of the greenhouse gas concentration growth.

The oscillation is initiated by total solar irradiance (TSI) which varies due to the Earth's elliptical orbit. Amplitude of the interannual ERB's oscillation changes due to random fluctuations in TSI, planetary albedo and outgoing longvawe radiation (OLR). Its experimentally determined fluctuations (at least a few Wm^{-2}) are much higher than an annual influence of increasing concentration of CO_2 (about 0.03 Wm^{-2}). This means that the observable global climate variations are independent on CO_2. A report on the corresponding computations has been presented by O. Kärner in the 9th International Conference on Climate Change (Las Vegas, July 7-9, 2014).

5.3 Remote sensing of water bodies

Ongoing international collaboration is based mainly on two FP7 projekts - under the IAPP Waters we hosted two guest researchers. Dr. Olaf Krüger continued studies about atmospheric correction over turbid waters and Philipp Grötsch finalised his paper about cyanobacterial bloom detection based on coherence between ferrybox observations, that was published in Journal of Marine Systems. To finalise the WaterS project and prepare for next collaboration, international conference "Challenges in the inland water remote sensing - future sensors, improved processing methods" took place in Tartu Observatory, Tõravere. Under the project VeeOBS, a new database was created to bring the handling and storing of the collected fieldwork data to a new level. At the moment, only data from our and our Estonian partners fieldworks are put in the database.

Relationships between two important parameters – phytoplankton absorption coefficient ($a_{ph}(442)$) and chlorophyll-a concentration ($C_{\text{Chl-a}}$) were investigated which resulted in masters' thesis (E. Kangro). It was discovered that the empirical algorithm for Estonian lakes is best described by positive power law ($C_{\text{Chl-a}} = 29.5 * a_{ph}(442)^{0.75}$; $R^2 = 0.76$, $N = 350$). Similar conversion law is used in MERIS (MEdium Resolution Imaging Spectrometer) Case 2 standard algorithm in order to retrieve Chl-a concentration product (Doerffer & Schiller, 2007) and developed area-specific relationship can

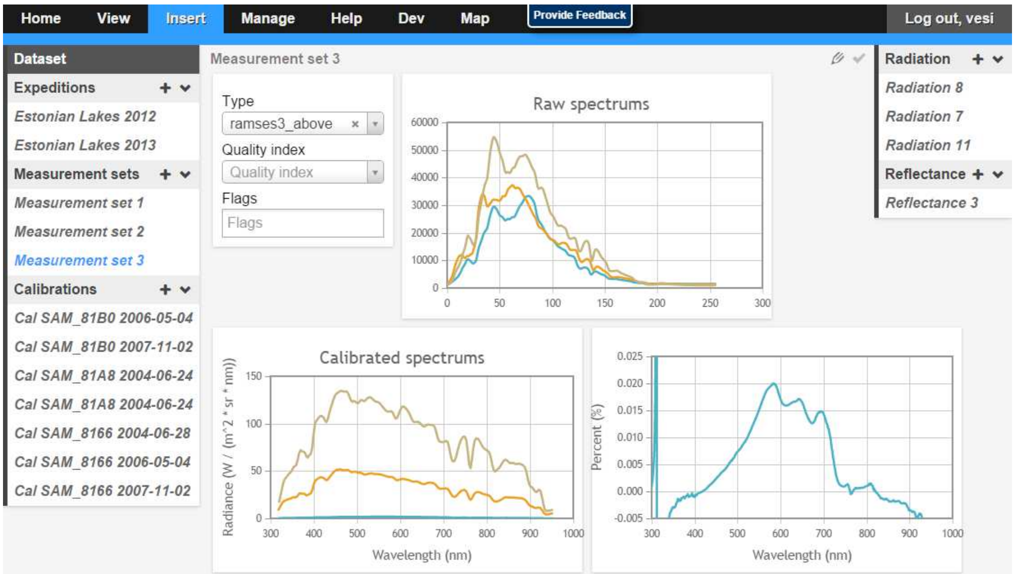


Figure 5.5: Database user interface – entering TriOS Ramses data. Andmebaasi kasutajaliides – TriOS Ramses andmete sisestamine.

be used for same purpose in algorithms of future sensors. The relationship is determined by the differences in temporal and spatial variability of these two parameters caused by the exchange of dominant algal groups during vegetation period. Phytoplankton biomass values and therefore absorption intensity and Chl-a concentration are in Võrtsjärv more than twice as high as in Lake Peipsi which also affects strength and shape of this relationship. Although phytoplankton community is during vegetation period dominated by cyanobacteria and diatoms in both lakes, the relatively higher contribution of cyanobacteria in Lake Võrtsjärv can be seen from the shape of the absorption spectra which have peaks around 440, 620 and 675 nm (Figure 5.6). In Lake Peipsi, on the other hand, there is a clearer seasonal variation between dominant algal groups as characteristic absorption peak of phycocyanin appears during the second half of the vegetation period. The flatter shape of spectra refers to relatively higher absorption intensity of diatoms and detritus. However, it can also indicate the influence of greater package effect which characterizes the aggregation and random distribution of chloroplasts in a phytoplankton cell and lessens the absorption intensity.

Our ongoing activity is remote sensing of shallow eutrophic waterbodies with cyanobacterial blooms. These waterbodies are important in socio-economic context, serving often as drinking water reservoirs or providing various ecosystem services (tourism, commercial and recreational fishing). Cyanobacterial blooms complicate situation, making the purification

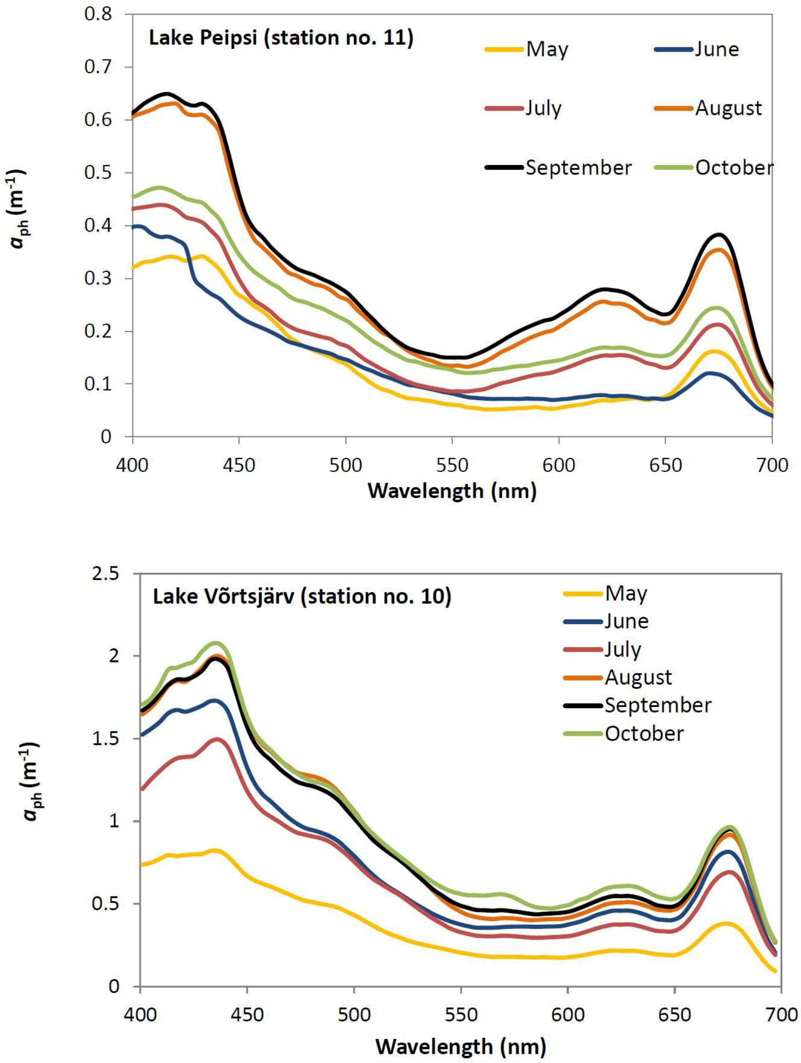


Figure 5.6: Variability of averaged (2010-2013) spectra of a_{ph} values in Lake Peipsi (upper) and Võrtsjärv (lower). Keskmiste (2010–2013) a_{ph} spektrite varieeruvus Peipsis (ülemine joonis) ja Võrtsjärves (alumine joonis).

of drinking water harder and restricting recreational activities. For example in L. Peipsi cyanobacterial blooms are a common feature, with *Microcystis, Aphanizomenon*, *Anabaena* and *Gloeotrichia echinulata* as main bloom-formers during summer and autumn. While conventional monitoring methods give only sparse point-estimations, the use of remote sensing methods allows better description of both temporal and spatial scale for mapping cyanobacterial bloom development. We have used Maximum Chlorophyll Index, based on MERIS red and NIR bands (Gower et al., 2008) for characterising cyanobacterial blooms (Figure 5.7).

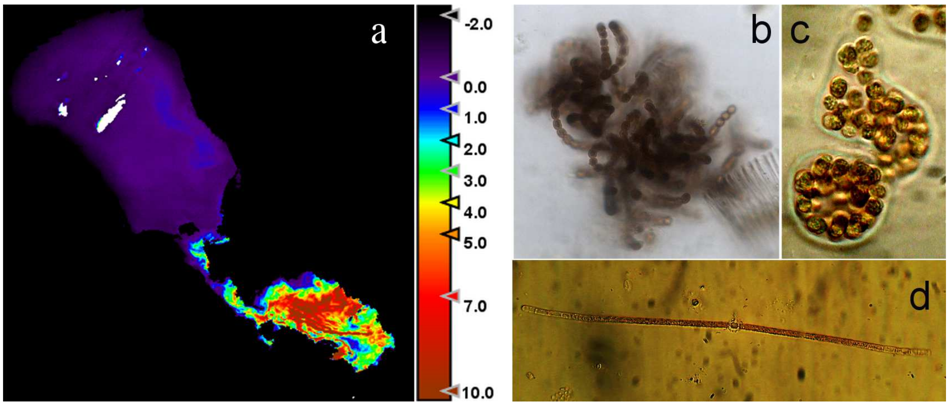


Figure 5.7: Start of the cyanobacterial bloom development according to Maximum Chlorophyll Index (MCI, [mW/(m^2 sr nm)]) in L. Pihkva in 11th July, 2010 (a) by K. Alikas. Dominant cyanobacteria *Anabaena lemmermannii* (b), *Microcystis wesenbergii* (c) and *Aphanizomenon flos-aquae* (d) on a right side. Photos by Kersti Kangro. Sinivetikaõitsengu algus Pihkva järves 2010. aasta juulis (11.07.2010) maksimaalse klorofülli indeksi (MCI, [mW/(m^2 sr nm)]) alusel (a). Paremal on peamised õitsengut põhjustavad sinivetikad: *Anabaena lemmermannii* (b), *Microcystis wesenbergii* (c) and *Aphanizomenon flos-aquae* (d). K. Kangro fotod.

Group of Remote sensing of Waterbodies continued with its regular fieldwork, when data together with Estonian Marine Institute (EMI) was collected on lakes Peipsi and Võrtsjärv. The field work time was chosen to match with the Landsat 8 overpass to continue the work of validating satellite data and produce new remote sensing algorithms. To fulfill the requirements of Water Framework Directive, extra samples were collected from Lake Ülemiste and Äntu Sinijärv, together with Centre for Limnology and from 5 Vooremaa lakes, which were also covered by WorldView-2 satellite image. As a new topic, M. Ligi participated in mapping the bottom vegetation at the coast of Hiiumaa, together with Estonian Marine Institute.

Fieldwork on Lake Peipsi. Välitööd Peipsi järvel.

6 Space technology Kosmosetehnoloogia

Eesti tudengisatelliidi programm algas 2008. aasta suvel Tartu Ülikoolis eesmärgiga edendada tudengite kosmosetehnoloogiaalaseid teadmisi. Projekt on olnud hindamatu õppevahend teaduse, tehnoloogia, tehnika ja matemaatika ainetes ja andnud tudengitele praktilise kogemuse kosmosetehnoloogia arendamises. Tudengisatelliidi meeskonna põhitegevus toimub Tartu Observatooriumis kosmosetehnoloogia osakonna teadlaste juhendamisel. Projekti raames saadeti 2013. aastal Vega kanderaketiga 670 km kõrgusele Maa-lähedasele päikese-sünkroonsele orbiidile Eesti esimene satelliit ESTCube-1. 2013. aastal kasutati satelliiti põhiliselt pildistamiseks ja andmete allalaadimiseks. Samal ajal jätkasid tudengid kiires tempos kõikide alamsüsteemide tarkvara täiustamist. 2014. aastal tegeleti peamiselt erinevate ootamatute tehniliste probleemide lahendamise ja elektrilise päikesepurje eksperimendiks valmistumisega. Sama aasta märtsis saavutas täisfunktsionaalsuse satelliidi asendi määramise ja kontrolli süsteem. Varsti peale seda avastati satelliidis tugev magnetiline häiritus, mis takistas satelliidi pöörlema panekut eksperimendiks ette nähtud telje ümber. Järgmistel kuudel töötati magnetmähiste väljundi parandusfunktsiooni kallal, mis võtaks arvesse laboris mõõdetud häiritusi ja püüaks selle negatiivseid efekte vähendada. Kahjuks selgus, et satelliidi sisemine magnetmoment on nii tugev, et selle mõju ei olnud võimalik oluliselt vähendada. Simulatsioonid näitasid, et elektrilise päikesepurje katset saab läbi viia ka diagonaaltelje ümber pööreldes. Segavast magnetmomendist ja sellest tulenevatest asendikontrolli probleemidest hoolimata õnnestus aprillis ESTCube-1 kaameraga teha esimesed pildid Eestist.

2014. aasta mais hakati testima satelliidi pöörlemiskiiruse muutmist. Septembri esimeses pooles saavutas satelliit nurkkiiruse 250 kraadi sekundis, mis oli vajalik 3 meetri traadi välja kerimiseks (esimene samm kogu 10 meetri välja kerimisel). 16. septembril alustati eksperimenti traadi pooli ja otsamassi luku põletamisega, millele järgnes katse kerida välja lühike jupp elektrilise päikesepurje traati. Telemeetria kohaselt õnnestusid kõik käsud, kuid alla laetud piltidelt ei olnud võimalik tuvastada traadi otsamassi. Järgnevalt tehti veel mitu ebaõnnestunud traadi väljakerimise katset, misjärel otsustati satelliidi pöörlemiskiirust veelgi suurendada lootuses, et ehk suurem tsentrifugaaljõud tõmbab mõne kinni jäänud osa lahti. 13. oktoobril saavutas ESTCube-1 pöörlemiskiiruse 841 kraadi sekundis, mis on teadaolevalt seni kõige suurem satelliidi kontrollitult saavutatud nurkkiirus. Pärast pöörlemiskiiruse vähendamist ja probleemile selgituse otsimist jõuti järeldusele, et mootor koos traadi pooliga ei pöörle. Selle põhjuseks on suure tõenäosusega kas mootori enda või pooli lukustussüsteemi rike. Paralleelselt

Figure 6.1: An image taken with the ESTCube-1 camera on April 23 capturing Estonia and its neighbours. 23. aprillil ESTCube-1 kaameraga tehtud pilt Eestist ja naabritest.

ESTCube-1 arendusega kavandavad Eesti tudengisatelliidi programmi tudengid ka järgmisi missioone ESTCube-2 ja ESTCube-3. ESTCube-3 lendab tõenäoliselt Kuu orbiidile ning ESTCube-2 on vaheetapp kõikide ESTCube-3 missiooniks vajaminevate uute tehnoloogiate katsetamiseks Maale lähemal, soodsamates sidetingimustes ja odavama stardihinnaga. 9.–11. juulil toimus Tartu Observatooriumis üle 50 osalejaga rahvusvaheline ESTCube'i suvekool, kus muude teemade hulgas arutati põhjalikult ka tulevaste missioonide detaile. Lisaks ESTCube'i missioonidele tekkis Eesti tudengisatelliidi programmi meeskonnal võimalus koostööks Euroopa Kosmoseagentuuriga (ESA) vahetades välja ühe European Student Earth Orbiter (ESEO) projekti meeskonna. Kahel organisatsioonil, Tartu Observatooriumil ja Budapesti Tehnoloogia ja Majandusülikoolil, paluti kirjutada pakkumine ESEO kaameramooduli kiirkorras ehitamiseks. 2014. aasta juulis valisid ESA ja ALMASpace välja Tartu Observatooriumi pakkumise. Kaameramoodul koosneb primaarsest kaamerast, mis on väga sarnane ESTCube-1 kaamerale ja sekundaarsest kaamerast, mis on ESTCube-1 kaamera edasiarendus ja on ligilähedane ESTCube-2 plaanitavale kaamerale.

Kosmosetehnoloogia osakonna tegevus toimub veel teisteski suundades:

- Satelliitside maajaam.

Tartu Observatooriumi satelliitside maajaam on sel aastal olnud aktiivses töös peamiselt EstCube-1 satelliidiga side pidamiseks. Maajaama tehniline lahendus võimaldab satelliidi automaatset jälgimist ja sellega sidepidamist ilma operaatori kohalolekuta. Aasta jooksul on täiendatud antennisüsteemide positsioneerimise täpsust ja andmeside töökindlust. Välja on arendatud saatevõimekus 144 MHz lainealas. Lisaks eelnevale on katsetatud raadiosignaalide vastuvõttu ka süvakosmoses asuvatelt kosmoseaparaatidelt 2,2 ja 8,4 GHz lainealadel. Seni kõige kaugem objekt, millelt saadetud raadiosignaali olemasolu oleme oma 3-meetrise paraboolantenniga detekteerinud on ESA Rosetta kosmoseaparaat, mis asus sel ajal väljaspool Jupiteri orbiiti rohkem kui 600 miljoni kilomeetri kaugusel Maast.

- Elektromagnetilise ühilduvuse (EMC) mõõtelabor.

On toimunud aktiivne töö EMC labori edasiarendamisel ja täiendamisel. Euroopa Liidu struktuurifondide toel on soetatud mõõtmisteks vajalik tehniline aparatuur, sealhulgas kalibreeritud mõõteantennid, mis katavad sagedusala 30 MHz kuni 18 GHz ja EMC analüsaatorvastuvõtja, mis katab sagedusala 10 Hz kuni 26,5 GHz. Lisaks on ehitatud arvuti abil juhitav pöördlaud testitava objekti asendi pööramiseks kajavabas ruumis. Alustati ka mõõtesüsteemi kalibreerimiseks vajalike testmõõtmistega. Peale kalibreerimist on EMC labor valmis reaalseteks mõõtmisteks nii Tartu Observatooriumi oma arendusprojektide, kui ka väljaspoolt saadud tellimuste täitmiseks. EMC labori poolt pakutavate võimaluste kasutamise vastu on tundnud huvi mitmed ettevõtted üle Eesti ja ka väljaspool Eestit.

6.1 First Estonian satellite

The Estonian Student Satellite programme started in the summer of 2008 at the University of Tartu with the objectives of promoting space research, being a valuable educational tool for science, technology, engineering, mathematical subjects and giving students hands-on experience in developing space grade hardware and software. The main development activities of the satellite team take place at Tartu Observatory under the supervision of researchers at the Department of Space Technology. On May 7, 2013, the first Estonian satellite ESTCube-1 was launched aboard the European Space Agency's Vega launcher to a 670 km sun-synchronous low Earth orbit. During the first year in orbit, the satellite was actively used for taking images and downloading data, while students rapidly continued improving software for all subsystems.

Year 2014 for ESTCube-1 comprised overcoming various challenges in orbit and working towards the execution of the E-sail experiment. In March 2014, the attitude determination and control system software reached its full functionality. Shortly after this, a strong magnetic disturbance within the satellite was discovered, which did not allow spinning up the satellite around the axis predetermined for the E-sail experiment. In the following months, engineers worked towards overcoming the disturbance by developing a coil output correction function that would take into account the disturbance measured in the lab and try to cancel the negative effects. However, the internal magnetic moment was so strong that its effects could not be reduced. According to simulations, it would also be possible to carry out the experiment with the satellite spinning around a different axis. Despite the magnetic disturbance and the resulting attitude control problems, the first full images of Estonia were taken in April. An example is shown in figure.

In May 2014, spin-up and detumbling tests in preparation for the E-sail experiment were started. In the beginning of September ESTCube-1 was spun up to 250 deg/s, which was the spin rate required for reeling out 3 m of the tether – the first step towards reeling out the planned 10 m. The experiment began on September 16 with burning the reel and end-mass locks, followed by an attempt to unreel a small amount of the E-sail tether. According to telemetry, all commands had been successful, however the downloaded images did not confirm deployment of the tether. Unreeling the tether was attempted several more times and it was decided to spin up the satellite even further to increase centrifugal force in hope of loosening any stuck components. On October 13, ESTCube-1 was spun up to 841 deg/s, which is the fastest spin rate known to be deliberately reached by any spacecraft. After spinning down to lower angular velocities, further investigation and tests led to the conclusion that the tether reel motor is not rotating, the reason being the failure of either the motor or the reel lock. In parallel with ESTCube-1 development, students and researchers have also been planning and developing the ESTCube-2 and ESTCube-3 missions. ESTCube-3 will most likely be a Moon mission and ESTCube-2 will be a stepping stone used to test the new technologies needed for ESTCube-3, but in better communication conditions closer to Earth and at a more affordable launch price. In July, a 3-day international ESTCube summer workshop with over 50 participants was held in Tartu Observatory, where among other topics, details of the ESTCube-2 and ESTCube-3 missions were discussed. In addition to the ESTCube missions, the Estonian Student Satellite team was presented an opportunity to cooperate with the European Space Agency (ESA) by replacing one of the teams in the European Student Earth Orbiter (ESEO) project. Two organizations, Tartu Observatory and the Budapest University of Technology and Economics, were asked to send their proposals to build the optical payload for the ESEO satellite at a very tight time schedule. In July 2014, ESA and ALMASpace selected the Tartu Observatory team to join the project. The optical payload will be composed of a primary camera similar to the one on ESTCube-1 and a secondary camera which is an improved version similar to that planned for ESTCube-2. By the end of 2014, almost 200 students had participated in the Estonian Student Satellite programme. These include students from the University of Tartu, Estonian Aviation Academy, Tallinn University of Technology, University of Life Sciences, Estonian National Defense College, many foreign universities and Estonian secondary schools. The project is supervised by researchers from Tartu Observatory and teaching staff from the University of Tartu.

6.2 Satellite communication ground station

The satellite communication ground station of Tartu Observatory has been used actively throughout the year in order to maintain reliable data communication with the satellite EstCube-1.

- Technical capability of the ground station enables fully automatic tracking of the satellite without presence of the operator. During the year, the tracking accuracy of the antenna system has been improved significantly.
- Implementation of the transmitting capability in 144 MHz frequency band improved reliability of the data processing and communication with the mission control server.
- A mobile ground station was developed.
- Successful experiments were performed to receive radio signals from the spacecrafts in deep space communicating in 2.2 GHz and 8.4 GHz

Figure 6.2: The mobile ground station developed at Tartu Observatory. Tartu Observatooriumis välja töötatud mobiilne maajaam

frequency bands. The most distant transmitted radio signal was detected from the ESA Rosetta spacecraft being at over 600 million kilometers from Earth at the time of reception.

6.3 Laboratories

- Systematic development and implementation of quality management is continued.
- Practical training was given to 17 students.
- Number of thesis defended on a basis of research carried out in the laboratories: 3 Master degrees, 3 Bachelor degrees.

6.3.1 Space technology and electronics

Figure 6.3: Development of innovative products at the laboratory for space technology. Innovaatiliste toodete arendamine kosmosetehnooogia laboris.

- Electrostatic Discharge (ESD) protected environment (EPA) is established in the electronics laboratory by following the guidelines of the standard series EVS-EN IEC 61340 (not certified).
- Design consultations and electronic performance tests of innovative product prototypes were performed for several Estonian enterprises and international partners.
- New electronic components inventory system is introduced with over 200 parts in it with the number increasing every day.

6.3.2 Electromagnetic compatibility (EMC)

- New test instruments including calibrated measurement antennas for frequency range between 30 MHz and 18 GHz and EMC analyzer covering frequency range between 10 Hz to 26.5 GHz were purchased.
- A special computer controlled turntable was developed for precise positioning of test objects in the anechoic chamber.
- In December the measurements for calibration of the testing facility were started. The calibration provides reliable basis for EMC testing within our own research and development projects as well for external customers.

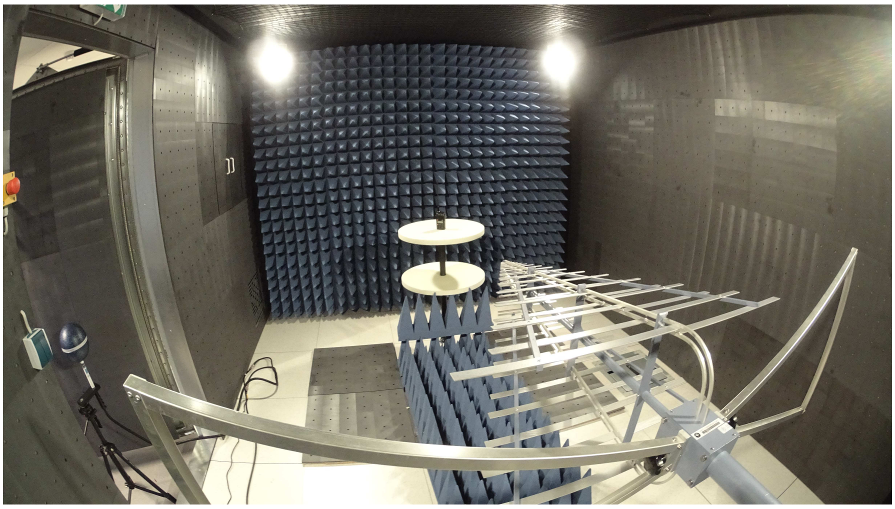


Figure 6.4: Anechoic chamber of the EMC test lab with installed measurement antenna and turntable Elektromagnetilise ühilduvuse katseteks kasutatav varjestatud ruum koos mõõteantenni ja pöördlauaga.

6.3.3 Environmental testing

- Cleanroom environment of Class 8 is established by following the guidelines of the standard EVS-EN ISO 14644-1 (not certified).
- Numerous of tests were performed for development and testing of space equipment (ESTCube and ESEO- the European Student Earth Orbiter projects).
- Vibration testing and thermal testing capabilities have been characterized and verified. Multiple payloads (satellite parts) have been successfully tested.
- Tests performed for 4 product prototypes from 3 different customers.
- Work has begun on development of shock testing facility.
- Automation and logging of thermal-vacuum thermal part has been done, automation of vacuum control still pending.
- A method and setup for thermal ambient tests of space equipment has been developed. The thermal chamber at Tartu Observatory was characterized by installing miniature temperature sensors in the thermal chamber. A custom software for data acquisition using a data logger was developed. Different sources of uncertainty were investigated and uncertainty budget for the chamber was established for specific loads that are tested at different levels of satellite development. The method achieves expanded measurement uncertainty of $\pm 2°$C for the temperature measurement range $(-40... + 85)°$C at 95% confidence level, k=2.

The uncertainty achieved by the method complies with the requirements for testing space equipment in thermal ambient testing.

6.3.4 Optics

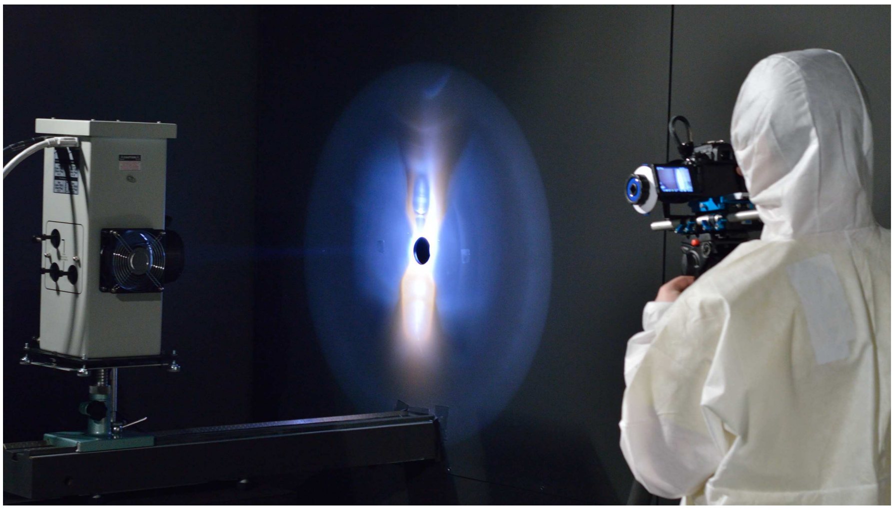


Figure 6.5: The optics lab is established in a cleanroom environment. Optikalabor asub puhasruumi tingimustes.

- Series of radiometric sources were calibrated for the absolute spectral irradiance to be used in the atmospheric research at TO.
- Several radiometers were calibrated for Estonian and international partners.
- Stray-light characteristics of the hyperspectral remote sensing radiometers were studied in the scope of development of the stray light removal algorithm.
- Optical characterization of innovative product prototypes were performed for several Estonian enterprises and international partners.
- Spectroradiometers from JRC (European Commission's Joint Research Centre) were characterized for stray light properties in the framework of MetEOC2 - Metrology for Earth observation and climate.

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7.1 Books Raamatud

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7.3 Papers in other journals and books Artiklid muudes ajakirjades ja kogumikes

7.3.1 Astronomy Astronoomia

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7.3.2 Remote sensing of environment Keskkonna kaugseire

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7.3.3 Space technology Kosmosetehnoloogia

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7.4 Popular Articles Aimeartiklid

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Annuk K.: Tõravere teleskoopide peeglid said säravamaks. *Tähetorni Kalender 2015*, 78–81, 2014.

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Kulu E.: Avastati uus klass ülikiirelt liikuvaid tähti. *Vaatleja*, 27.01.2014.

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Puss A.: Tähistaevas jaanuaris 2014. *Vaatleja*, 08.01.2014.

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Reinart A.: Tiit Nilson 75. In: *Kaugseire Eestis 2014*, eds. A. Aan, K. Narusk. Keskkonnaagentuur, Tallinn, 08–11, 2014.

Sepp T.: Ürgsed võbinad ja musklis teleskoop. *Horisont 4*, 28–32, 2014.

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Tempel E.: Laniakea, meie suurim kodu. *Vaatleja*, 03.09.2014.

Tempel E.: Raamat, milleta ma oma eriala ette ei kujuta. *Horisont* 1, 60, 2014.

Tempel E.: Tumeaine ja kosmilise võrgustiku lugu. *Akadeemia* 7, 1302–1305, 2014.

Verro K.: Veebruarikuu tähistaevas 2014. *Vaatleja*, 03.02.2014.

Veismann U., Valder V.: Lendav eesti vaip ehk Mistra kosmoses. *Eesti Ekspress nr 2,* 9.01.2014, 28–29.

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Voolma K., *Nilson T.*, Pilt E.: Okkalainelane Euroopas, Saaremaal ja satelliidipildil. *Eesti Mets, 46*, 38–43, 2014.

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7.5 Other papers Muud artiklid

Viik T., Ojaste, I.: The Activities of the Estonian Naturalists' Society in 2012, *Papers on Anthropology*, XXII, 325–329, 2013.

Aunap R., Oja T., *Peterson U.*: Maa mõõdistamine ja kaugseire. Üldmaateadus, Õpik kõrgkoolidele. Koostanud Ülo Mander ja Ülle Liiber, Eesti Loodusfoto, Tartu 2014, 16–67, 2014.

7.6 Preprints Preprindid

Einasto J.: Yakov Zeldovich and the Cosmic Web Paradigm. In: *Proceedings IAU Symposium No. 308, "The Zeldovich Universe: Genesis and Growth of the Cosmic Web"*, 2014, [ArXiv: 1410.6932].

Guo Q., *Tempel E.*, Libeskind N. I.: Galaxies in Filaments Have More Satellites: the Influence of the Cosmic Web on the Satellite Luminosity Function in the SDSS. [arXiv: 1403.5563].

Hütsi G., Gilfanov M., Kolodzig A., Sunyaev R.: Probing Large-Scale Structure with Large Samples of X-ray Selected AGN. I. Baryonic Acoustic Oscillations. [arXiv:1403.5555].

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Karak B.B., Käpylä P.J., Käpylä M.J., Brandenburg A., Olspert N., *Pelt J.*: Magnetically Controlled Stellar Differential Rotation Near the Transition from Solar to Anti-Solar Profiles. [http://arxiv.org/abs/1407.0984].

Kanemaru T., Hikage C., *Hütsi G.*, Terukina A., and Yamamoto K.: What Can we Learn from Higher Multipole Power Spectra of Galaxy Distribution in Redshift Space? [arXiv:1501.0437].

8 Participation in conferences and workshops
Osavõtt konverentsidest ja seminaridest

8.1 Astronomy Astronoomia

Tracing the Cosmic Web (Leiden, The Netherlands, 17.02.–21.02.2014) – E. Tempel, E. Saar, L.J. Liivamägi, O. Tihhonova.
Tempel E.: Detecting Filamentary Patterns in the Cosmic Web: Applications (oral presentation).

ASTRONET Board Meeting (The Hague, The Netherlands, 10.03.–11.03.2014) – L. Leedjärv.

Astroplate 2014: International Workshop on Scientific Use, Digitization and Preserving Astronomical Photographic Records (Prague, Czech Republic, 18.03–21.03.2014) – T. Tuvikene.
Tuvikene T.: Building up APPLAUSE: Workflow for Plate Digitization, Data Extraction and Publication (oral presentation).

Seminar in the Princeton University (Princeton, USA, 24.03.2014) – J. Einasto.
Einasto J.: Formation of the Cosmic Web (oral presentation).

New York Estonian House (New York, USA, 29.03.2014) – J. Einasto.
Einasto J.: The Structure of the Universe (oral presentation).

IAU Symposium 306: Statistical Challenges in 21st Century Cosmology (Lisbon, Portugal, 25.05.–29.05.2014) – E. Tempel, E. Saar, L.J. Liivamägi.
Tempel E.: Detecting Multi-Scale Filaments in Galaxy Distribution (poster).

American Astronomical Society Meeting #224 (Boston, USA, 05.06.2014).
Martin J. C., Betzler A., Barrett D., Cason A., *Eenmäe T.*, Kneip R., Martignoni M.: Multi-Wavelength Light Curve of SN 2014G. #421.06 (poster).

ASTRONET Joint Call Workshop (Hamburg, Germany, 11.06.–12.06.2014) – L. Leedjärv.

Conference Zeldovich 100 (Space Center Institute, Moscow, Russia, 16.06.2014) – J. Einasto.
Einasto J.: Yakov Zeldovich and the Formation of the Cosmic Web Paradigm (oral presentation).

IAU Symposium No. 308, "The Zeldovich Universe: Genesis and Growth of the Cosmic Web" (Tallinn, Estonia, 23.06.–28.06.2014) – A. Aret, J. Einasto, M. Einasto, M. Gramann, U. Haud, G. Hütsi, R. Kipper, T. Kuutma, L.J. Liivamägi, T. Lillemaa, E. Saar, T. Sepp, E. Tago, A. Tamm, E. Tempel, P. Tenjes, J. Vennik.
Einasto J.: Yakov Zeldovich and the Cosmic Web Paradigm (oral presentation).
Einasto M.: Tracing the High Redshift Cosmic Web With Quasar Systems (oral presentation).

Tempel E.: Detecting Filamentary Pattern in the Cosmic Web: Galaxy Filaments as Pearl Necklaces (oral presentation).
Saar E.: Adaptive Density Estimator for Galaxy Surveys (oral presentation).
Tamm A.: The Different Lives of Galaxies at Different Environmental Density Levels (oral presentation).
Tenjes P.: The Zeldovich Universe. Genesis and Growth of the Cosmic Web (oral presentation).
Kipper R.: The Properties of Gaseous Disks at Intermediate Redshifts from Kinematic Data Modeling (oral presentation).
Kipper R.: The Effect of Luminosity Density of Large Scale Structure to Fundamental Plane (poster).
Kuutma T.: Structural Decomposition of Galaxies in the CALIFA survey (poster).
Lietzen H., Einasto M.: It Takes a Supercluster to Rise a Galaxy (oral presentation).
Nevalainen J., Liivamägi L.J., Tempel E., Branchini E., Roncarelli M., Giocoli C., Heinämäki P., *Saar E.*, Bonamente M., *Einasto M.*: Finding and Characterising WHIM Structures Using the Luminosity Density Method. (poster).
Vennik J.: Properties of Satellite Galaxies in Nearby Groups (poster).

European Week for Astronomy and Space Science 2014 (Geneva, Switzerland, 30.06.–03.07.2014) – L. Leedjärv.

CSC Summer School in High-Performance Computing (Espoo, Finland, 30.06.–09.07.2014) – R. Kipper, T. Kuutma.

nIFTy Cosmology: Numerical Simulations for Large Surveys (Madrid, Spain, 13.07.–19.07.2014) – E. Tempel, T. Sepp.
Tempel E.: FoF Group Finding and Mass Estimation (oral presentation).

3^{rd} *Scientific Writing for Young Astronomers* (Tihany, Hungary, 24.08.–28.08.2014) – T. Kuutma, J. Laur.

11th Potsdam Thinkshop: Satellite Galaxies and Dwarfs in the Local Group (Potsdam, Germany, 25.08.–29.08.2014) – J. Vennik.
Vennik J.: Properties of Satellite Galaxies in Nearby Groups (poster + oral summary).

Living Together: Planets, Host Stars and Binaries (Litomyšl, Czech Republic, 08.09.–12.09.2014) – L. Leedjärv.
Gális R., Hric L., *Leedjärv L.*, Kundra E.: Outburst Activity of the Symbiotic System AG Dra (poster).

ASTRONET Forum on Astronomy in Latvia (Riga, Latvia, 17.09.2014) – L. Leedjärv.

ASTRONET Forum on Astronomy in Lithuania (Vilnius, Lithuania, 18.09.2014) – L. Leedjärv.

Ioffe Workshop on GRBs and Other Transient Sources (St. Petersburg, Russia, 22.09.–26.09.2014) – I. Vurm.

Vurm I.: Radiative transfer in GRB jets (invited talk).

The Annual Meeting 2014 of the Astronomische Gesellschaft (Bamberg, Germany, 22.09.–26.09.2014) – T. Tuvikene.

Tuvikene T.: Making Archival Photographic Observations Accessible: the APPLAUSE Database and PyPlate Software (oral presentation).

Tuorla-Tartu Annual Meeting 2014: Small and Large scale Universe (Tuorla, Finland, 01.10.–03.10.2014) – E. Saar, T. Sepp, E. Tempel, I. Vurm.

Tempel E.: Filamentary Pattern in the Cosmic Web (oral presentation).

Saar E.: Super-large Structures in the Universe (oral presentation).

Sepp T.: Is it Better to be More Right or Less Wrong (oral presentation).

Vurm I.: Radiative mechanisms in gamma-ray bursts (talk).

Gruber Prize Ceremony (Yale University, USA, 01.10.2014) – J. Einasto.

Einasto J.: Near Field Cosmology – My Way (oral presentation).

Seminar in the Yale University Astronomy Department (Yale University, USA, 02.10.2014) – J. Einasto.

Einasto J.: Evolution of the Cosmic Web (oral presentation).

Seminar at Leibniz-Institut für Astrophysik Potsdam (Potsdam, Germany, 16.10.2014) – E. Tempel, E. Saar.

The Star of Bethlehem: Historical and Astronomical Perspectives. A Multi-Disciplinary Discussion (Groningen, The Netherlands, 22.10.–24.10.2014) – L. Leedjärv.

6-th KIAS Workshop on Cosmology and Structure Formation (Seoul, Korea, 04.11.2014) – J. Einasto, M. Einasto, E. Saar.

Einasto J.: The Cosmic Web Paradigm – Status and Problems (oral presentation).

Einasto M.: Quasar Systems in a High-Rredshift Universe (oral presentation).

Saar E.: Adaptive Luminosity Density Estimator (invited talk).

Seminar in the Korea Institute of Advanced Science (Seoul, Korea, 10.11.2014) – J. Einasto.

Einasto J.: Cosmology in Tartu Observatory (oral presentation).

Einasto M.: (Active) Galaxies in the Cosmic Web (oral presentation).

Saar E.: Bootstrapping Correlation Functions (invited talk).

Seminar at Valencia University (Valencia, Spain, 26.11.2014) – E. Tempel, E. Saar.

Tempel E.: Laniakea and Galactic Filaments (oral presentation).

Tempel E.: Galaxy Filaments as Pearl Necklaces (oral presentation).

8.2 Remote sensing of environment Keskkonna kaugseire

Baltic Earth Workshop on Natural Hazards and Extreme Events in the Baltic Sea Region (Helsinki, Finland, 30.01.—31.01.2014) – O. Kärner.

Post P., *Kärner O.*: Climate Tolerance – a Sensible Way to Define Weather Extremes (poster).

Group of Earth Observations Conference (Geneva, Switzerland, 12.01.–17.01.2014) – A. Reinart.

Global Vegetation Monitoring and Modeling International Conference (Avignon, France, 03.02.–07.02.2014) – M. Lang, J. Pisek.

Pisek J., He L., Chen J.M., Govind A., Sprintsin M., Ryu Y., Arndt S., Hocking D., Wardlaw T., *Kuusk J.*, Oliphant A.J., Korhonen L., Fang H.: Characterization, Validation and Intercomparison of Clumping Index Maps from POLDER, MODIS, and MISR Data (poster).

Pisek J., Sonnentag O., *Raabe K.*, Richardson A., Mõttus M., Zou X., *Annuk K.*: Is the Spherical Leaf Inclination Angle Distribution Really the Best Assumption (when you have no data)? (poster).

GLaSS Workgroup Review Meeting (Amsterdam, The Netherlands, 16.03.–17.03.2014) – A. Reinart.

Introducing Remote Sensing seminar (GLaSS) (Bremen, Germany, 17.03.–19.03.2014) – A. Reinart.

Copernicus User Awareness & Training Event (Tallinn, Estonia, 09.04.–10.04.2014) – U. Peterson, A. Reinart.

Peterson U.: Examples of Forest Remote Sensing in Estonia (oral presentation).

COST Action ES1309 Innovative optical Tools for Proximal Sensing of Ecophysiological Processes (OPTIMISE) 1st Management Committee Meeting (Brussels, Belgium, 25.04.2014) – L. Hallik, J. Kuusk.

European Geosciences Union General Assembly 2014 (Vienna, Austria, 27.04.–02.05.2014) – M. Nikopensius, K. Raabe, J. Pisek.

Nikopensius M., *Raabe K., Pisek J.*: Spectral Reflectance Patterns and Temporal Dynamics of Common Understory Types in Hemi-Boreal Forests in Järvselja, Estonia (poster).

Raabe K, Pisek J., Sonnentag O., *Annuk K.*: Seasonal and Vertical Changes in Leaf Angle Distribution for Selected Deciduous Broadleaf Tree Species Common to Europe (poster).

Kosmosetehnoloogiate ja uudsete satelliidirakenduste tutvustamine ning koolitus "Veidi lähemalt kaugseirest" (Tõravere, 02.05.2014) – U. Peterson.

Peterson U.: Põllumajanduslike parameetrite kaugseire seire Eesti keskkonnaseire programmis Remote Sensing of Agricultural Parameters in the National Environmental Programme (oral presentation).

Soome-Eesti kaugseire seminar (Tõravere, 07.05.–08.05.2014) – E. Asuküll, M. Lang, A. Reinart, U. Peterson, K. Voormansik, K. Zālite.

Lang M.: HemiSPherical Project Manager – new software to calculate canopy transmittance from hemispherical images (oral presentation).

Asuküll E.: CDOM estimation from MERIS images (oral presentation).

Voormansik K.: Grassland polarimetric signatures with C- and X-band SAR (oral presentation).

Zālite K.: Monitoring of Estonian Grasslands with Repeat-Pass Interferometry (oral presentation).

Nordic Ozone Group (NOG) Meeting 2014 (Norrköping, Sweden, 08.05.–09.05.2014) – K. Eerme.

Eerme K.: On the UV Research Activities in Estonia (oral presentation).

Eerme K., Veismann U., Aun M., Vastsenko A., Virronen K., Aruoja I.: Modification of UV Spectral Doses by Clouds and Aerosols (oral presentation).

WMO/UNEP 9th Ozone Research Managers Meeting (Geneva, Switzerland, 14.05.–16.05.2014) – K. Eerme.

Sentinel-2 for Science Workshop, ESA-ESRIN (Frascati (Rome), Italy, 20.05.–22.05.2014) – U. Peterson.

Peterson U., Liira J., Kardakov A., Budenkova J.: Forest Area Changes and Impact of Forest Boundary Delineation on Change Detection in Forested Landscapes in Northeastern Europe (poster).

Nanosat Project Roundtable and 4S Conference (Mallorca, Spain, 23.05.–01.06.2014) – A. Reinart.

NordBaltRemS PhD Training Course on Sea-Truthing of Satellite Imagery and Bio-Optical Modelling in Askö Laboratory (Askö, Sweden, 25.05.–31.05.2014) – E. Asuküll.

Asuküll E.: CDOM Estimation from MERIS Images (oral presentation).

6th IEEE/OES Baltic Symposium (Tallinn, Estonia, 26.05.–29.05.2014) – M. Ligi.

Ligi M.: Prototype and First Field Measurements for Multi-Spectral Volume Scattering Meter (MVSM) (poster).

Trans-Atlantic Training – Krakow 2014: Land Use/Land Cover Change and Ecosystem Processes (Krakow, Poland, 05.06.–07.06.2014) – M. Mõistus.

Mõistus M., Lang M., A. Sims: Estimation of Fractional Forest Cover from Airborne Laser Scanning Data in Abandoned Agricultural Land (poster presentation).

COST ESSEM COST Action ES1001: SMOS Mission Workshop (Ponte, Italy, 10.06.–15.06.2014) – A. Reinart.

The 12th International Conference on New Developments and Applications in Optical Radiometry (NEWRAD 2014) (Espoo, Finland, 24.06.–27.06.2014) – R. Vendt, J. Kuusk.

Ansko I., Vendt R., Kuusk J., Reinart A., Lepist M.: Calibration and Characterization of Remote Sensing Equipment (poster).

14th Conference on Cloud Physics / 14th Conference on Atmospheric Radiation / Anthony Slingo Symposium (Boston, USA, 07.07.–11.07.2014) – H. Ohvril.
Ohvril H., Neiman L., Kattai K., Kannel M., Okulov O., Kallis A., *Russak V.*, Terez E., Terez G., Gushchin G., Abakumova G., Gorbarenko E.: Global Dimming and Brightening Versus Atmospheric Column Transparency in Europe, 1906–2013 (poster).

9th International Conference on Climate Change (Las Vegas, Nevada, USA, 07.07.–09.07.2014) – O. Kärner.
Kärner O.: Decline of the Theory on Anthropogenic Global Warming (panel talk).

Copernicus User Forum (Brussels, Belgium, 09.07.–11.07.2014) – A. Reinart.

International Aerosol Conference (Busan, Korea, 28.08.–02.09.2014) – H. Ohvril.
Ohvril H., Neiman L., Kattai K., Okulov O., Kallis A., *Russak V.*, Terez E., Terez G., Gushchin G., Abakumova G., Gorbarenko E.: Multiannual Time Series of Column Transparency and Aerosol Content, 1906–2013 (oral presentation).

15th World Lake Conference (Perugia, Italy, 31.08.–05.09.2014) – A. Reinart.
Alikas K., Kangro K., Randoja R., Philipson P., *Asuküll E., Reinart A.*: Robust Remote Sensing Algorithms to Derive Ecological Status for Lakes (oral presentation).

Workshop of the Baseline Surface Radiation Network (BSRN) (Bologna, Italy, 08.09.–12.09.2014) – A. Kallis.
Kallis A., *Russak V.*, Ohvril H., Jõeveer A., Nurmela K., Niklus I.: Status of Tartu–Tõravere BSRN Station, Estonia (poster).

Tallinna Ülikooli arenduskonverents (Tallinn, 11.09.2014) – U. Veismann.

IAF Annual Meeting and International Astronautical Congress (Cosmotech) (Toronto, Canada, 27.09.–04.10.2014) – A. Reinart.

Eesti oskuskeele päev (Tallinn, 08.10.2014) – U. Veismann.

COST Action ES1309 Innovative Optical Tools for Proximal Sensing of Ecophysiological Processes (OPTIMISE) 1st Workshop and 2nd Management Committee Meeting (Milan, Italy, 08.10.–10.10.2014) – L. Hallik, J. Kuusk.

8th Shallow Lakes Conference (Antalya, Turkey, 11.10.–17.10.2014) – K. Kangro, U. Peterson.
Kangro K., Alikas K., Reinart A.: Mapping Cyanobacterial Development in Shallow Lake Peipsi (Estonia / Russia) by Maximum Chlorophyll Index (MCI) (poster).
Erdoğan S., Filiz N., Beklioglu M., *Kangro K.*, Feldmann T., Hejzlar J., Sorf M., Papastergiadou E., Stefanidis K., Scharfenberger U., Mahdy A., Angeler D.G., Baho D.L., Sondergaard M., Jeppesen E.: Effects of Climate, Eutrophication and Water Level Changes on Phytoplankton Community Structure and Diversity: Pan-European Mesocosm Experiments (poster).

Peterson U., Liira J., Kuresoo L.: Changes of Macrophyte Area in Shallow Lake Salong a Latitudinal Gradient in Eastern Europe Within 30 years (oral presentation).

Horizon2020 Space Advisory Report Presentation (Brussels, Belgium, 13.10.–14.10.2014) – A. Reinart.

International Conference "Aerosol and Atmospheric Optics", Dedicated to the 100th Anniversary of Prof. G.V. Rosenberg (1914–1982), (Moscow, Russia, 21.10.–24.10.2014) – H. Ohvril.

Ohvril H.A., Neiman L.O., Kattai K.M., Okulov O.V., Kallis A.G., *Russak V.K.*, Terez E.I., Terez G.A., Gushchin G.K., Abakumova G.M., Gorbarenko E.V.: O Periodizatsii Prozrachnosti Tolshchi Atmosfery, 1906–2013 (oral presentation).

Ocean Optics XXII (Portland ME, USA, 25.10.–31.10.2014) – E. Kangro, M. Ligi.

Kangro E., Kangro K., Alikas K.: The Relationship Between the Phytoplankton Absorption Coefficient and Chlorophyll-a Concentration for Remote Sensing Application of Estonian Large Lakes (poster).

Ligi M., Kutser T., Paavel B., *Reinart A.*, Kauer T., Vahtmäe E.: Spatial Variations of Baltic Sea IOPs (poster).

Eesti kaugseirepäevad (Tõravere, 21.10.–22.10.2014) – K. Alikas, E. Asuküll, A. Reinart, K. Kangro, E. Kangro, A. Kuusk, J. Kuusk, H. Kuuste, M. Lang, T. Nilson, U. Peterson, K. Zālite, K. Voormansik.

Kuusk A.: Kaugseire radiomeetria (oral presentation).

Kuusk J.: Optikalabori võimekus kaugseire rakendusteks (oral presentation).

Kuuste H.: Nanosatelliitide võimalused Maa seireks – EstCube pardakaamera uued arendused (oral presentation).

Voormansik K., Praks J., *Zālite K.*, Olesk A.: Polarimeetrilised radariandmed keskkonnaseireks (oral presentation).

Alikas K., Kangro K., Randoja R., Asuküll E., Reinart A.: Satelliidi-info kasutamise võimalused veekogude seisundi määramiseks Eesti suurtes järvedes (oral presentation).

Lang M., Arumäe T.: Kaugseire kasutamisest praktilistes metsanduslikes rakendustes Eestis (oral presentation).

Peterson U., Liira J.: Maismaa kaugseire Eesti keskkonnaseire programmis (oral presentation).

GLEON 16 (Jouvence (Canada, 26.10.–01.11.2014) – K. Kangro.

Kangro K., Vilbaste S., Laas A.: Phytoplankton Dynamics in Combination With High Frequency Temperature and Oxygen Data (poster).

Finnish Remote Sensing Days 2014 (Helsinki, Finland, 27.10.–28.10.2014) – E. Asuküll, J. Pisek, K. Raabe.

Pisek J., Lang M., Kuusk J.: What is the Most Suitable Viewing Configuration for Retrieval of Forest Understory Reflectance from Multi-Angle Remote Sensing Data? (oral presentation).

Asuküll E.: What Can Fine Resolution Satellites Provide for Small Colored Lakes? (oral presentation).

ForestSAT2014 Conference (Riva del Garda (TN), Italy, 04.11.–07.11.2014) – M. Lang, U. Peterson, T. Arumäe.

Budenkova J., Kardakov A., Liira J, *Peterson U.*: Cross-Border Comparison of Forest Cover Changes in Northeastern Europe Caused by Clear-Cutting and Afforestation of Former Agricultural Land (poster).

Estonian-Finnish Satellite Ground Station Negotiation (Helsinki, Finland, 17.11.–19.11.2014) – A. Reinart.

Konverents Metsakorraldus 95 (Tallinn, 03.12.2014) – M. Lang.

Arumäe T., *Lang M.*: Metsa takseertunnuste hindamine kaugseire abil (oral presentation).

2nd Joint ESA-EUMETSAT Sentinel-3 Validation Team (S3VT) Meeting (Darmstadt, Germany, 03.12.–04.12.2014) – I. Ansko, A. Reinart.

Ansko I., Kuusk J.: Examples of the Optical Calibrations and Characterizations at Tartu Observatory (oral presentation).

Vendt R.: Optical measurement capabilities at Tartu Observatory (oral presentation).

III Eesti teaduskeele konverents (Tallinn, 05.12.–06.12.2014) – U. Veismann.

Estonian Space Research and Technology for European Community (Brussels, Belgium, 08.12.–09.12.2014) – A. Reinart.

8.3 Space Technology Kosmosetehnoloogia

University of Latvia Annual Conference (Riga, Latvia, 05.02.2014) – A. Slavinskis.

NANOSAT FP7 Review Meeting (Brussels, Belgium, 26.02.–28.02.2014) – U. Kvell, E. Kulu.

ESTCube-1 International Workshop (Tartu, Estonia, 14.03.2014) – ESTCube team.

NANOSAT Seminar (Bremen, Belgium, 18.03.–19.03.2014) – M. Noorma.

Estonian Physics Days (Tartu, Estonia, 21.03.2014) – M. Noorma, A. Slavinskis. *Noorma M., Slavinskis A.*: ESTCube-1 progress report (oral presentation).

DevClub.lv meeting (Riga, Latvia, 17.04.2014) – I. Sünter.

Sünter I.: ESTCube-1 Firmware Upgrades and Testing (oral presentation).

Meris Validation Team (MVT) Meeting (Sopot, Poland, 07.05.–09.05.2014) – R. Vendt, I. Ansko.

Vendt R.: Qualification of the Optical Laboratory (oral presentation).

Ansko I.: RAMSES Stray-Light Correction (oral presentation).

Small Satellites and Services Symposium (Mallorca, Spain, 26.05.–28.05.2014) – A. Slavinskis, H. Kuuste.

Slavinskis A.: ESTCube-1 Camera Design and Characterization (oral presentation).

Slavinskis A.: ESTCube-1 Attitude Determination: In-flight Experience (poster).

Slavinskis A., Ehrpais H., Kuuste H., Sünter I., Kulu E., Viru J., Kütt J., Valner R., Tammeoja K., Drozdov P., *Noorma M.*: ESTCube-1 Attitude Determination: In-flight Experience (poster presentation).

International Conference and Exhibition on Space Technologies, Exhibition stand (Riga, Latvia, 05.06.–06.06.2014) – A. Slavinskis.

Symposium "ESA and European Space Activities: Actors and Context" (Tallinn, Estonia, 11.06.2014) – A. Slavinskis, K. Zā lite, U. Kvell, E. Kulu, I. Sünter.

The 12th International Conference on New Developments and Applications in Optical Radiometry (NEWRAD 2014) (Espoo, Finland, 24.06.–27.06.2014) – R. Vendt, J. Kuusk.

Ansko I., Vendt R., Kuusk J., Reinart A., Lepist, M.: Calibration and Characterization of Remote Sensing Equipment (poster presentation).

Seminar at ESTEC (Noordwijk, The Netherlands, 15.07.2014) – A. Slavinskis, M. Noorma.

Slavinskis A., Noorma M.: ESTCube-1 Status Update, Report (oral presentation).

ESTCube-1 International Workshop (Tartu, Estonia, 09.07.–11.07.2014) – ESTCube team.

The 41st Annual European Meeting on Atmospheric Studies by Optical Methods (Stockholm, Sweden, 18.08.–21.08.2014) – K. Laizans.

Laizans K.: Calibration and Characterization of Optical Instrumentation in Tartu Observatory (oral presentation).

ESTCube-1 International Workshop (Tartu, Estonia, 20.08.2014) – ESTCube team.

ESEO Workshop 2014 (Bertinoro/Forli, Italy, 01.09.–19.09.2014) – I. Sünter.

Tartu Conference on Space Science and Technology (Tartu, Estonia, 22.09.2014) – A. Slavinskis, M. Noorma.

Slavinskis A.: ESTCube-1 Attitude Determination and Camera Flight Results (oral presentation).

Noorma M.: Status Update on ESTCube-1 Mission Results (oral presentation).

Ehrpais H.: ESTCube-1 Attitude Control (Oral presentation).
Liias P.: New CubeSat Structure and Mechanics Product Family (oral presentation).

65th International Astronautical Congress (Toronto, Canada, 03.10.2014) – M. Pajusalu, M. Noorma, S. Lätt.
Pajusalu M.: Electrical Power System for ESTCube-1 Nanosattelite: Lessons Learned from in-Orbit Operations (oral presentation).

Space Economy in the Multipolar World (Vilnius, Lithuania, 22.10.2014) – M. Pajusalu.
Pajusalu M.: Analysis of the Electrical Power System for ESTCube-1 (invited talk).

European CubeSat Symposium (Estavayer-le-Lac, Switzerland, 15.10.2014) – P. Liias, E. Kulu, M. Eerme, P. Orusalu, M. Noorma.
Noorma M.: Lessons Learned from Developing and Producing Structure and Mechanical Systems for ESTCube-1 (oral presentation).

Seminar at Royal Institute of Technology (Stockholm, Sweden, 06.11.2014) – A. Slavinskis.
Slavinskis A.: ESTCube-1 In-orbit Experience and Lessons Learned (invited talk).

Seminar at Finnish Meteorological Institute (Helsinki, Finland, 28.11.2014) – A. Slavinskis.
Slavinskis A.: ESTCube-1 In-orbit Experience and Lessons Learned (oral presentation).
Slavinskis A.: ESTCube-1 Nanosatellite: Electric Solar Wind Sail Demonstration (oral presentation).

8.4 Miscellaneous Muud koosolekud ja ettevõtmised

Astronoomia lahtise võistluse žürii liikmed (Tartu, 14.04.2013) – T. Eenmäe, R. Kipper, T. Sepp.

Rahvusvahelise astronoomiaolümpiaadi treeninglaagrid (Tõravere, 19.05.–25.05; 16.09.–19.09.2014) – T. Eenmäe, R. Kipper, J. Laur, T. Liimets, T. Sepp, T. Tuvikene.

Nõupidamine "Eesti rahvusvahelistes teadusorganisatsioonides" (Eesti Teaduste Akadeemia, Tallinn, 19.05.2014) – L. Leedjärv.
Leedjärv L.: Eesti Rahvuslik Astronoomia Komitee (suuline ettekanne).

Astronoomiahuviliste XIX kokkutuleku korraldamine (Toila, 08.08.–12.08.2014) – T. Eenmäe, T. Liimets, K. Verro.

Teadlaste ÖÖ (Tõravere, 26.09.2014) – K. Annuk, V. Allik, T. Eenmäe, J. Laur, J. Leedjärv, T. Liimets, H. Lätt, M. Ruusalepp, T. Sumberg, E. Tempel, T. Tuvikene, K. Verro, J. Vennik, K. Voormansik.
Voormansik K.: Linnastumise jälgimine kosmosest ja seosed inimeste tervisega (oral presentation).

The XIX International Astronomy Olympiad (Bishkek, Kyrgyzstan, 11.10.–22.10.2014) – T. Eenmäe, T. Sepp (jury member).

Kohtumine Kiruna kommuuni valitsusega, eesmärgiks lülitada Rootsi Struve kaare turismivõrgustikku (Kiruna, Rootsi, 22.10.–24.10.2014) – T. Viik.

Viik T.: The Significance of the Struve Arc (oral presentation).

9 Scientific seminars at the Observatory Observatooriumis toimunud teaduslikud seminarid

9.1 Astronomy Astronoomia

22.01.2014 – Elmo Tempel: Tööriistakast: Bisous mudel.

29.01.2014 – Maret Einasto: Superparvede morfoloogia ja galaktiline koostis. Vol. 2. SDSS superclusters: morphology and galaxy content. Vol. 2.

12.02.2014 – Tiit Sepp: Parvestades Universumit. Clustering the Universe.

22.02.2014 – Jaan Einasto: Formation of the Cosmic Web.

19.03.2014 – Anti Hirv: Mõned seosed SDSS-DR8 galaktikate orientatsioonide ja Universumi suuremastaabilise struktuuri vahel. Some relations between galaxy orientations and large scale structure of Universe in SDSS-DR8.

26.03.2014 – Tiit Sepp: Kuidas teine Muskel inimesed inflatsiooni üle rõõmustama pani ning näitas aegruumi värelusi. How the second Bicep caused people to be happy about inflation and showed us space vibes.

09.04.2014 – Jaan Pelt: Minu töökast lahti... Let us open my toolbox...

16.04.2014 – Laurits Leedjärv: Täheassotsiatsioonide heledaimate tähtede muutlikkuse vaatlused. Variability survey of the most luminous stars in stellar associations.

23.04.2014 – Timothée Delubac (Laboratoire d'Astrophysique, Lausanne, Switzerland): Baryon acoustic oscillations in the Lyman-alpha forest of BOSS DR11 quasars.

30.04.2014 – Juhan Liivamägi: Tihedusvälja projektsioonide analüüsist (ja WHIM'ist). Analysis of density field projections (and WHIM).

14.05.2014 – Tõnu Viik: Joseph Nicolas Delisle'i elu lugu.

21.05.2014 – Magistri- ja bakalaureusetööde proovikaitsmised.

28.05.2014 – Maret Einasto: Kvasarisüsteemid ja kosmiline võrgustik. Tracing high redshift cosmic web with quasar systems.

04.06.2014 – Mirt Gramann: Galaktikaparvede ja gruppide omadused ning keskkond. Clusters and groups for the SDSS galaxies.

11.06.2014 – Michaela Kraus (Ondřejov Observatory, Czech Republic): Pulsations as a mass-loss trigger in B-type supergiants.

18.06.2014 – Dieter Nickeler (Ondřejov Observatory, Czech Republic): MHD flows at astropauses and in astrotails.

03.09.2014 – Matteo Barnabe (Dark Cosmology Centre, Niels Bohr Institute, University of Copenhagen, Denmark): The dark and luminous mass structure of lens galaxies.

10.09.2014 – Elmo Tempel: Bisous model – applications.

17.09.2014 – Lluís Hurtado-Gil: (Observatori Astronómic, Universitat de Valéncia (IFCA-OAUV) Valéncia, Spain): The ALHAMBRA Survey: Evolution of Galaxy Clustering with Segregation.
08.10.2014 – Tiit Sepp: Kas on parem olla rohkem õige või vähem vale.
22.10.2014 – Kristjan Kannike (KBFI): Classical Scale Invariance and Inflation. Klassikaline skaalainvariantsus ja inflatsioon.
29.10.2014 – Taavi Tuvikene: From digitized photographic plates to time-domain astronomy. Digitaliseeritud fotoplaatidest ajatelje astronoomiani.
19.11.2014 – Antti Tamm: Galaktikad hoolivad keskkonnast.
10.12.2014 – Kristiina Verro: Peajada eelsete tähtede otsingutest Wolf-Rayet tähtede ümber.
17.12.2014 – Laurits Leedjärv: Petlemma tähe valgus 2000 aastat hiljem.

9.2 Remote sensing of environment Keskkonna kaugseire

09.01.2014 – Sebastian Traud: Greenhouse gases measurements and model results.
27.01.2014 – Lea Hallik: Leaf traits along vertical (within canopy) gradient of light availability.
03.02.2014 – Kersti Kangro: EU Water Framework Directive and remote sensing of Estonian large lakes.
10.02.2014 – Aarne Männik: Numerical models of atmosphere in the Laboratory of Atmospheric Physics, University of Tartu.
17.02.2014 – Kaupo Voormansik: X-band Synthetic Aperture Radar Applications for Environmental Monitoring / X-laineala tehisava-radari rakendused keskkonnakaugseireks.
03.03.2014 – Margit Aun: Reconstruction of UVA and UVB radiation at Tõravere, Estonia, for years 1955-2003 / Rekonstrueeritud UVB ja UVA kiirgus Tõraveres aastatel 1955-2003.
10.03.2014 – Tiit Nilson: Comments on a few papers concerning tree structure and its role in solar radiation field / Mõnest teadusartiklist seoses puu struktuuri ja selle rolliga taimkatte kiirgusvälja kujunemisel.
17.03.2014 – Kairi Raabe: Seasonal and vertical changes in leaf angle distribution for deciduous broadleaf tree species common to Estonia / Lehenurgajaotuste sesoonsed ja vertikaalsed muutused Eestis levinud lehtpuudel.
24.03.2014 – Joel Kuusk: Lühiülevaade Keskkonnaobservatooriumi spektromeetrist.
24.03.2014 – Steffen Noe: Järvselja SMEAR station.
31.03.2014 – Tauri Arumäe: Lennukilidari kasutamine metsa struktuuri kirjeldamisel / Using ALS data for estimating forest characteristics.

7.04.2014 – Martin Ligi: Capabilities of new algorithm to analyse satellite based spectral measurements over nutrient rich lakes / Uute algoritmide võimekus satelliidi-põhiste spektrimõõtmiste analüüsimiseks toitainerikaste järvede näitel.

14.04.2014 – Ave Kodar: Metsa fenoloogia: läbipaistvuse mõõtmisest taimkatteindeksi väärtuseni

21.04.2014 – Maris Nikopensius: Alustaimestiku spektraalne dünaamika ja ajaline muutlikkus poolboreaalsetes metsades Järvseljal, Eestis.

21.04.2014 – Viivi Russak: Pikalaineline kiirgus Eestis / The long-wave radiation in Estonia.

05.05.2014 – Imre Aruoja: Mõjuteguritega kaalutud UV-kiirguse muutlikkus Eestis / Variation of action spectra weighted UV radiation in Estonia.

12.05.2014 – Hannes Keernik: Lühiülevaade uurimisvisiidist Berliini Vaba Ülikooli Kosmoseteaduse Instituuti: atmosfääri niiskussisalduse määramine satelliitide abil.

12.05.2014 – Martin Valgur: Radarsat satelliidiprogramm.

12.05.2014 – Martin Jüssi: Sentinel-1 missioon planeerimine, teostus, tulevik.

19.05.2014 – Evelin Kangro: Fütoplanktoni neeldumiskoefitsendi ja klorofüll-a kontsentratsiooni vaheline seos kaugseire rakendusteks Eesti suurte järvede näitel.

26.05.2014 – Kätlin Aun: Läänemere jääkatte lagunemise uurimine MODIS satelliidipiltide põhjal.

26.05.2014 – Georgi Majas: Püsivate peegeldajate analüüs Ida-Virumaal.

26.05.2014 – Piia Post: EUMETSAT satelliitidest, instrumentidest ja SAF-idest.

02.06.2014 – Imre Aruoja, Evelin Kangro, Maris Nikopensius, Kairi Raabe: Magistritööde proovikaitsmised.

09.06.2014 – Andres Kuusk: WorldView-2 kaliibrimiseksperiment Järvseljal.

08.09.2014 – Anu Reinart: Arutelu kaugseire osakonna tegevustest.

15.09.2014 – Jan Pisek: How spatially representative are our Järvselja RAMI stands?

02.10.2014 – Mait Lang: Monteith hüpoteesil ja satelliitidelt tehtavatel kiirgusmõõtmistel põhinevate produktsioonihinnangute seosed metsade majandamisega.

09.10.2014 – Jan Pisek: Estimation of seasonal dynamics of understory NDVI in northern forests using MODIS BRDF data: semi-empirical versus physically-based approach.

16.10.2014 – Martin Ligi: Läänemere rannikuvete optilised omadused.

30.10.2014 – Kalju Eerme, Uno Veismann: Päikese ultraviolettkiirguse mõõtmine Benthami spektromeetriga.

06.11.2014 – Alisa Krasnova: Annual and diurnal dynamics of CO2 fluxes and factors controlling them (Järvselja flux tower).

13.11.2014 – Tiit Nilson: Okkalainelase kahjustuskolle Saaremaal Kihelkonnal Landsati piltidelt

20.11.2014 – Kalju Eerme: Ultraviolettkiirguse spektraalse koostise muutumine päeva ja aasta jooksul.

27.11.2014 – Ilmar Ansko: Valitud kalibreerimisi.

04.12.2014 – Erko Jakobson: Coupling between Arctic and northern Europe climate, according to NCEP-CFSR and ERA-INT reanalyses.

16.12.2014 – Sinai Mwagomba: A Method for Thermal Ambient Tests of Space Technology Equipment in a Thermal Chamber – Development and Validation (Master thesis).

18.12.2014 – Marta Mõistus: Lehepinnaindeksi kaardistamine aerolidari andmete ja poolsfääri fotode põhjal SMEAR-jaama ümbruses olevatel aladel.

10 Membership in scientific organizations
Teadusorganisatsioonide liikmed

Academia Europaea – J. Einasto
American Association of Variable Star Observers – T. Eenmäe
American Astronomical Society – J. Einasto
American Geophysical Union – K. Alikas (student member), E. Jakobson, J. Pisek, A. Reinart, K. Uudeberg (student member)
American Society of Photobiology – U. Veismann
ASTRONET Board – L. Leedjärv
Board of Directors "Astronomy and Astrophysics" – A. Tamm
Board of the Tartu Astronomy Club – E. Tago
British Interplanetary Society – U. Veismann
Copernicus User Forum Eesti esindaja – A. Reinart
Editorial Board "Agricultural and Forest Meteorology" – A. Kuusk
Editorial Board "Baltic Astronomy" – T. Kipper
Editorial Board "Baltic Forestry" – M. Lang
Eesti Astronoomia Selts – K. Annuk, T. Eenmäe, J. Einasto, M. Gramann, A. Hirv, T. Kipper, I. Kolka, L. Leedjärv, T. Liimets, T. Nugis, J. Pelt, A. Puss, M. Ruusalepp, E. Tago, E. Tempel, T. Tuvikene, U. Veismann, T. Viik
Eesti Füüsika Selts – A. Aret, K. Eerme, J. Einasto, T. Kipper, L. Leedjärv, S. Lätt (board member), A. Reinart, E. Saar, A. Sapar, P. Tenjes, T. Viik
Eesti Geofüüsika Komitee / Estonian Geophysical Committee – K. Eerme
Eesti Rahvuslik Astronoomia Komitee / Estonian National Committee on Astronomy – J. Einasto, L. Leedjärv (Chair), E. Saar, T. Viik
Eesti Kirjanduse Selts – U. Veismann
Eesti Looduseuurijate Selts – J. Einasto (auliige), K. Eerme, V. Russak, A. Sapar, U. Veismann, T. Viik (auliige)
Eesti Teaduste Akadeemia / Estonian Academy of Sciences – J. Einasto, E. Saar, A. Sapar
European Association of Remote Sensing Laboratories (EARSeL) – the department of atmospheric physics
European Astronomical Society – K. Annuk, J. Einasto, M. Gramann, G. Hütsi, T. Kipper, I. Kolka, L. Leedjärv, T. Nugis, E. Saar, A. Sapar, I. Suhhonenko, E. Tago, P. Tenjes, U. Veismann, J. Vennik, T. Viik
Euroscience – U. Veismann
Euro–Asian Astronomical Society – A. Aret (board member), J. Einasto, A. Sapar
Field Editor "Agronomie. Agriculture and Environment" – A. Kuusk
The Gaia Data Processing and Analysis Consortium (DPAC), Coordination Unit CU8: Astrophysical Parameters – I. Kolka

German Astronomical Society – J. Einasto
GDR Géométrie stochastique – E. Tempel, E. Saar
Institute of Electrical and Electronical Engineers (IEEE) – S. Lätt (student member), J. Pisek
International Association for Great Lakes Research (IAGLR) – K. Alikas (student member)
International Astronomical Union – K. Annuk, A. Aret, J. Einasto, M. Einasto, M. Gramann, U. Haud, A. Hirv, G. Hütsi, T. Kipper, I. Kolka, L. Leedjärv, T. Nugis, J. Pelt, E. Saar, A. Sapar, I. Suhhonenko, E. Tago, A. Tamm, E. Tempel, P. Tenjes, U. Veismann, J. Vennik, T. Viik
International Astrostatistics Association – E. Saar.
Kosmoseasjade nõukogu – A. Reinart
The International Society for Optical Engineering (SPIE) – U. Veismann, S. Lätt (student member)
TÜ ajaloo küsimusi – T. Viik (member of the editorial board)
Marie Curie Fellowship Association – A. Reinart
Optical Society of America – S. Lätt (student member)
Royal Astronomical Society – J. Einasto (associated member)
Ultraviolettkiirguse, osooni ja aerosoolide uurimise koordineerimise Eesti Nõukogu – K. Eerme, U. Veismann
Õpetatud Eesti Selts – U. Peterson, T. Viik

11 Teaching and Popularizing Õppetöö ja populariseerimine

11.1 Lecture courses and seminars Loengukursused ja seminarid

Astronomy Astronoomia – P. Tenjes, University of Tartu.
General Astronomy Üldine astronoomia – P. Tenjes, University of Tartu.
Hydrodynamics I Hüdrodünaamika I – P. Tenjes, University of Tartu.
Methods of Mathematical Physics Matemaatilise füüsika meetodid – P. Tenjes, University of Tartu.
Physical Cosmology Füüsikaline kosmoloogia – M. Gramann, University of Tartu.
Global Physics, Globaalfüüsika – M. Gramann together with H. Ohvril, K. Tarkpea and O. Tihhonova, University of Tartu.
The Equations of Mathematical Physics Matemaatilise füüsika võrrandid – T. Viik, University of Tartu.
Seminar in Astrophysics Astrofüüsika seminar – R. Kipper together with P. Tenjes, University of Tartu.
Fundamentals of Remote Sensing Kaugseire alused – U. Peterson, University of Tartu.
Environmental Monitoring Keskkonnaseire – U. Peterson, Estonian University of Life Sciences.
Modelling of Environmental Processes and Spatial Analysis Looduslike protsesside modelleerimine ja ruumianalüüs – U. Peterson together with A. Kiviste, Estonian University of Life Sciences.
Geographic Information Systems Geograafilised Informatsioonisüsteemid – U. Peterson and M. Lang, Estonian University of Life Sciences.
Remote Sensing in Nature Looduse kaugseire – M. Lang, Estonian University of Life Sciences.
Fundamentals of the Environmental Physics II Keskkonnafüüsika alused II – H. Ohvril, M. Aun, H. Keernik, University of Tartu.
Environmental Science Keskkonnaõpetus – K. Eerme, University of Tartu.
Remote Sensing of Environmental I Keskkonnakaugseire I – K. Alikas, T. Nilson, J. Pisek, O. Krüger, A. Kodar, M. Ligi, University of Tartu.
In the frame of a course " Methods of Investigation of Water Bodies" a lecture "Methods of Hytoplankton Investigation". Loengukursuse "Veekogude uurimise meetodid" raames loeng "Fütoplanktoni uurimise meetodid" – K. Kangro, Estonian University of Life Sciences.
In the frame of a course "Technology of Ecosystems" a lecture "Technology of Ecosystems". Loengukursuse"Ökosüsteemide tehnoloogia" raames loeng "Järvede taastamise meetodid" – K. Kangro, University of Tartu.

In the frame of a course "Bioindication" a lecture "Algoindication". Loengukursuse "Bioindikatsioon" raames loeng "Algoindikatsioon" – K. Kangro, University of Tartu.

Modern Metrology Kaasaegse metroloogia alused – M. Noorma, M. Vilbaste, R. Vendt, University of Tartu.

Astronomy Course for the Nõo High School Astronoomia kursus Nõo Reaalgümnaasiumi 12. klassidele – K. Annuk, L. Leedjärv, M. Ruusalepp, E. Tempel, T. Viik.

11.2 Popular lectures Populaarteaduslikud loengud ja esinemised

5 intervjuud raadiole ja ajalehtedele – T. Viik.

10 intervjuud raadiole, televisioonile ja ajalehtedele/ajakirjadele – E. Tempel.

8 intervjuud välisajakirjandusele – E. Tempel.

Aktuaalsed teemad astronoomias (Tartu Tähetorni Astronoomiaring, 21.01.2014) – T. Eenmäe, J. Pelt, A. Tamm, E. Tempel.

The Development of the World View on the Universe (Eesti Füüsika päevad, 31.01.2014) – J. Einasto.

Ülevaade ESTCube-1 projektist (Eesti Raadioamatööride Ühingu talvepäevad, Tallinn, 01.02.2014) – J. Kütt.

Tumedad jõud astronoomias: tumeaine ja tume energia (Tartu Tähetorni Astronoomiaring, 04.02.2014) – E. Tempel.

ESTCube: tudengiteadus kosmoses (TudengiTeaduse päev AHHAA keskuses, Tartu 12.02.2014) – M. Pajusalu.

Miks tähed tähtsad on? (Õpilasteaduse konverents, Tõravere, 14.02.2014) – L. Leedjärv.

Kosmoloogilise edu saladus (Elva Gümnaasium, 06.02.2014) – E. Tempel.

Universumi ehitus – tumeaine ja tumeenergia, Loengusari "Google'ist ei piisa" (Eesti Rahvusraamatukogu, Tallinn, 18.02.2014) – P. Tenjes.

Galaktikate tekkimine ja arenemine paisuvas universumis (Tartu Rahvaülikool, Tartu, 19.02.2014) – P. Tenjes.

Satelliidijälg supernooval ("Labor", Vikerraadio, 02.03.2014) – T. Eenmäe.

Kaksiktähed läbi aegade (Tartu Tähetorni Astronoomiaring, 18.03.2014) – T. Eenmäe.

Tumedad elemendid Universumis: aine ja energia (Eesti Füüsika Päevad, 20.03.2014) – E. Tempel.

Minu mobilitase grant: tumeaine otsingud (Mobilitase seminar, Tallinn, 25.03.2014) – E. Tempel.

The Structure of the Universe (New York Estonian House, 29.03.2014) – J. Einasto.

Discussion with Dr. Martti Raidal on topics "Searching Dark Matter" (Tartu University, 04.04.2014) – J. Einasto.

TÜ visioonikonverentsi sessiooni modereerimine (Tartu Ülikool, 10.04.2014) – M. Noorma.

Universumi saladused: tumeaine ja tumeenergia. Kuidas tekivad galaktikad? (Tallinna Reaalkooli teadusnädal, 15.04.2014) – E. Tempel.

Universumi kaardistamine - galaktikate jaotusest superparvedeni (Füüsika üliõpilaste seltsi seminar, 16.04.2014) – E. Tempel.

Välisplaneedid tänases õhtutaevas ja katsed neid vallutada (Tartu Tähetorni Astronoomiaring, 19.04.2014) – A. Puss.

Talk in honour of Prof. Ene Tiit "Ene Tiit 80 – Pictures from the Beginning of the Path" (Tartu University, 21.04.2014) – J. Einasto.

Astronoomia värskeimad uudised (Tartu Tähetorni Astronoomiaring, 06.05.2014) – R. Kipper.

Intervjuu ajalehele Helsinkin Sanomat (08.05.2014) – M. Noorma, M. Pajusalu, S. Lätt, A. Slavinskis.

Eesti esimene satelliit ESTCube-1 ja tema roll kosmose vallutamisel (Kosmoseõhtu Põlvas, Põlva 15.05.2014) – M. Pajusalu.

Joseph Nicolas Delisle'i elu ja tegevus (Tartu Tähetorni Astronoomiaring, 20.05.2014) – T. Viik.

Miks tähed tähtsad on? (Ettekanne Noarootsi Gümnaasiumi õpilastele, Tõravere, 20.05.2014) – L. Leedjärv.

Sada kuuskümmend aastat Eesti Looduseuurijate Seltsi (Akadeemiline Põllumeeste Selts, 21.05.2014) – T. Viik.

Universumi struktuur ja evolutsioon (Eesti Teaduste Akadeemia visiit Saaremaale, 22.05.2014) – J. Einasto.

Struve geodeetiline kaar (Õpilaskonverents Simunas, 29.05.2014) – T. Viik.

Satelliitside aparatuuri demonstratsioon (Eesti Raadioamatööride ühingu suvine kokkutulek, Tooraku, 28.06.2014) – V. Allik, T. Eenmäe.

Gaasiline Universum (Astronoomiahuviliste XIX Üle-Eestiline kokkutulek, Toila, 09.08.2014) – A. Tamm.

Galaktikad seest ja väljast (Astronoomiahuviliste XIX Üle-Eestiline kokkutulek, Toila, 09.08.2014) – T. Kuutma.

ESTCube-1 ja edasi (Astronoomiahuviliste XIX Üle-Eestiline kokkutulek, Toila, 09.09.2014) – J. Kütt

Astronoomiauudised (Astronoomiahuviliste XIX Üle-Eestiline kokkutulek, Toila, 10.08.2014) – J. Laur.

Tähtede uurimine suurte taevaülevaadete ajastul (Astronoomiahuviliste XIX Üle-Eestiline kokkutulek, Toila, 10.08.2014) – T. Eenmäe.

BICEPS'i inflatsioon – mida me tegelikult mõõtsime? (Astronoomiahuviliste XIX Üle-Eestiline kokkutulek, Toila, 11.08.2014) – T. Sepp.

Aegade algusest lõpuni (X Teaduse Suvekool, Käsmu, 24.08.2014) – L. Leedjärv.

Planeedid eeloleval talvel (Tartu Tähetorni Astronoomiaring, 30.08.2014) – A. Puss.

Intervjuu meediakanalile StarParty (StarSpace SIA, 06.09.2014) – A. Slavinskis.

Millega tegelevad astronoomid Tõravere mäel (Audentese Erakool, Tallinn, 15.09.2014) – M. Ruusalepp.

Taevasfäär ja taevakehade liikumine (Rahvusvahelise astronoomiaolümpiaadi treeninglaager, Tõravere, 17.09.2014) – J. Laur.

Kosmoselendude mõju inimesele (DOTE klubi, 18.09.2014) – T. Viik.

Linnastumise jälgimine kosmosest ja seosed inimeste tervisega (Teadlaste ÖÖ, Tartu Observatoorium, 26.09.2014) – K. Voormansik.

Teadlaste ÖÖ üritused Tõraveres (Tõravere, 26.09.2014) – V. Allik, K. Annuk, A. Puss, M. Ruusalepp, E. Tempel, J. Laur, H. Lätt, T. Sumberg, J. Vennik.

Veekaugseire üldised alused ja probleemid (Tartu Tähetorni Astronoomiaring, 07.10.2014) – M. Ligi.

Vesi Päikesesüsteemis ja elu eksoplaneetidel ("Puust ja Punaseks", Raadio 2, 10.10.2014) – T. Eenmäe.

Meie kosmiline kodu (Koolivaheaja õpituba, Meeri Seltsimaja, 20.10.2014) – L. Leedjärv.

Radarsatelliidid (Tartu Tähetorni Astronoomiaring, 21.10.2014) – K. Voormansik.

Matemaatiline aparatuur kosmoloogias (Matemaatikute doktorikooli seminar, 29.10.2014) – E. Tempel.

Intervjuu Läti regionaalsele telekanalile saates "Iepazisti Tartu" (29.10.2014) – K. Laizans.

Populaarteaduslik kosmoloogia (Miina Härma Gümnaasium, 05.11.2014) – E. Tempel.

Rosetta ja eksokomeedid, kosmosereisid ("Puust ja Punaseks", Raadio 2, 17.11.2014) – T. Eenmäe.

Joseph von Fraunhofer – suur optikateadlane (Tartu Tähetorni Astronoomiaring, 18.11.2014) – T. Viik.

John Couch Adams ja Neptuuni avastamise lugu (Tartu Tähetorni astronoomiaring, 16.12.2014) - T. Viik.

Intervjuu ERR telesaatele "Teaduspalavik" (16.12.2014) – I. Sünter, H. Ehrprais, I. Kolka, E. Kulu.

Seeria ettekandeid teemal "ESTCube-1 missiooni kasutamine tehnoloogilise kõrghariduse edendamiseks – M. Noorma.

Eesti Energia noorte ettevõtluskonkursi Entrum sessioon, Tallinna Ülikool – 11.01.2014.

Füüsikaõpetajate Päevad, Voore – 31.01.2014.

Tamme Gümnaasium, Tartu – 04.02.2014.

Tartu Erakool, Tartu – 21.02.2014.

Tori Põhikool, Pärnumaa – 25.02.2014.

Paikuse Põhikool, Pärnumaa – 25.02.2014.
Kiili Gümnaasium, Harjumaa – 06.03.2014.
Kaitseväe Teaduspäev – 14.03.2014.
Tartu Kesklinna Kool, Tartu – 31.03.2014.
Antsla Gümnaasium, Antsla – 01.04.2014.
PARE personalijuhtimise konverents – 11.04.2014.
Eesti Füüsikaüliõpilaste Seltsi seminar – 11.04.2014.
ESTCube-1 esimese aastapäeva pressikonverents – 07.05.2014.
Türi Ühisgümnaasiumi suvekool, Türi – 04.06.2014.
TÜ õppejõudude suveakadeemia "Oma õpetamise arendamine: kollegiaalne tagasiside", Männiku turismitalu, 18.–19.08.2014.
Tartu hariduskonverents, Tartu – 26.08.2014.
Rahvusvahelinel Teadusinstrumentide komisjoni sümposion, TÜ ajaloo muuseum, Tartu – 26.08.2014
TÜ loodus- ja tehnoloogiateaduskonna avaaktus, Tartu – 01.09.2014.
TÜ loodus- ja tehnoloogiateaduskonna esmakursuslaste konverents, Tartu – 13.09.2014.
Jaapani noorte delegatsioon, Tõravere – 15.09.2014.
Tartu Kosmoseteaduse ja -tehnoloogia konverents, 22.–24.09.2014.
USA õhujõudude delegatsioon, Tallinn – 26.09.2014.
Norra Kaitseväe delegatsioon, Tõravere – 07.10.2014.
KBFI seminar, Tallinn – 16.12.2014.
Eesti Energia noorte ettevõtluskonkursi Entrum avasessioon, Jõhvi – 28.10.2014.
Tartu Erakool, Tartu – 10.11.2014.
Avaliku sektori juhtimiskonverents, Pärnu – 20.12.2014.
Eesti Majas Torontos, Kanada – 18.11.2014.
Eesti teaduskeele konverents, Tallinna Ülikool, Tallinn – 06.12.2014.
Rosma kooli lapsed Physicum, Tartu – 12.12.2014.
Eesti tudengisatelliidi töötuba Kino Kosmos IMAX avamisel, Tallinn – 18.12.2014.

11.3 Theses defended, supervised and refereed by the staff of the Observatory Observatooriumi töötajate poolt kaitstud, juhendatud ja oponeeritud väitekirjad

11.3.1 Ph.D. theses Doktoritööd

K. Voormansik: X-band Synthetic Aperture Radar Applications for Environmental Monitoring. .X-laineala tehisava-radari rakendused keskkonnakaugseireks Ph.D. Thesis, University of Tartu.
Defence Kaitsmine: 14.02.2014.

Supervisors Juhendajad: D.Sc. Mart Noorma (University of Tartu), Ph.D. Rein Rõõm (University of Tartu).
Opponents Oponendid: Ph.D. Liis Sipelgas, Tallinn University of Technology, Estonia.
Ph.D. Laurent Ferro-Famil, University of Rennes, France.

11.3.2 M.Sc. theses Magistritööd

M. Noorma – *E. Kulu*: Trends of Development in Nanosatellite Technology. Nanosatelliitide tehnoloogia arengutrendid. (M.Sc.), University of Tartu.

A. Slavinskis – *G. Šteinbergs*: Development of a Programming Language for Automatisation of Commands and Implementation in the Mission Control System of the ESTCube-1 Satellite. (M.Sc.), Ventspils University College.

R. Vendt – *K. Laizans*: A Method for Characterization of Vibration Testing Setups. Meetod vibratsioonikatseseadmete omaduste kirjeldamiseks. (M.Eng.), University of Tartu.

I. Leito – *A. Pung*: Computational Estimation of Receptor-anion Binding in Solution. Arvutuslik retseptor-anioon seondumise uurimine lahusekeskkonnas. (M.Eng.), University of Tartu.

K. Zālite, M. Noorma – *I. Sünter*: Software for the ESTCube-1 Command and Data Handling System. ESTCube-1 käsu- ja andmehaldussüsteemi tarkvara (M.Sc.), University of Tartu.

A. Slavinskis, V. Allik – *G. Olentšenko*: Prototype Design of ESTCube-2 Attitude and Orbit Control System. ESTCube-2 asendi ja orbiidi juhtimissüsteemi prototüübi disain. (M.Sc.), University of Tartu.

U. Kvell – *I. Ploom*: Analysis of Variations in Orbital Parameters of CubeSats. Kuupsatelliitide orbitaalparameetrites toimuvate muutuste analüüs (M.Sc.), University of Tartu.

R. Vendt, I. Leito – *S. Mwagomba*: A Method for Thermal Ambient Tests of Space Technology Equipment in a Thermal Chamber – Development and Validation. Meetod kosmosetehnoloogia seadmete katsetamiseks temperatuurikeskkonnas – väljatöötamine ja valideerimine (M.Eng.), University of Tartu.

U. Kvell – *J. Okugbeni*: Security Implementation of Mission Control System (MCS) in ESTCube-1. Satelliidi ESTCube-1 missioonijuhtimissüsteemi turvalisuse parendamine (M.Sc.), University of Tartu.

E. Tempel, K. Pärna – *M. Bussov*: Statistical Study of the Structure of the Universe: Relations between Filaments, Galaxies and Galaxy Groups. Universumi struktuuri statistiline uurimine: filamentide, galaktikate ja galaktikaparvede vahelised seosed. (M.Sc), University of Tartu.

E. Tempel – *O. Tihhonova*: Modelling Galaxy Stellar Dynamics on the Base of Andromeda. Galaktikate stellaardünaamika modelleerimine Andromeeda näitel. (M.Sc), University of Tartu.

P. Tenjes – *T. Tuvi*: Production Mechanism of Cosmic Rays by Supernova Remnants. Kosmiliste kiirte tekkemehhanism supernoova jäänukites (M.Sc.), University of Tartu.

K. Alikas, K. Kangro – *E. Kangro*: The Relation Between Phytoplankton Absorption Coefficient and Chlorophyll-a Concentration for Remote Sensing Applications for Large Estonian Lakes. Fütoplanktoni neeldumiskoefitsiendi ja klorofüll-a kontsentratsiooni vaheline seos kaugseire rakendusteks Eesti suurte järvede näitel (M.Sc.), University of Tartu.

J. Pisek – *M. Nikopensius*: Spectral Reflectance Patterns and Seasonal Dynamics of Common Understory Types in Three Mature RAMI Hemi-Boreal Forests. Alustaimestiku spektraalne dünaamika ja ajaline muutlikkus poolboreaalsetes metsades Järvseljal, Eestis. (M.Sc.), University of Tartu.

J. Pisek – *K. Raabe*: Seasonal and vertical changes in leaf angle distribution for deciduous broadleaf tree species common to Estonia. Lehenurgajaotuste sesoonsed ja vertikaalsed muutused Eestis levinud lehtpuudel. (M.Sc.), University of Tartu.

K. Eerme – *I. Aruoja*: Variation of Action Spectra Weighted Ultraviolet Radiation in Estonia. Mõjuteguritega kaalutud ultraviolettkiirguse muutlikkus Eestis (M.Sc.), University of Tartu.

K. Eerme – *K. Virronen*: Solar Ultraviolet Radiation in Estonia (based on the measurements of Tõravere). Päikese ultraviolettkiirgus Eestis (Tõravere mõõtmisandmete põhjal) (M.Sc.), University of Tartu.

11.3.3 B.Sc. theses Bakalaureusetööd

M. Pajusalu – *R. Raabe*: ESTCube-1 Energy Production Simulator and Analysis of Telemetry Data. ESTCube-1 energiatootluse simulaator ja telemeetria andmete analüüs (B.Sc.), University of Tartu.

K. Zālite, K. Voormansik – *G. Majas*: Analysis of Permanent Scatterer Properties by Land Cover Type in Ida-Virumaa. Püsivate peegeldajate omaduste analüüs maakatte tüübi järgi Ida-Virumaal (B.Sc.), University of Tartu.

K. Voormansik – *K. Kalam*: Winter Effects for Permanent Scatterer Densities with Respect to Land Types. Talve mõju püsivate peegeldajate tihedusele sõltuvalt maakattetüübist (B.Sc.), University of Tartu.

M. Pajusalu, V. Allik – *H. Haljaste*: Magnetic Field Simulator for ESTCube-1 Testing. Magnetvälja simulaatori arendamine satelliidi ESTCube-1 testimiseks (B.Sc.), University of Tartu.

J. Pelt – *S. Kõiv*: Fast Computation of Trigonometric Sums in Astronomical Time Series Frequency Analysis. Trigonomeetriliste summade kiire arvutamise meetodid astronoomiliste aegridade sagedusanalüüsis (B.Sc.), University of Tartu.

I. Kolka, T. Eenmäe – *R. Voog*: Detecting Spectroscopic Binaries Among Per OB1 Association Massive Stars. Spektroskoopiliste kaksiktähtede tuvastamine Per OB1 assotsiatsiooni massiivsete tähtede seast (B.Sc.), University of Tartu.

I. Kolka, T. Eenmäe – *Ü. Kivila*: Determining the Physical Parameters of Eclipsing Binary BD+48 1098.Varjutusmuutliku kaksiktähe BD +48 1098 füüsikaliste parameetrite määramine (B.Sc.), University of Tartu.

V. Allik, T. Eenmäe – *T. Värbu*: Support Structure for Satellite Communication Antennas. Mobiilse satelliitsidejaama antennisüsteemi tugikonstruktsioon (B.Sc.), Estonian Aviation Academy.

V. Allik – *M. Allik*: Redesign of the Antenna Pointing Controller at Tartu Observatory Satellite Communication Ground Station. Tartu Observatooriumi satelliitside maajaama antennipööraja kohandamine madalaorbiidiliste satelliitide jälgimiseks(B.Sc.), Estonian Aviation Academy.

11.3.4 Refereeing of theses Oponeerimine

L. Leedjärv – *Ü. Kivila*: Determining the Physical Parameters of Eclipsing Binary BD+48 1098. Varjutusmuutliku kaksiktähe BD +48 1098 füüsikaliste parameetrite määramine (B.Sc.), University of Tartu.

L. Leedjärv – *R. Voog*: Detecting Spectroscopic Binaries Among Per OB1 Association Massive Stars. Spektroskoopiliste kaksiktähtede tuvastamine Per OB1 assotsiatsiooni massiivsete tähtede seast (B.Sc.), University of Tartu.

J. Laur – *S. Kõiv*: Fast Computation of Trigonometric Sums in Astronomical Time Series Frequency Analysis. Trigonomeetriliste summade kiire arvutamise meetodid astronoomiliste aegridade sagedusanalüüsis (B.Sc.), University of Tartu.

R. Vendt – *K. Kalam*: Winter Effects for Permanent Scatterer Densities with Respect to Land Types. Talve mõju püsivate peegeldajate tihedusele sõltuvalt maakattetüübist (B.Sc.), University of Tartu.

K. Voormansik – *S. Mwagoma*: A Method for Thermal Ambient Tests of Space Technology Equipment in a Thermal Chamber – Development and Validation. Meetod kosmosetehnoloogia seadmete katsetamiseks temperatuurikeskkonnas – väljatöötamine ja valideerimine (M.Eng.), University of Tartu.

U. Kvell – *K. Puusepp*: ICD Systems' Remote Control and Monitoring Tool for Android. ICD kontrollsüsteemide seire- ja juhtimisrakendus Androidile (M.Eng.), University of Tartu.

M. Mõistus – *G. Majas*: Analysis of Permanent Scatterer Properties by Land Cover Type in Ida-Virumaa. Püsivate peegeldajate omaduste analüüs maakatte tüübi järgi Ida-Virumaal (B.Sc.), University of Tartu.
U. Veismann – *I. Aruoja*: Variation of Action Spectra Weighted Ultraviolet Radiation on Estonia. Mõjuteguritega kaalutud ultraviolettkiirguse muutlikkus Eestis (M.Sc.), University of Tartu.
U. Veismann – *E. Kulu*: Trends of Development in Nanosatellite Technology. Nanosatelliitide tehnoloogia arengutrendid (M.Sc.), University of Tartu.
T. Nilson – *K. Aun*: Studying the Decay of Sea Ice in the Baltic Sea using MODIS Satellite Pictures. Läänemere jääkatte lagunemise uurimine MODIS satelliidipiltide põhjal (M.Sc.), University of Tartu.
T. Tuvikene – *O. Tihhonova*: Modelling Galaxy Stellar Dynamics on the Base of Andromeda. Galaktikate stellaardünaamika modelleerimine Andromeeda näitel (M.Sc.), University of Tartu.

11.3.5 Supervising the students research Õpilaste uurimistööde juhendamine

E. Tempel – *K. Kree*: Mõõtmisviisid astronoomias ja Andromeeda galaktika kaugus Ernst Julius Öpiku idee järgi, Hugo Treffneri Gümnaasium.
E. Tempel – Summer students. Suvised praktikandid – Kaspar Kliimask, Stella Reino.

11.3.6 Diploma thesis Diplomitööd

U. Kvell, M. Noorma – *F. Kaminski*: Orbital Analysis of the SWEST Mission. (Diploma Thesis), Aachen University of Applied Sciences.
R. Vendt, M. Noorma – *F. Schulze*: Development of a Short Arm Centrifuge for Space Testing. (Diploma Thesis), Aachen University of Applied Sciences.

11.4 Practical trainig Tööpraktika

11.4.1 Space technology Kosmosetehnoloogia

Karoli Kahn – University of Tartu (Estonia); 01.01.–31.12.2014.
Toivo Värbu – Estonian Aviation Academy (Estonia); 01.01.–30.06.2014.
Mari Allik – Estonian Aviation Academy (Estonia); 01.01.–30.06.2014.
Manca Štrucelj – University of Ljubljana (Slovenia); 17.03.–17.07.2014.
Jaan Viru – University of Tartu (Estonia); 12.04.–30.06.2014.
Agnes Vask – University of Tartu (Estonia); 23.04.–30.06.2014.
Aleš Ferlan – University of Ljubljana (Slovenia); 28.04.–28.08.2014.

Surmit Bhui – University of Petroleum & Energy Studies (India); 17.05–15.08.2014.
Sumana Mukherjee — University of Petroleum & Energy Studies (India); 17.05–15.08.2014.
Egils Avots – Ventspils University College (Latvia); 26.05.–30.09.2014.
Karlis Luksis – Ventspils University College (Latvia); 26.05.–30.09.2014.
Samu-Pekka Ojanen – Tampere University of Technology (Finland); 02.06.–02.09.2014.
Taavi Adamson – University of Tartu (Estonia); 02.06.–31.08.2014.
Hendrik Ehrpais – University of Tartu (Estonia); 02.06.–30.09.2014.
Georgi Olentšenko – University of Tartu (Estonia); 02.06.–19.12.2014.
Markus Rene Pae – Gustav Adolfi gümnaasium (Estonia); 09.06.–31.08.2014.
Robert Aare – University of Tartu (Estonia); 19.06.–31.08.2014.
Kristaps Dreja – Ventspils University College (Latvia); 16.06.–16.09.2014.
Olga Tjurkina – Ventspils University College (Latvia); 16.06.–16.09.2014.
Kristen Altof – Tallinn University of Technology / Technical University of Berlin (Estonia); 25.06.–30.08.2014.
Mario Fernández Palos – Complutense University of Madrid (Spain); 30.06.–30.09.2014.
Sriram Hariharan – Lulea Technical University (Sweden); 01.07.–30.09.2014.
Laur Joost – University of Tartu (Estonia); 10.07.–31.12.2014.
Jaanus Kalde – University of Tartu (Estonia); 16.07.–31.12.2014.
Sinai Mwagomba – University of Tartu (Estonia); 26.08.–19.12.2014.
Kerli Prants – University of Tartu (Estonia); 19.09.–01.09.2015.
Miroslav Rolko – University of Tartu (Estonia); 01.10.–21.06.2015.

11.4.2 Astronomy Astronoomia

Stella Reino – University College of London (UK); 11.08.–10.09.2014.

11.4.3 Support services Tugiteenused

Liis Kurvits – Tartu Kutsehariduskeskus (Estonia); 20.10.–14.11.2014.

12 Staff Koosseis (31.12.2014)

Director / Direktor	Anu Reinart (Ph.D.)

Department of Astrophysics Astrofüüsika osakond

Group of stellar physics Tähefüüsika töörühm

Senior research associate / Vanemteadur	Laurits Leedjärv (Ph.D.) (Head of Department / Osakonna juhataja)
Senior research associate / Vanemteadur	Kalju Annuk (Ph.D.)
Senior research associate / Vanemteadur	Indrek Kolka (Ph.D.)
Research associate / Teadur /0.60)	Anti Hirv (Ph.D.)
Research associate / Teadur	Taavi Tuvikene (Ph.D.)
Research associate / Teadur	Tõnis Eenmäe (M.Sc.)
Research associate / Teadur	Tiina Liimets (M.Sc.)
Scientific adviser / Teaduslik nõustaja(0.20)	Tõnu Kipper (D.Sc.)
Junior research associate / Nooremteadur 0.80)	Jaan Laur ((M. Sc.)
Technician / Tehnik (0.25)	Kristiina Verro

Group of theoretical astrophysics Teoreetilise astrofüüsika töörühm

Scientific adviser / Teaduslik nõustaja (0.20)	Arved Sapar (D.Sc., Prof., EAS[1])
Leading research associate / Juhtivteadur	Jaan Pelt (Ph.D.)
Senior research associate / Vanemteadur	Tõnu Viik (D.Sc.)
Research associate / Teadur	Anna Aret (Ph.D.)
Research associate / Teadur (0.20)	Indrek Vurm (Ph.D)

[1]Member of the Estonian Academy of Sciences Eesti Teaduste Akadeemia akadeemik

Department of Cosmology Kosmoloogia osakond

Group of cosmology Kosmoloogia töörühm

Leading research associate / Juhtivteadur	Enn Saar (D.Sc., EAS[1])
(Head of Department / Osakonna juhataja)	
Senior research associate / Vanemteadur (0.75)	Jaan Einasto (D.Sc., Prof., EAS[1])
Senior research associate / Vanemteadur	Maret Einasto (D.Sc.)
Senior research associate / Vanemteadur	Mirt Gramann (Ph.D.)
Senior research associate / Vanemteadur	Erik Tago (Ph.D.)
Senior research associate / Vanemteadur	Jukka Nevalainen (Ph.D.)
Senior research associate / Vanemteadur	Gert Hütsi (Ph.D.)
Research associate / Teadur	Ivan Suhhonenko (Ph.D.)
Research associate / Teadur	Lauri J. Liivamägi (M.Sc.)
Research associate / Teadur	Boris Zhivkov Deshev (M.Sc.)
Junior research assoc. / Nooremteadur (0.30)	Rain Kipper (M.Sc.)
Technician / Tehnik (0.50)	Peeter Einasto
Technician / Tehnik (0.20)	Triin Einasto
Leading engineer / Juhtinsener (0.50)	Margus Sisask

Group of physics of galaxies Galaktikate füüsika töörühm

Senior research associate / Vanemteadur	Urmas Haud (D.Sc.)
Senior research associate / Vanemteadur	Jaan Vennik (Ph.D.)
Senior research associate / Vanemteadur (0.25)	Peeter Tenjes(D.Sc.)
Research associate / Teadur	Antti Tamm (Ph.D.)
Research associate / Teadur	Elmo Tempel (Ph.D.)
Research associate / Teadur	Tiit Sepp (M.Sc)
Junior research associate / Nooremteadur (0.10)	Teet Kuutma (M.Sc.)
Engineer / Insener (0.50)	Maarja Bussov (M.Sc.)
Technician / Tehnik (0.25)	Moorits Mihkel Muru
Technician / Tehnik (0.10)	Olga Tihhonova /M.Sc.)

[1]Member of the Estonian Academy of Sciences Eesti Teaduste Akadeemia akadeemik

Department of remote sensing of environment Keskkonna kaugseire osakond

Group of remote sensing of vegetation Taimkatte kaugseire töörühm

Leading research associate / Juhtivteadur	Andres Kuusk (D.Sc.) (Head of Department / Osakonna juhataja)
Senior research associate / Vanemteadur	Tiit Nilson (D.Sc., Prof.)
Senior research associate / Vanemteadur	Joel Kuusk (Ph.D.)
Senior research associate / Vanemteadur	Lea Hallik (Ph.D.)
Senior research associate / Vanemteadur	Jan Pisek (Ph.D.)
Senior research associate / Vanemteadur (0.50)	Mait Lang (Ph.D.)
Senior research associate / Vanemteadur (0.50)	Urmas Peterson (Ph.D.)
Junior research associate / Nooremteadur (0.40)	Kairi Raabe (M.Sc.)
Engineer / Insener (0.10)	Tõnu Lükk (M.Sc.)
Engineer / Insener	Marta Mõistus (M.Sc.)
Technician / Tehnik	Tõnu Prans

Group of remote sensing of atmosphere Atmosfääri kaugseire töörühm

Senior research associate / Vanemteadur (0.90)	Kalju Eerme (Ph.D.)
Senior research associate / Vanemteadur(0.75)	Uno Veismann (Ph.D.)
Senior research associate / Vanemteadur (0.80)	Erko Jakobson (Ph.D.)
Research associate / Teadur (0.50)	Viivi Russak (D.Sc.)
Research associate / Teadur (0.40)	Aivo Reinart (B.Sc)
Research associate / Teadur (0.30)	Olavi Kärner (Ph.D.)
Junior research assoc. / Nooremteadur (0.20)	Margit Aun (M.Sc.)
Engineer / Insener	Ilmar Ansko (M.Sc.)
Engineer / Insener (0.25)	Hannes Keernik (M.Sc.)

Group of remote sensing of water bodies Veekogude kaugseire töörühm

Research associate / Teadur (0.50)	Kersti Kangro (Ph.D.)
Research associate / Teadur (0.60)	Krista Alikas (M.Sc.)
Junior research associate / Nooremteadur (0.50)	Elar Asuküll (M.Sc.)
Junior research associate / Nooremteadur (0.50)	Evelin Kangro (M.Sc.)
Engineer / Insener (0.50)	Martin Ligi (M.Sc.)
Engineer / Insener (0.20)	Kristi Uudeberg (M.Sc.)
Software engineer / Tarkvara insener (0.40)	Reiko Randoja

Department of space technology Kosmosetehnoloogia osakond

Senior research associate / Vanemteadur (0.50)	Mart Noorma (Ph.D.)
	(Head of Department / Osakonna juhataja)
Research associate / Teadur	Riho Vendt (Ph.D.)
Research associate / Teadur (0.70)	Kaupo Voormansik (Ph.D.)
Research associate / Teadur (0.80)	Silver Lätt (M.Sc.)
Leading engineer / Juhtivinsener	Viljo Allik (M.Sc.)
Junior research assoc. / Nooremteadur (0.20)	Andris Slavinskis (M.Sc.)
Junior research assoc. / Nooremteadur (0.20)	Karlis Zalite (M.Sc.)
Engineer / Insener	Henri Kuuste
Engineer / Insener (0.30)	Erik Kulu (M.Sc.)
Engineer / Insener (0.50)	Urmas Kvell (M.Sc.)
Engineer / Insener (0.30)	Indrek Sünter (M.Sc.)
Quality specialist / Kvaliteedi spetsialist (0.50)	Astrid Pung (M.Sc.)
Technician / Tehnik (0.50)	Anni Sisas
Technician / Tehnik	Kaspars Laizans (M.Eng.)
Programmer / Programmeerija (0.50)	Martin Valgur

Department of support services Tugiteenuste osakond

Head of department / Osakonna juhataja	Tiia Lillemaa
Project co-ordinator / Projektide koordinaator	Marge Kliimask (M.Sc.)
Records manager / Dokumendihaldur	Ulvi Nigol
Head book-keeper / Pearaamatupidaja	Külli Kärner
Senior book-keeper / Vanemraamatupidaja	Evelin Kelner
Maternity leave / Lapsehoolduspuhkus	Diana Toots

Management Haldusosakond

Vice director, managment / Haldusdirektor	Enno Ruusalepp
	(Head of Department / Osakonna juhataja)
IT senior specialist / IT peaspetsialist	Tõnu Veeranna
Engineer / Insener (0.25)	Toivo Kuusk
Housekeeper / Majahoidja	Leida Kivirand
Electrician / Elektrik-haljastustehnik	Ülo Kivirand
Repair technician / Remonditööline	Henn Leitu
Cleaner / Koristaja	Helvi Vennik

Visitor centre Külastuskeskus

Head of department / Osakonna juhataja	Mare Ruusalepp (Ph.D.)
Project manager / Projektijuht (0.75)	Heli Lätt
Project manager assist. / Projektijuhi abi (0.75)	Triin Sumberg
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