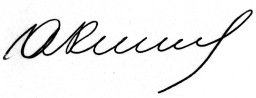
Contents Sisukord

Eessõna

Sellel aastal jõudsid Tartu Observatooriumi nimi ja töö tulemused kõrgemale kui kunagi varem, seda tõesti sõna otseses mõttes!
7. mail startis Eesti esimene satelliit Euroopa Kosmoseagentuuri raketil Vega ja töötab sellest saadik 660 km kõrgusel Maa orbiidil. Sellega jõudis lõpule üle viie aasta rahvusvahelises meeskonnas toimunud nanosatelliidi arendustöö, valmisid üliõpilaste lõputööd ja kogunes materjali teadusartikliteks. Kuigi ESTCube-1 missioon on veel lõpule viimata ja seisab ees elektrilise päikesepurje komponendi katsetamine, oleme saavutanud avalikkuse siira ja positiivse huvi kosmosetehnoloogia kaasaegsete arengute vastu. Meeskonna eestvedaja, Tartu observatooriumi kosmosetehnoloogia osakonna juht Mart Noorma pälvis oma töö eest Vabariigi Presidendi hariduspreemia ja mitmeid teisi tunnustusi. Ka astronoomidel on põhjust rõõmustada – ja mitte ainult kõrge autasu saanud noore tippteadlase Elmo Tempeli üle. Aasta lõpus startis Euroopa Kosmoseagentuuri kosmoseteleskoop Gaia. Selle missiooni ettevalmistamine on kestnud meie teadlaste kaasabil juba üle kümne aasta ja nüüd jätkatakse ka andmete analüüsiga. Atmosfäärifüüsika osakonna baasil loodi kaks uut osakonda: kaugseire osakond ja kosmosetehnoloogia osakond, mis vastab täpsemini sisulisele tegevusele. Väga oluline pikemas perspektiivis on külastuskeskuse laiendamine. Meie uuenenud peamajas on palju paremad võimalused jätkata astronoomia ja Maa seire teadussuundade ja rakenduste tutvustamist. Täiesti uus valdkond on meie jaoks aktiivõppe programmide ettevalmistamine, millega soovime toetada koolide loodusteaduste ja füüsika õpetajaid ning motiveerida noori valima reaal- ja tehnikaalasid oma tulevaseks elukutseks. Kust mujalt see uus põlvkond kosmoseteadlasi ikka tuleb, kui me neid ise ette ei valmista.



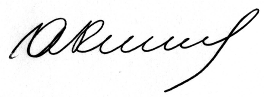
Anu Reinart
Direktor

Tõraveres
veebruar 2014

Foreword

This year the work of our students, researchers and engineers reached higher level than ever before in the direct meaning of the word. On May 7th, the first Estonian satellite ESTCube-1 was launched on board of the European Space Agency's new launcher Vega to the Low Earth Polar Orbit at 660 km. It is the result of more than five years of cooperation between many Estonian universities and our international partners. Now our technology has proven its quality in space, more than 40 BA theses have been prepared and material for tens of scientific papers has been collected. Even while the scientific mission has not been completed yet, we have already received very positive feedback from media and public. ESTCube-1 programme advisor, head of our Space Department Mart Noorma has been awarded the President of the Republic Educational Award. Also our astronomers may be very proud of their achievements – Elmo Tempel received the President of Republic Young Researcher's Award. Furthermore, the European Space Agency launched its new space telescope GAIA and our astronomers have contributed to this projevt as partners in the GAIA preparation team; now all we need to do is to wait for the first data to analyze.

Last year, two new departments were established in Tartu Observatory on the basis of the former Department of Atmospheric Physics: Departments of Earth Observation and Department of Space Technology. Such structure accords better to our real work and competences. Our brand new laboratories are equiped with many new scientific instruments and will be soon ready to provide new services. The completion of our new Visitor Centre is amongthe milestones of 2013. In the renovated main building we have more space for visitors – students, teachers and guests who are interested in astronomy, application of space technology or modern methods to the environmental monitoring. I hope the new generation of researchers will grow under guidance of our experienced and friendly team.



Anu Reinart
Director

Tõravere
February 2014

1 Ülevaade

1.1 Uurimisteemad ja grandid

1.1.1 Sihtfinantseeritavad teadusteemad

2013. aastal jätkus Tartu Observatooriumis (TO) kolme sihtfinantseeritava teadusteema täitmine.

- Tumeenergia, tumeaine ja struktuuri teke Universumis (teema juht E. Saar) – 236 036 EUR.
- Evolutsiooni hilisfaasis tähtede ja nende ümbriste vaatluslik ja teoreetiline uurimine (teema juht T. Kipper) – 283 121 EUR.
- Taimkatte kvantitatiivne kaugseire (teema juht A. Kuusk) – 80 150 EUR,

1.1.2 Eesti Teadusagentuuri grandid

Eesti Teadusagentuuri kaudu rahastastati nelja Eesti Teadusfondi granti:

- Grant 8290: M. Lang – Kaugseire, metsanduslike andmebaaside ning metsakasvu ja -heleduse mudeli lõimimine pideva metsakorralduse süsteemi poolboreaalsete metsade jaoks – 11 370 EUR.
- Grant 8906: L. Leedjärv – Täheassotsiatsioonide heledaimate tähtede muutlikkuse uuring – 9 364 EUR.
- Grant 8970: J. Kuusk – Optiliste kaugseiremõõtmiste täpsust mõjutavad metroloogilised faktorid – 6 000 EUR.
- Grant 9428: A. Tamm – Galaktiliste ketaste ja sferoidide osakaal Universumis – 7 080 EUR.

Need grandisummad ei sisalda asutuse üldkululõivu. Viimane (20% grantide summast) eraldati otse observatooriumi eelarvesse.

Eesti Teadusagentuur rahastas ka kahte mobiilsusgranti ja kahte personaalset uurimistoetust:

- Mobiilsusgrant ERMOS-32: J. Pisek – Taimkatte grupeerumisindeksi määramine satelliidisensori MERIS mitme vaatesuuna mõõtmisandmetest – 28 215 EUR.
- Mobiilsusgrant ERMOS-35: G. Hütsi – Kosmiline suuremastaabiline struktuur: efektiivne vahend fundamentaalfüüsika kontrolliks – 22 364 EUR.
- Personaalne uurimistoetus PUT232: J. Pisek – Metsa aluspinna struktuur ja hooajaline dünaamika mitme vaatesuuna kaugseirest – 24 480 EUR.
- Personaalne uurimistoetus PUT246: J. Nevalainen – Kuhu kadusid pooled barüonid? – 55 600 EUR.

1.1.3 Euroopa Liidu 7. raamprogrammi projektid

- EL 7. raamlepingu projekt GA 251527 (WaterS). Strateegiline partnerlus "Täiustatud vee kvaliteedi parameetrite määramine optilisest signatuurist" (01.06.2010–31.05.2014): TO koordinaator A. Reinart – 1 954 453 EUR (TO kogumaksumus).
- EL 7. raamprogrammi projekt GA 262733 (ESAIL) "Elektrilise päikesepurje tehnoloogia" (01.12.2010–30.11.2013): TO koordinaator M. Noorma – 202 337 EUR (TO kogumaksumus).
- EL 7. raamprogrammi projekt GA 311970 (FORMIT) "Metsade majandamisvõimalused Euroopas kliimamuutuste mõju leevendusvõimekuse tõstmiseks" (01.10.2012–30.09.2016): TO koordinaator 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 koordinaator A. Reinart – 190 400 EUR (TO kogumaksumus).
- EL 7. raamprogrammi projekt GA 313116 (NANOSAT) "Utilizing the potential of NANOSATellites for the implementation of European Space Policy and space innovation (24 kuud): TO koordinaator M. Noorma – 95 800 EUR (TO kogumaksumus).
- J. Kuusk osaleb põhitäitjana EMÜ projektis 8-2/T11062PKTF "Kliimamuutuste uuringute infrastruktuuri INCREASE rahvusvaheline kasutus", projekti vastutav täitja L. Hallik, EMÜ.

1.1.4 Euroopa kosmoseagentuuri Euroopa koostööriikide programmi projektid

- Projekt ORAQUA "Teenuspõhised optilise radiomeetria rakendused veekeskkonna jaoks (01.12.2011–31.12.2013): A. Reinart – 500 000 EUR (TO kogumaksumus).
- Projekt GAIA "Emissioonjoontega tähtede klassifitseerimine Gaia kataloogis" (01.01.2011–31.12.2013): L. Leedjärv – 199 983 EUR (TO kogumaksumus).

1.1.5 Euroopa Liidu struktuuritoetused

- Infrastruktuuri arendamise projekt (3.2.0201.10–0013) "Tartu Observatooriumi infrastruktuuri arendusprojekt" (01.06.2008–31.12.2014): A. Reinart – 270 760 EUR.
- Teaduse tippkeskuste arendamine (3.2.0101.11–0031) "Dark matter in (Astro)particle Physics and Cosmology" (2011–2015): TO koordinaator E. Saar, projektijuht A. Tamm – 382 135 EUR.

- Keskkonnakaitse ja -tehnoloogia teadus- ja arendustegevus (KESTA) (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 – 57 465 EUR.
- Keskkonnakaitse ja -tehnoloogia teadus- ja arendustegevus (KESTA) (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 – 152 752 EUR.
- Keskkonnakaitse ja -tehnoloogia teadus- ja arendustegevus (KESTA) (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 J. Jaagus (TÜ), TO projektijuht E. Jakobson – 36 105 EUR (projekti kogumaksumus).
- Riikliku tähtsusega teaduse infrastruktuuri kaasajastamine (3.2.0304.11-0395) "Eesti Keskkonnaobservatoorium" (01.01.2012–31.12.2013): juhtpartner Tartu Ülikool, TO projektijuht A. Kuusk – 87 000 EUR.
- Keskkonnatehnoloogia teadus- ja arendustegevuse toetamine (3.2.0801.11-0012) "Aeglaselt kulgevate nähtuste tuvastamise kaugseiremeetodite täiustamine"(23.03.2012–31.12.2014): TO koordinaator U. Peterson – 19 804 EUR.
- Keskkonnatehnoloogia teadus- ja arendustegevuse toetamine (3.2.0801.11-0041) "Eesti kiirguskliima" (23.03.2012–31.08.2015): juhtpartner Tartu Ülikool, TO koordinaator K. Eerme – 60 403 EUR.
- Teadus- ja arendusasutuste teadusaparatuuri ja seadmete kaasajastamine (3.2.0302.11-0290) "Kosmosetehnoloogia labor" (01.07.2011–06.07.2013): M. Noorma – 36 047 EUR.
- Teadus- ja arendusasutuste teadusaparatuuri ja seadmete kaasajastamine (3.2.0302.11-0292) "Satelliidimaajaam" (01.07.2011–06.07.2013): S. Lätt – 74 111 EUR.
- Teadus- ja arendusasutuste teadusaparatuuri ja seadmete kaasajastamine (3.2.0302.12-0427) "Kaugseireaparatuuri testimiskompleks" (01.11.2011–17.12.2013): M. Noorma – 166 000 EUR.
- Teadus- ja arendusasutuste teadusaparatuuri ja seadmete kaasajastamine (3.2.0302.12-0428) "Astronoomiliste vaatluste efektiivsuse tõstmine" (01.11.2011– 17.12.2013): K. Annuk – 100 000 EUR.
- Väikesemahulise teaduse infrastruktuuri kaasajastamine teadusteema (3.2.0301.11-0376) "Tumeenergia, tumeaine ja struktuuri teke Universumis" raames (06.03.2012– 31.12.2013): E. Saar – 63 000 EUR.
- Väikesemahulise teaduse infrastruktuuri kaasajastamine teadusteema (3.2.0301.11-0377) "Taimkatte kvantitatiivne kaugseire" raames (06.03.2012–31.12.2013): A. Kuusk – 39 000 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 – 21 136 EUR.
- Programmi "Teaduse rahvusvahelistumine" algatus (3.2.0601.11-0001) "Eesti osalus Euroopa Lõunaobservatooriumis" (01.08.2010–31.08.2015): L. Leedjärv – 7 208 EUR.

1.1.6 COST projektid

- Spektrimõõtmiste vahendid taimkatte biofüüsikaliste parameetrite ning voomõõtmistornide andmete jaoks Euroopas. COST projekt ES0903 (2009–2013): TO koordinaator – M. Lang.
- Biomass kui potentsiaalne ja konkurentsivõimeline energia allikas Balti mere piirkonnas. INTERREG IV A projekt. Koostöö Ventspilsi Ülikooliga. Kaugseire konsultant M. Lang.

1.1.7 Muud projektid ja lepingud

- Satelliidifotode töötlemine, põldude niitmise analüüs ja fotode täpsuse kirjeldus Põllumajanduse Registrite ja Informatsiooni Ameti (PRIA) tellimusel: K. Voormansik – 1 000 EUR.
- Deklareeritud põllupindade kontroll kaugseirevahenditega. Teadus- ja arendusleping PRIA-ga, Põllumajanduse Registrite ja Informatsiooni Ametiga: U. Peterson – 2 556 EUR.
- Eesti maastike muutuste uuringud ja kaugseire. Riikliku keskkonnaseire programmi allprogramm, Keskkonnaministeerium: U. Peterson – 9 640 EUR.
- SA Eesti Teadusagentuuri teaduse populariseerimise konkursi toetus Eesti tudengisatelliidi programmi elluviimiseks (01.04.2012–31.03.2013): M. Noorma – 15 000 EUR.
- Kosmoseteaduse ja -tehnoloogia populariseerimise programm (Haridus- ja Teadusministeerium) (07.05.2013–30.04.2014): M. Ruusalepp – 14 000 EUR.
- Innovatiivsete aktiivõppeprogrammide loomine Tartu Observatooriumis õpilaste keskkonnateadlikkuse tõstmiseks ja uurimusliku maailmanägemuse kujundamiseks (KIK projekt) (02.2013–10.2014): H. Lätt – 46 000 EUR.

Nende teemade ja projektide raames tehtust leidub põhjalikum ülevaade peatükkides 3–5.

1.2 Töötajad

Observatooriumi töötajaskonnas toimusid mitmed muutused:

- 01. jaanuaril alustas kosmosetehnoloogia osakonnas tööd Aire Olesk, tööleping lõppes 30.06.2013.
- 01. veebruarist asus külastuskeskuse projektijuhi kohale 0,2 koormusega Heli Lätt.
- 08. aprillil asus raamatukogu hoidjana tööle Maret Kivirand.
- 01. maist asus projektide koordinaatori ametikohale Marge Kliimask.
- 01. juunist asusid kaugseire osakonda 0,25 koosmusega tööle Kairi Raabe ja Maris Nikopensius.
- 19. augustil lahkus pensionile observatooriumi kauaegne raamatukogu juhataja Maire Rahi.
- 30. augusti lahkus omal soovil kosmoloogia töörühma teadur Ivar Suisalu.
- 01. septembrist alustas astrofüüsika osakonnas 0,25 koormusega tööd Kristiina Verro.
- 30. septembril lahkus töölt kosmoloogia töörühma teadur Heidi Lietzen.
- 01. oktoobrist asusid kosmoloogia osakonda 0,5 koormusega tööle Olga Tihhonova ja samuti 0,5 koormusega Teet Kuutma.
- 01. novembril asus 0,2 koormusega külastuskeskuses tööle Triin Sumberg ja veekogude kaugseire töörühmas 0,6 koormusega Evelin Kangro.

19. juunil 2013 a kaitses Tartu Ülikoolis edukalt oma doktoriväitekirja kosmosetehnoloogia osakonna teadur Riho Vendt. Doktoritööd juhendasid vanemteadur D.Sc. M. Noorma ja D.Sc. T. Kübarsepp (Tallinna Tehnikaülikool).

Kõigi muutuste tulemusena oli 31. detsembril 2013 Tartu Observatooriumis tööl 104 inimest, neist 61 teadustöötajat ja 17 teadustööd tegevat inseneri ja tehnikut.

1.3 Tunnustused

- Laialdaselt pälvis tunnustust ESTCube-1 meeskonna juht Mart Noorma, kelle juhtimisel saadeti 2013 aasta 7. mail kosmosesse Eesti esimene satelliit.
  1. President Toomas Hendrik Ilves nimetas 2013. aasta Vabariigi Presidendi hariduspreemia laureaadiks tudengisatelliidi ESTCube-1 projektijuhi Mart Noorma.

Vabariigi Presidendi hariduspreemia üleandmine 30. oktoobril 2013. Vasakult: Jaan Kalda, Tiiu Peäske, Eesti Vabariigi President Toomas Hendrik Ilves, Epp Vodja ja Mart Noorma. The winners of the Educational Awards 2013 (October 30th, 2013). From the left: Jaan Kalda, Tiiu Peäske, President of the Republic of Estonia Toomas Hendrik Ilves, Epp Vodja and Mart Noorma (Foto: Arno Mikkor/Presidendi Kantselei).

  2. Eesti Rahvusringhääling valis ESTCube-1 kosmosesse saatmise *Aasta teoks*,
  3. Ajaleht Postimees nimetas Mart Noorma *Aasta Inimeseks*.

- Elmo Tempel sai Vabariigi Presidendi Kultuurirahastu 2013 aasta noore teadlase preemia.

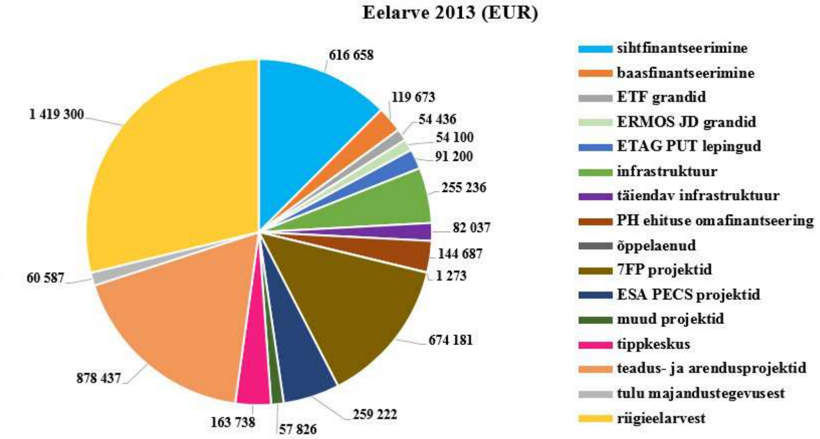
Lea Tempel, Elmo Tempel, president Toomas Hendrik Ilves ja preemia rahastaja, ettevõtja Väino Kaldoja. Lea Tempel, Elmo Tempel, President of the Republic of Estonia Toomas Hendrik Ilves and funder, entrepreneur Väino Kaldoja. (Foto Jelena Rudi/Presidendi Kantselei)

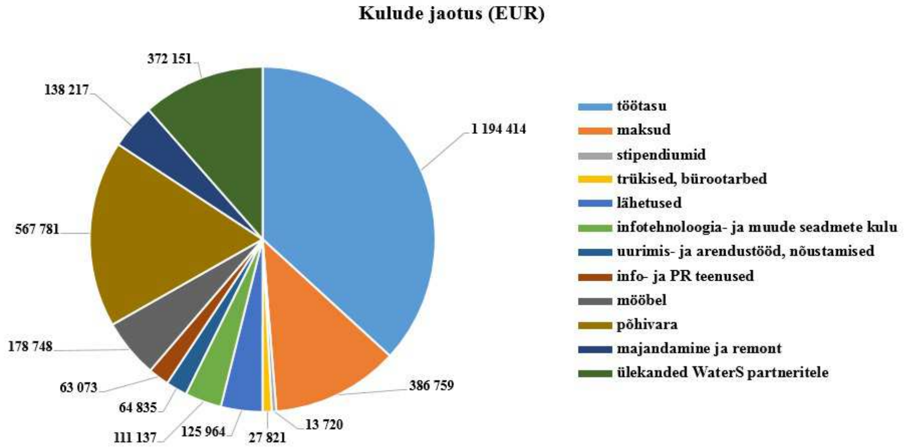
- Akadeemik Jaan Einasto valiti Turu Ülikooli audoktoriks (31.05.2013).
- Akadeemik Jaan Einasto moodustas Tartu Ülikooli sihtasutuse juurde rahvusvahelise omanimelise stipendiumi fondi, millega toetatakse astronoomia ja kosmosetehnoloogia alast teadustööd tegevaid noori teadlasi. Fondi asutamiseks annetas akadeemik 50 000 USD (37 386 eurot). Fondi eesmärk on edendada Eesti innovaatilist arengut, toetades astronoomia ja kosmosetehnoloogia alast rahvusvahelist koostööd Tartu Ülikooli, Tartu Observatooriumi ja teiste maailma ülikoolide ning teadusasutuste vahel, toetades teadmiste populariseerimist noortes teadusliku maailmapildi kasvatamiseks. Pidulik dokumentide allkirjastamine toimus 20. juunil 2013.
- 2. detsembril esitles akadeemik Jaan Einasto Tartu Ülikooli Ajaloomuuseumi valges saalis oma raamatut "Dark Matter and Cosmic Web Story". Raamatu andis välja World Scientific Publishing Co.
- Elar Asuküll sai "Parima posteri auhinna" Kreekas, Ateenas toimunud kaugseire seminaril.

1.4 Eelarve

Tartu Observatooriumi kogu eelarve 2013. aastal oli 3 513 290 EUR, millest 1 419 300 EUR laekus riigieelarvest sihtotstarbeliselt teadus-arendustegevuseks ja sellega seotud projektide läbiviimiseks (eelarve jaotus näidatud aastaraamatu joonisel). Lisaks laekus 2 094 000 EUR ERF toetusi, FP7 projektide, ESA projektide ja muude väliste projektide kaudu (jaotus näidatud lisatud joonisel).

Tulud ja kulud jagunesid järgnevalt:





Observatooriumi teadustöötajate keskmine töötasu 2013. a lõpul oli 1 419 EUR kuus.

1.5 Aparatuur ja seadmed

Euroopa Liidu struktuuritoetuste ”Majanduskeskkonna arendamise rakenduskava” alameetmest ”Teadus- ja arendusasutuste teadusaparatuuri ja seadmete kaasajastamine” rahastatud Tartu Observatooriumi projektide raames soetati järgnevat aparatuuri ja seadmeid:

- TAP21-1. 2013 aastal sisustati kosmosetehnoloogia laboratoorium järgmise eriotstarbelise teadusaparatuuriga:
  1. kliimakamber,
  2. vibratsioonistend,
  3. mõõteseadmed arendatava aparatuuri elektriliste parameetrite kontrolliks ja reguleerimiseks,
  4. vahendid pindmontaaži teostamiseks.
- TAP21-2. Satelliidi maajaam. 2013. aastal rajati operatiivse satelliitkaugseire info vastuvõtmiseks vajalik infrastruktuur:
  1. soetati satelliitside antennisüsteem,
  2. vastuvõtu ja monitooringu aparatuur,
  3. ning ülitäpne tugisageduse genereerimise ja jaotamise süsteem.
- TAP37-1. Kaugseireaparatuuri testimiskompleks. 2013. aastal soetati:
  1. termovaakumsüsteem,
  2. rajati elektromagnetiliste häirete vaba kamber.
- TAP 37-2. Astronoomiliste vaatluste efektiivsuse tõstmiseks soetati 2013 aastal:
  1. vaatlusandmete arhiveerimise ja töötlussüsteem,
  2. aluminiseeriti suure teleskoobi peeglid,
  3. renoveeriti teleskoobi kuppel,
  4. vahetati torni aknad ja uksed,
  5. isoleeriti teleskoobi samba ümbrus ühtlase temperatuuri tagamiseks tornis.
- Koostöös firmaga Hohenheide OÜ (Toomas Kübarsepp, Madis Lepist) valmis InGaAs elementidega lõksdetektor kiirgusallikate absoluutseks radiomeetriliseks kalibreerimiseks lainepikkuste vahemikus 950–1500 nm.
- Teaduse väikemahulise infrastruktuuri kaasajastamiseks hangiti teadusteema SF0180009Bs11 projekti raames mere- ja magevee spektraalse neeldumiskoefitsiendi mõõtesüsteem a-Sphere.
- Tartu Observatooriumi infrastruktuuri arendusprojekti raames soetati renoveeritud peahoonesse:
  1. uus sisustus, sh kontori-, seminari- ja puhkeruumidesse,
  2. teabekeskuse ja arvutiklassi mööbel ning tehnika.
- 1,5-m teleskoobiga vaadeldi 55 ööl ja robotteleskoobiga 63 ööl.

1.6 Teadusnõukogu töö

Lähtudes teadusnõukogu ettepanekust, tegi direktor oma käskkirjaga 2. maist 2013 observatooriumi struktuuris muudatused, moodustades lisaks olemasolevatele osakondadele:

- tugiteenuste osakonna, osakonna juhataja – Tiia Lillemaa,
- haldusosakonna, osakonna juhataja – Enno Ruusalepp,
- külastuskeskuse, keskuse juhataja – Mare Ruusalepp.

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.

11. jaanuari koosolekul arutati institutsionaalsete uurimistoetuste tegemist ja observatooriumi struktuuri muutmist. Samuti arutati 22. veebruaril toimuva strateegiapäeva läbiviimist.

11. veebruari koosolekul otsustati välja kuulutada konkurss kaugseire eriala teadustöötajatele. Arutati ka strateegiapäeva läbiviimisega seoses olevaid küsimusi.

25. märtsi koosolekul toimus konkurss kaugseire eriala teadustöötajatele. Juhtivteaduriks kaugseire erialal valiti Andres Kuusk, Vanemteaduriteks kaugseire erialal valiti Jan Pisek, Urmas Peterson ja Mait Lang. Kinnitati lõppenud ETF grantide aruanded. Aruanded esitasid A. Kuusk (ETF grant nr. 7725), U. Haud (ETF grant nr. 7765) ja E. Saar (ETF grant nr. 8005). Ühehäälselt kinnitati kõik aruanded.

26. augusti koosolekul toimus teekaardi objektide arutelu. Silver Lätt esitas ülevaate ESA-ga seni tehtud koostööst. Algamas on kaks rahvusvahelistumise programmi – algatus COSMOTECH ja GEOKOSMOS. ESA (PECS) programmidest PECS-1 ja PECS-2 rääkis L. Leedjärv ja kosmosetehnoloogia laboratooriumite arenguplaanidest M. Noorma. Kuulutati välja konkurss juba traditsiooniliste nimeliste stipendiumite saamiseks.

16. septembri koosolekul koostati teadusliku nõukogu tööplaan järgnevaks, 2013/2014 tööaastaks. Plaanis on mitmed suuremad üritused: 23.–28. juunini toimub Tallinnas IAU Sümpoosion "Zeldovitši Universum", mais toimub projekti WATERS konverents ning septembris tähistame Tartu Observatooriumi peahoone avamise 50. aastapäeva rahvusvahelise kosmosetehnoloogia konverentsiga.

07. septembri koosolekul toimus nimeliste stipendiumite väljaandmine. Stipendiumite taotlejad esinesid ettekannetega:

Olga Tihhonova: Galaktikate modelleerimine (E.J. Öpiku nimelise stipendiumi taotleja),

Tuule Mall Kull: Päikeseenergia passiivse kasutamise potentsiaal erineva geomeetria ja komponentidega hoonetel Eesti kliimas (J. Rossi nimelise stipendiumi taotleja).

Kairi Raabe: Kas lehtede nurkjaotus Eesti ja Soome lehtpuudel muutub kui funktsioon Päikese kõrgusest ja aastaajast (J. Rossi nimelise stipendiumi taotleja).

Elar Asuküll: Vees lahustunud värvunud orgaanilise aine määramine satelliidipiltidelt (J. Rossi nimelise stipendiumi taotleja).

Tanel Voormansik: Ilmaradari andmete kvaliteeti mõjutavad tegurid ja radariandmete analüüs Sürgavere ilmaradari näidetel (J. Rossi nimelise stipendiumi taotleja).

Mihkel Pajusalu: ESTCube-1 energialahendused (Ch. Villmanni nimelise stipendiumi taotleja).

Pika arutelu tulemusena said stipendiumid Olga Tihhonova, Tanel Voormansik, Kairi Raabe ja Mihkel Pajusalu.

28. oktoobri koosolekul analüüsiti, miks Tartu Observatoorium ebaõnnestus institutsionaalsete uurimistaotluste voorus – kahest taotlusest sai rahastamise ainult üks taotlus oluliselt väiksemal määral. Samuti toimus arutelu edasise tegevuse planeerimisest nii lühiajalises kui pikemas ajaskaalas.

11. novembri koosolekul arutati rahastamata teadustöötajate olukorda observatooriumis ja uue IUT ettevalmistamist.

16. detsembril toimunud koosolekul esitati T. Nilsoni kandidatuur Eesti Vabariigi teaduspreemiate kandidaadiks pikaajalise tulemusliku teadus- ja arendustöö eest. Samuti arutati observatooriumi arengukava muutmise vajalikkust ja tehti ettepanekuid, kuidas seda teha.

1.7 Suhted avalikkusega

Kohe aasta algul, 21. jaanuaril tõid kosmosetehnoloogia insenerid ja tudengid avalikkuse ette oma kätetöö – Eesti esimese satelliidi ESTCube-1 esitlusel Tallinna Teletornis. Satelliit saadeti parlamendi spiikri akadeemik Ene Ergma tunnustavate sõnade ja rohkete heade soovide saatel teele Euroopa Kosmoseagentuuri poole, et ette valmistada tema paigaldamist kanderaketile. Mart Noorma ja kogu satelliidi ehitajate meeskond oli sellest saadik suure avaliku tähelepanu all nii päevalehtede esikaanel kui tele- ja raadiosaadetes.

Kogu Eesti (ja ka paljud välismaised) silmad olid pööratud Tartu Observatooriumi suure saali ekraanile mai esimestel päevadel, kui kosmosejaamast Prantsuse Gujaanas startis ESA uue põlvkonna raketil Vega meie esimene satelliit EstCube-1. Stardi esialgselt määratud päeval, 5. mail, olid Tõraveres kohal kõigi suuremate telekanalite kaamerad ja ETV valmistas ette saadet "Pealtnägija" (eetris ETV 08.05.2013), paraku lükati start halbade ilmastikuolude tõttu edasi. Kõige uudihimulikumad olid aga 7. mai varahommikul uuesti Tõraveres ja said vahetult kaasa elada nii edukale stardile kui esimestele tõenditele, et meie väike satelliit on tööle hakanud, teeb oma tiire ümber Maa ja peab korralikult sidet juhtimiskeskusega Tartu observatooriumis ja Tartu Ülikooli füüsikainstituudis.

Kogu meeskond Tallinna Teletornis ESTCube-1-te teele saatmas The ESTCube-1 team at the Tallinn TV Tower.

Eesti Astronoomia Seltsi egiidi all toimus järjekordne, XVIII astronoomiahuviliste kokkutulek "Kosmoseriik Eesti 2013" Tartu Observatooriumis. Korraldajad olid observatooriumi noored astronoomid T. Liimets, T. Eenmäe, ning üliõpilased K. Verro, R. Matjus ja R. Voog. Traditsioonide järgi perseiidide maksimumi ajal toimuv üritus tõi kokku igas vanuses ja erinevatelt elualadelt inimesi üle Eesti. Tegevust oli palju: kuulati põnevaid ettekandeid, loendati perseiide ja vaadeldi tähti, käidi ekskursioonil Lennundusmuuseumis, kohalikus aktinomeetriajaamas ja observatooriumi uutes laboriruumides ning tutvuti Tõravere teleskoopidega. K. Verro kirjutas kokkutulekust ka artikli, mis on avaldatud *Tähetorni Kalendris 2014*.

2013-ndal aastal vedasid TÜ Teaduskooli hallatavat riiklikku ja ülemaailmset Astronoomiaolümpiaadi Tartu Observatooriumi töötajad T. Sepp, T. Eenmäe ja R. Kipper. Eesti Olümpiaadi riiklik voor toimus taaskord "IX Astronoomia lahtise võistluse" nime all 14. aprillil. Sellest võistlusest võttis osa 28 õpilast, mis on mõnevõrra kesisem kui varasematel aastatel. Osalenutest selekteeriti kümme paremat, kellest said Eesti Rahvuskoondise kandidaadid ülemaailmsele võistlusele. Kahes kolmepäevases treeninglaagris selgus Eesti võistkond ülemaailmsele võistlusele. Lisaks eelmainitutele tuleb tänada ka korraldamisel aidanud kauaegset olümpiaadi eestvedajat Jaak Jaanistet ja üliõpilasi Olga Tihhonovat ja Jasper Kurski.

Eesti võistkond. Vasakult: Taavet Kalda, Carel Kuusk, Jaanika Raik, Kaarel Hänni ja Silver Juvanen. Members of the Estonian team. From the left: Taavet Kalda, Carel Kuusk, Jaanika Raik, Kaarel Hänni ja Silver Juvanen.

Üleilmaailmsele võistlusele 6–14. septemberil sõitsid meeskonna juhtidena T. Sepp, T. Eenmäe ja R. Kipper ning koondise liikmetena Jaanika Raik, Kaarel Hänni ja Carel Kuusk (kõik Tallina Prantsuse lütseumist) nooremas astmes ning Silver Juvanen (Nõo reaalgümnaasiumist) ja Taavet Kalda (Tallinna Gustav Adolfi gümnaasiumist) vanemas astmes. Üleilmne olümpiaad toimus juba 18. korda ning sedapuhku Leedus. Võisteldi kolmes voorus – teooria (astronoomiaülesannete lahendamine), vaatlus (palja silma ja teleskoobiga öötaeva tundmine) ja praktika (üksikute suuremate probleemide lahendamine kasutades andmeanalüüsi). Arvestades fakti, et Eestis kooliprogrammis astronoomiat enam pole, oli Eesti koondise tulemused 1 hõbe (C. Kuusk) ja 2 pronksi (K. Hänni, T. Kalda) ning 2 diplomit (J. Raik, S. Juvanen) suurepärased ning Eesti edestas nii mõndagi suuremat riiki, olles kindlalt kõige tugevam Balti riik.

2013. aastal lõppes Tartu Observatooriumi peahoone kapitaalne renoveerimine ning teaduslikud töötajad kolisid 1,5-m teleskoobi tornist, Stellaariumi ruumidest ja kombinaathoonest välja. Siis aga algas 1,5-m teleskoobi peegli aluminiseerimine, millele järgnes Stellaariumi ruumide remont. Vaatamata nendele häirivatele teguritele käis Tõraveres 154 gruppi ligikaudu 4000 huvilisega. Populariseerimine jätkus ka veebipõhiselt saidi *www.astronoomia.ee* kaudu. Pidevalt ilmus sinna uusi artikleid, uudiseid, juhtnööre, mida vaadelda jne. Autorid on observatooriumi noored teadlased ja kogu lehekülge hooldab Taavi Tuvikene.

Uueks suunaks Tõraveres tehtava teadustöö populariseerimisel on kaugseire võimaluste tutvustamine, selleks valmis aktiivõppeprogramm "Keskkonnaharidusliku aktiivõppe läbiviimise võimalused Tartu Observatooriumis, Tõraveres", mida on tutvustatud koolitustel õpetajatele (21.08.2013) ja Nõo Reaalgümnaasiumi 11-ndate klasside õpilastele. Kokku võttis üritustest osa 60 inimest. Koostatud on rändnäitus "Kosmosetehnoloogia meie igapäevaelus", mida on tutvustatud:

1. Tartu Kutsehariduskeskuses,
2. Tartu Decartes'i Lütseumis,
3. Nõo Reaalgümnaasiumis,
4. Viljandi Gümnaasiumis.

Tartu Observatooriumi teadlased avaldasid kaks raamatut.

- Vanemteadur Uno Veismanni raamatu "Ilmaruumi künnisel " pidulik esitlus toimus Tõraveres 5. septembril
- Akadeemik Jaan Einasto raamatu "Dark Matter and Cosmic Web Story" pidulik esitlus toimus 2. detsembril Tartu Ülikooli Ajaloo Muuseumi valges saalis.

Observatooriumi teadlaste arvukad populaarteaduslikud kirjutised on üksikasjaliselt ära toodud lk. 94, avalikud loengud ja intervjuud lk. 122.

Ilmus Tähetorni Kalender 2014 (90. aastakäik) ja juba traditsiooniline Tähistaeva Kalender 2014. Mõlema kalendri kalendaariumi osa arvutused tegi Alar Puss.

1.8 Tänuavaldused

Meie teadlased on saanud rahalist või muud toetust paljudelt asutustelt üle maailma. Oleme tänulikud kõigile toetajatele, nende nimed leiate inglisekeelsest osast leheküljel 36.

2 Summary

2.1 Research projects and grants

2.1.1 Target financed projects

In 2013, research in the framework of three target financed projects was continued:

- Dark Energy, Dark Matter, and the formation of structure in the Universe (principal investigator E. Saar) – 236 036 EUR.
- Observational and theoretical investigation of stars and their envelopes during advanced evolutionary phases (principal investigator T. Kipper) – 283 121 EUR.
- Quantitative remote sensing of vegetation covers (principal investigator A. Kuusk) – 80 150 EUR.

2.1.2 Estonian Research Council grants

The Estonian Research Council financed four Estonian Science Foundation grant projects from our Observatory:

- Grant 8290: M. Lang – Integration of remote sensing, forest growth and reflectance models with existing databases into continuous inventory systems of hemi-boreal forests – 11 370 EUR.
- Grant 8906: L. Leedjärv – Time-resolved survey of the most luminous stars in stellar associations – 9 364 EUR.
- Grant 8970: J. Kuusk – Study of metrological factors limiting complex optical measurements in remote sensing and atmospheric research – 6 000 EUR.
- Grant 9428: A. Tamm – Share of galactic discs and spheroids in the Universe – 7 080 EUR.

Those amounts do not contain institutional overheads. The latter (20% of each grant) was transferred separately to the budget of the Observatory.

The Estonian Research Council also financed two mobility grants and two personal research fundings:

- Mobility grant ERMOS-32: J. Pisek – Retrieving foliage clumping index from multi-angle MISR measurements – 28 215 EUR.
- Mobility grant ERMOS-35: G. Hütsi – Large-scale structure of the Universe – a powerful probe of fundamental physics – 22 395 EUR.
- Personal research funding PUT232: J. Pisek – ForESt undersTory StructurE and sEasonal Dynamics by multi-angle remote Sensing (EST SEEDS) - 24 480 EUR.
- Personal research funding PUT246: J. Nevalainen – Where have half the baryons gone? – 55 600 EUR.

2.1.3 The European Commission 7th Framework Programme projects

- FP7 project GA 251527 ”Strategic partnership for improved basin-scale Water quality parameter retrieval from optical Signatures (WaterS)” (01.06.2010–31.05.2014) continued: Consortium coordinator A. Reinart – Full cost for TO 1 954 453 EUR.
- FP7 project GA 262733 (ESAIL) ”Electric sail propulsion technology” (01.12.2010–30.11.2013) continued: M. Noorma – Full cost for TO 202 337 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 partner 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 partner A. Reinart – Full cost for TO 190 400 EUR.
- FP7 project GA 313116 (NANOSAT) ”Utilizing the potential of NANOSATellites for the implementation of European Space Policy and space innovation” 24 months: TO partner M. Noorma – Full cost for TO 95 800 EUR.
- J. Kuusk participates in the project 8-2/T11062PKTF An integrated network on climate change research activities on shrubland ecosystems (INCREASE) agreement for transnational access (Estonian University of Life Sciences), PI L. Hallik.

2.1.4 European Space Agency Programme for European Cooperating States

- Project ORAQUA ”Services based on optical radiometry applications for aquatic environment” (01.01.2011–31.12.2013): A. Reinart – Full cost for TO 500 000 EUR.
- Project GAIA ”Emission Line Star Classification in the Gaia Catalogue” (01.01.2011–31.12.2013): L. Leedjärv – Full cost for TO 199 983 EUR.

2.1.5 Financing from the EU Structural Funds

- Project (3.2.0210.10–0013) ”Renovation and development of Tartu Observatory infrastructure” (01.06.2008–31.12.2014): A. Reinart – 270 760 EUR.
- Programme for Centres of Excellence in Research project (3.2.0101.11–0031) ”Dark matter in (Astro)particle Physics and Cosmology” (2011–2015): TO koordinaator E. Saar, project leader A. Tamm – 382 135 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 coordinator A. Reinart, project leader K. Uudeberg – 57 465 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 coordinator A. Reinart, project leader J. Kuusk – 152 752 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 J. Jaagus, University of Tartu, TO coordinator E. Jakobson – 36 105 EUR (Full cost of project).
- Estonian Research Infrastructures Roadmap project (3.2.0304.11-0395) ”Estonian Environmental Observatory” (01.01.2012–31.12.2012): Leading partner University of Tartu, TO project leader A. Kuusk – 87 000 EUR.
- Environmental technology R&D project (3.2.0801.11-0012) ”Improving methods for remote sensing of slowly proceeding phenomena” (23.03.2012–31.12.2014): U. Peterson – 19 804 EUR.
- Project (3.2.0801.11-0041) ”Estonian radiation climate”financed from the European Regional Development Fund and coordinated by the University of Tartu. Partners – Tartu Observatory and Estonian Meteorological and Hydrological Institute: K. Eerme (project manager) – 60 403 EUR.
- Research equipment and facilities project (3.2.0302.11–0290) ”Space Technology Laboratory” (01.07.2011–06.06.2013): M. Noorma – 36 047 EUR.
- Research equipment and facilities project (3.2.0302.11–0272) ”Satellite Ground Station” (01.07.2011–06.06.2013): S. Lätt – 74 111 EUR.
- Research equipment and facilities project (3.2.0302.12-0427) ”Test facilities for remote sensing equipment” (01.11.2011–17.12.2013): M. Noorma – 166 000 EUR.
- Research equipment and facilities project (3.2.0302.12-0428) ”Increasing effectiveness of astronomical observations” (01.11.2011–17.12.2013): K. Annuk – 100 000 EUR.
- Small equipment to the research topic "Dark Energy, Dark Matter and formation of structure in the Universe"(3.2.0301.11-0376) (06.03.2012–31.12.2013): E. Saar – 63 000 EUR.
- Small equipment to the research topic "Quantitative remote sensing of vegetation covers"(3.2.0301.11-0377) (06.03.2012–31.12.2013): A. Kuusk – 39 000 EUR.

- Internationalization of research project (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 – 21 136 EUR.
- Internationalization of research project (3.2.0601.11-0001) ”Participation of Estonia in the European Southern Observatory – ESTO-ESO” (01.11.2011–31.08.2015): L. Leedjärv – 7 208 EUR.

2.1.6 COST projects

- COST project ES0903 ”Spectral Sampling Tools for Vegetation Biophysical Parameters and Flux Measurements in Europe” (2009–2013): TO coordinator M. Lang.
- Potential and competitiveness of biomass as energy source in Central Baltic Sea Region / Pure Biomass (CB56). INTERREG IV project. Ventspils University College. Remote sensing consultant M. Lang.

2.1.7 Some other projects and contracts

- Review of declared agricultural parcels with remote sensing methods, Estonian Agricultural Registers and Information Board: K. Voormansik – 1 000 EUR.
- Review of declared agricultural parcels with remote sensing methods: U. Peterson – 2 556 EUR.
- National programme of environmental monitoring, subprogramme ”Studies on change of Estonian landscapes and remote sensing”, Ministry of the Environment: U. Peterson, 9 640 EUR.
- Estonian Research Council's science popularization grant to support the Estonian student satellite EstCube-1 (01.04.2012–31.03.2013): M. Noorma – 15 000 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; 02.2013–10.2014): H. Lätt – 33 000 EUR.

A scientific report about the activities within these projects and topics will be given in Chapters 3–5.

2.2 Staff

Some changes in the staff of the Observatory took place:

- From Jan 1, Aire Olesk was employed in the department of space technology, her contract ended in June 30,
- From Feb 1, Heli Lätt was employed as a project leader of the Visitor Centre (0.2 workload).
- From Apr 8, Maret Kivirand was employed as the librarian.
- From June 1, Kairi Raabe and Maris Nikopensius were employed in the department of remote sensing (0.25).
- On Aug 19, Maire Rahi, the long time librarian retired.
- On Aug 30, Ivar Suisalu from the department of cosmology resigned willingly.
- From Sept 1, Kristiina Verro was employed in the department of astrophysics (0.25).
- On Sept 30, the research associate in the department of cosmology Heidi Lietzen resigned.
- On Oct 1, Olga Tihhonova and Teet Kuutma were employed in the department of cosmology (both 0.5).
- On Nov 1, Triin Sumberg was employed in the Vistors Centre (0.2) and Evelin Kangro in the working group of remote sensing of water bodies (0.6).

On June 19, 2013 the research associate of the group of Space technology Riho Vendt successfully defended his Ph.D. thesis in the University of Tartu.

As a result of all the changes, the number of people employed by the Tartu Observatory was 104 on December 31, 2013. Of them, 61 are on the position of researchers and 17 on that of research engineers.

2.3 Awards

- ESTCube-1 project leader Mart Noorma who directed the launch of first Estonian satellite on May 7, 2013 was acknowledged several times:
  1. President of the Republic of Estonia Toomas Hendrik Ilves nominated the ESTCube-1 project leader Mart Noorma the Winner of the Educational Award 2013 of the President.
  2. The Estonian Public Broadcasting elected the launch of the satellite *The Deed of the Year*,
  3. The Postimees newspaper nominated him *The Man of the Year*.

Mart Noorma accepting the prize *The man of the Year*. From left: Mart Noorma, Merit Kopli – the Editor-in-Chief of Postimees. Mart Noorma vastu võtmas "Aasta inimese" auhinda. Pildil koos ajaleht "Postimees" peatoimetaja Merit Kopliga (paremal) (Photo: Peeter Langovits/Postimees).

- Elmo Tempel received the prize of the Cultural Foundation of the President as a young scientist of the year 2013.
- Academician Jaan Einasto was elected a honorary doctor of the University of Turku (31.05.2013).
- Academician Jaan Einasto established an international Jaan Einasto stipend fund at the foundation of the University of Tartu. This fund supports young scientists in the fields of astronomy and space technology. For establishing the fund Academician Jaan Einasto donated 50 000 USD (37 386 EUR). The object of the fund is to advance the innovative

development of Estonia, supporting the international cooperation between the University of Tartu, the Tartu Observatory and other world universities and scientific institutions in astronomy and space technology, supporting also the popularization of knowledge to cultivate the scientific world vision in young persons. The festive signing of the documents took place on June 20, 2013.

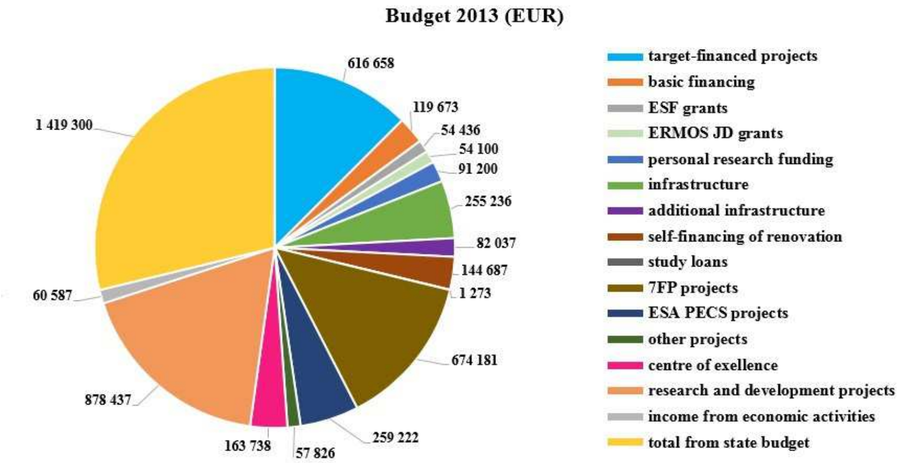
- On Dec 2, Academician Jaan Einasto presented his book ”Dark Matter and Cosmic Web” in the White Hall of the University of Tartu History Museum. The book was published by the World Scientific Publishing Co.

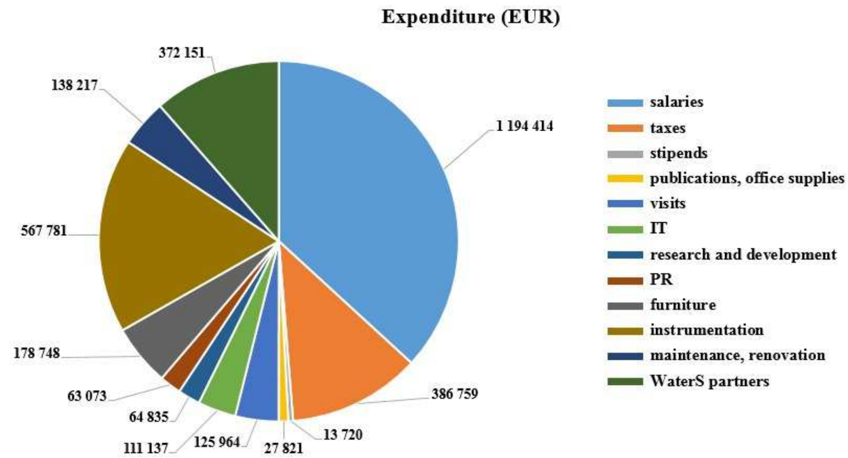
Jaan Einasto at his book presentation. Jaan Einasto oma raamatu pidulikul esitlusel.

- Elar Asuküll was awarded the best poster award at the remote sensing meeting in Creece, Athens.

2.4 Budget

Total budget of Tartu Observatory in 2013 was 3 513 290 EUR, where 1 419 300 EUR are from governmental funding for the research and related projects (figure in annual report). Additional 2 094 000 EUR are from European Regional Fund, FP7, ESA and other projects (figure represent the distribution of total budget).





The mean monthly salary of researchers was approximately 1 419 EUR by the end of 2013.

2.5 Instruments and facilities

Tartu Observatory was successful in obtaining financing for several projects from the subprogramme ″Modernization of the research apparatus and equipment″ of the implementation plan of the European Union structural funds "Development of the economic environment":

- TAP21-1. Space technology Laboratory was equipped in 2013 with new facilities:
  1. climatic chamber,
  2. vibration testing system,
  3. instruments for measuring and controlling of electrical parameters of devices etc.
- TAP21-2. Satellite ground station. To establish the infrastructure for a ground station of satellite communication we obtained:
  1. a 3-m diameter parabolic and yagi antennas with mounts and positioners,
  2. ground station for satellite and amateur radio communication,
  3. reference frequency generation and distribution system for station.
- TAP 37-1. Test facilities for remote sensing equipment. In 2013 the equipment for testing the equipment in thermal vacuum environment and a shielded anechoic chamber for testing electromagnetic compatibility were installed.
- TAP 37-2. For increasing effectiveness of astronomical observations during the year 2013:
  1. all the mirrors of 1.5-m telescope were aluminized,
  2. the telescope foundation was isolated in order to obtain stable temperature,
  3. the spectrograph was rebuilt,
  4. the integrated system for archiving the observation results was prepared.

  In the framework of the small equipment programme related to the target financed topics:
- Spectrophotometer a-Sphere was purchased for measurement of optical absorption of liquids in lab and field environment at depth of up to 100 m.
- In collaboration with Hohenheide OÜ (Toomas Kübarsepp, Madis Lepist) a trap detector based on InGaAs elements was built for absolute radiometric calibration of radiation sources in the wavelength range of 950–1500 nm.
- Renovation and development of Tartu Observatory infrastructure and furnishing the main building (conference room, studies, visitor center, cafeteria etc) took place.

2.6 Scientific Council

According to the proposal of the Scientific Council, there are three additional departments in the structure of observatory:

- department of support services, head of department – Tiia Lillemaa,
- management department, head of department – Enno Ruusalepp,
- visitor center, head of department – Mare Ruusalepp.

The members of the Tartu Observatory Scientific Council in 2013 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.

Scientific Council had 9 meetings in 2013.

On Jan 11, the council discussed the possible institutional research funding and the change in the structure of the observatory. Also the conducting of the strategy day on Feb 22 was discussed.

On Feb 11, the council decided to declare the contest the posts of the researchers in remote sensing. Again, the conducting of the strategy day on Feb 22 was discussed.

On March 25, the contest the posts of the researchers in remote sensing took place. Andres Kuusk was elected leading research associate, Jan Pisek, Urmas Peterson and Mait lang were elected senior research associate. The reports of the finished ETF grants were certified unanimously: A. Kuusk (ETF grant no 7765), U. Haud (ETF grant no 7765) and E. Saar (ETF grant no 8005).

On Aug 26, the objects of the road map were discussed. Silver Lätt presented an overview of the collaboration with ESA. Two programmes of the internationalization are about to begin: COSMOTECH and GEOKOSMOS. Laurits Leedjärv reported on the programmes PECS-1 and PECS-2. Mart Noorma reported on the development plans of the labs of space technology. The contest on the traditional designated stipends was declared.

On Sept 16, The working plan for the scientific council for 2013/2014 was drawn up. There are many big events in the plan: in May the final event of the project WATERS will take place, in June there will be the IAU symposium "The Zeldovich Universe" in Tallinn and in September the conference on space technology will take place in Tartu.

On Sept 7, the winners of the designated stipends were announced. The applicants gave their reports:

Olga Tihhonova: Modelling of galaxies (applied for the E.J. Öpik stipend);

Tuule Mall Kull: The potential of passive use of the solar energy for buildings with different geometry and components in Estonian climate (applied for the J. Ross stipend);

Kairi Raabe: Does the angular distribution of Estonian and Finnish desiduous trees change as a function of Sun's altitude and season? (applied for the J. Ross stipend);

Elar Asuküll: The determination of the coloured organic matter solved in water by satellite photos (applied for the J. Ross stipend);

Tanel Voormansik: The factors having the effect on the quality of weather radar and the analysis of the radar data on the basis of the Sürgavere weather radar data (applied for the J. Ross stipend);

Mihkel Pajusalu: ESTCube-1 energy solutions (applied for the Ch. Villmann stipend).

After a long discussion the stipends were given to O. Tihhonova T. Voormansik, K. Raabe and M. Pajusalu.

On Oct 28, the council analysed why the Tartu Observatory failed in the institutional research funding round – from two applications only one was financed. The further activities were discussed both in the short and long time scale.

On Nov 11, the situation in the observatory and the preparation for the next round of the institutional research funding were discussed.

On Dec 16, T. Nilson was nominated as a candidate for the Estonian Science Prize for a long productive research. Also the need for the modification of the observatory development plan was discussed and the ways how to do it.

2.7 Public relations

Just in the beginning of the year, January 21st 2013, the students and engineers of space technology revealed their masterpiece to public – it was the presentation of the first Estonian satellite ESTCube-1 at the Tallinn TV Tower. On this event, the satellite was dispatched along with all the good credits and wishes from the Speaker of the Parliament of Estonia, the academician Ene

Ergma, to the European Space Agency, where it was prepared for mounting on the launch vehicle. From this moment on, the leader of the project Dr. Mart Noorma and his team have gained a lot of public interest as being introduced on the cover pages of daily newspapers as well as on the national television and radio programmes.

On the first days of May, all attention in Estonia (and some from abroad) was focused on the screen at the main conference hall of Tartu Observatory to see how the new generation carrier VEGA is taking our first satellite ESTCube-1 to orbit from the European Spaceport at French Guiana. On May 5th, at the time initially scheduled for the launch of the satellite, all major Estonian TV stations (including Estonian Public Broadcasting Company with the special program "Pealtnägija" aired later on 08.05.2013) were present with their cameras at Tõravere. Unfortunately the launch was postponed due to the bad weather conditions at the spaceport. The most curious and true fans were present again in the early hours of May 7th to observe the successful launch as well the first proof, that our satellite has come into operation as it was orbiting around the Earth and making good communication with the ground stations at the University of Tartu and Tartu Observatory. The astronomer and amateur radio enthusiast T. Eenmäe was the first one who recognized the call decoded into beeping Morse code and declared with confidence "That's ESTCube-1".

This year the 18th meeting of Estonian amateur astronomers was held in Tartu Observatory from 9th to 13th August (during the maximum of Perseid meteor shower). Celebrating the ESTCube-1 launch, the main topic was "Space Country Estonia 2013". Event was organized by young astronomers and students from the Observatory T. Liimets, T. Eenmäe and students Kristiina Verro, Robert Matjus and Rene Voog.

In 2013 T. Sepp, T. Eenmäe and R. Kipper of the Tartu Observatory were among the organizers of the World Astronomy Olympiad, administered by the Science School of the University of Tartu. The round of the Estonian Olympiad took place again under the name "The IX Open Astronomy Competition" on Apr 14. In this competition 28 pupils participated which is somewhat less that in the previous years. Ten best were selected from the participants and they became candidates for the Estonian National Team to the world olympiad. In the two three-day training camps it became clear who of them got the tickets to the world olympiad. In addition to those mentioned we would like to thank the long-time instigator of these olympiads Jaak Jaaniste and the young students of the Tartu University Olga Tihhonova and Jasper Kursk who helped the organizers.

The team leaders T. Sepp, T. Eenmäe and R. Kipper went to the world competition together with team members Jaanika Raik, Kaarel Hänni and Carel Kuusk (all from the Tallinn French Lycée) in the younger grade and Silver Juvanen (Nõo Real Gymnasium) and Taavet Kalda (Tallinn Gustav Adolf Gymnasium) in the elder grade. The World Olympiad took place already for the 18th time and this time in Lithuania. The competition was held in three stages – theory (solving astronomical exercises), observation (with the naked eye and telescope, knowledge of the night sky) and practice (solution of some bigger problems using the data analyse). Taking into account the fact that there is no curricula of astronomy in Estonian schools, the results of the Estonian team were brilliant – one silver medal (C. Kuusk), two bronze medals (K. Hänni and T. Kalda) and two diplomas (J. Raik and S. Juvanen). Estonian team left behind the teams of some big countries and was definitely the best team of the Baltic countries.

Renovation of the main building of Tartu Observatory ended in 2013, but some reconstruction works in the building of the 1.5-meter telescope began as well as the reconstruction of the Stellaarium rooms. This made very difficult to receive groups of visitors at Tõravere. In spite of all difficulties, about 4000 visitors in about 154 groups were still received in 2013.

Popularization of astronomy in internet was also active. The website *www.astronoomia.ee* was continuously upgraded by young researchers of the Observatory, under the supervision of Taavi Tuvikene.

The new direction in the popularization of research done at Tartu Observatory is the presentation of the possibilities of the remote sensing. A programme "The possibilities to carry out the active study of environmental education in Tartu Observatory" was composed and it was presented to teachers (Aug 21) and to the 11th grade students of the Nõo Real Gymnasium. Altogether 60 persons took place in these presentations. The travelling exhibition "Space technology in our everyday life" was put together and this has been shown in the:

1. Tartu Centre of Vocational Studies,
2. Tartu Descartes Lycée,
3. Nõo Real Gymnasium,
4. Viljandi Gymnasium.

The list of numerous popular-scientific articles by our scientists are presented on the page 94, public lectures and interviews on the page 122.

The 90th issue of the Calendar of the Observatory was published as well as traditional Calendar of the Starry Sky.

2.8 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
- IUPAP Women In Physics Travel Grant (2013)
- 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 Dark Energy, Dark Matter and formation of structure in the Universe Tumeenergia, tumeaine ja struktuuri teke Universumis

E. Tempel koos kolleegidega KBFI-st uurisid võimalikke instrumentaalefekte Fermi LAT andmetest ja leidsid, et küsimus, kas see teleskoop mõõtis tumeaine annihilatsioonisignaali Galaktika keskmest, on veel lahtine. Nad näitasid ka, et positronide suurt hulka kosmilistes kiirtes, mille leidsid nii PAMELA kui AMS kosmoseaparaadid, saaks seletada lokaalse tumeaine annihilatsiooniga.

Jukka Nevalainen veab kadunud barüonaine otsimise projekti. Koos E. Tempeli ja L.J. Liivamäega koostasid nad taevakaardi, kust võiks seda ainet näha kaugemate röntgenkiirguse allikate neeldumisspektris, ja esitasid vaatlustaotluse XMM-teleskoobile. Taotlust peeti huvitavaks, kuid lükati siiski tagasi, ja praegu valmistame ette taotlust NASA teleskoobile Chandra, võttes arvesse eelnevaid märkusi.

G. Hütsi koos kolleegidega uuris Universumi suuremastaabilise struktuuri kaardistamise võimalust uue eROSITA kosmosemissiooni abil ja näitas, et need andmed võivad anda palju kasu nii struktuuri uurimisele kui ka aktiivsete tuumadega galaktikate (AGN) mõistmisele. Nad pakkusid ka välja uue AGN heledusfunktsiooni seletuse. G. Hütsi hindas struktuuri ürgset mitte-Gaussilisust, kasutades maxBCG parvi, ja leidis, et seda pole olemas.

Seth Cohen (Dartmouth College, USA), M. Einasto ja J. Vennik koos Ryan Hickoxi ja Gary Wegneriga (Dartmouth College) jätkasid rikaste galaktikaparvede alamstruktuuride uurimist. Nad uurisid seoseid parvede alamstruktuuride ja tähetekkega galaktikate vahel parvedes. Uurimuses kasutatud parvevalim on suurim, mida niisuguses töös seni kasutatud. Töös leiti korrelatsioon alamstruktuuride olemasolu vahel galaktikaparvedes ja tähetekkega galaktikate hulga vahel: mitmekomponendilistes parvedes on suhteliselt rohkem tähetekkega galaktikaid kui ühekomponendilistes parvedes. Galaktikaparvede ja parvekomponentide äärealades on tähetekkega galaktikaid suhteliselt rohkem kui keskosades. Need tulemused viitavad sellele, et galaktikagruppide ja parvede liitumine mõjutab galaktikate omadusi parvedes, surudes tähetekke alla, või indutseerides täheteket liituvate gruppide äärealadel.

M. Einasto, H. Lietzen ja mitmed teised kosmoloogia grupi teadurid uurisid seoseid galaktikate superparvede morfoloogia ja galaktilise koostise vahel. Töös leiti, et superparvedes on suhteliselt rohkem punaseid, varast tüüpi, madala tähetekkega galaktikaid kui väikese tihedusega ümbruses. Superparved viib nende morfoloogia järgi jagada filamentideks ja ämblikeks. Filament-tüüpi superparvedes on suhteliselt rohkem punaseid, madala tähetekkega galaktikaid kui ämblik-tüüpi superparvedes. Ühe ja sama rikkusega galaktikagruppides on rohkem punaseid, varast tüüpi, madala tähetekkega galaktikaid, kui need grupid asuvad filament-tüüpi superparvedes, võrreldes ämblik-tüüpi superparvedega.

Filament-tüüpi superparvedes on galaktikagruppide peagalaktikate omakiirused suuremad kui ämblik-tüüpi superparvedes. Rikaste superparvede galaktilised koostised on erinevad. Selle töö tulemused näitavad, et superparved on oluliseks keskkonnaks, mis mõjutab neis asuvate galaktikate ja galaktikasüsteemide omadusi.

M. Einasto, E. Tago ja H. Lietzen koostasid Sloani Taevaülevaate seitsmenda väljaande (SDSS DR7) kataloogi põhjal ulatusliku kaugete kvasarite valimi. Valimisse kuulub 22 381 kvasarit, kattes ligi 1/6 kogu taevaalast punanihke vahemikus 1,0 kuni 1,8. Eesmärgiks on avastada ja uurida kõige suuremaid süsteeme Universumis. Kvasarite süsteemide leidmiseks kasutati analoogiliselt galaktikaparvedega klasteranalüüsi meetodit. Võrreldes tulemusi kvasarite ja juhuslike valimite korral ilmnes, et kvasarite süsteemid on kahtlaselt sarnased juhuslikest valimistest saadud süsteemidega – see viitab võimalusele, et kvasarite süsteeme polegi olemas. Tulemused on täpsustamisel.

Tuorla ja Tartu kosmoloogid Pasi Nurmi juhtimisel jätkasid tumeaine halode ja galaktikagruppide omaduste võrdlemist aru saamaks, kas vaatlustest leitud galaktikagruppe võib pidada ühise tumeaine haloga objektideks. See uurimus näitas, et halode ja gruppide omadused on paljuski sarnased, kuid leiti ka terve rida huvitavaid erinevusi, mille põhjuseks võivad olla nii piirangud simulatsioonides galaktikate leidmise poolanalüütilistes skeemides kui ka vaatluslikud piirangud.

M. Einasto jätkas koos E. Saare, V. Martinezi, J. Einasto ja L.J. Liivamäega BAO keradele vastavate struktuuride otsimist meie kosmilises lähiümbruses. Nad uurisid kauguste jaotusi rikastest galaktikaparvedest teiste parvede ning gruppideni, ning leidsid, et selles jaotuses on maksimum kaugusel 120 Mpc. See viitab tiheduse maksimumile vastaval kaugusel. Lähem analüüs näitas, et rikka galaktikaparve A1795 ümber moodustavad galaktikad, grupid ja superparved ligikaudu sfäärilise kihi raadiusega 120 Mpc. See on suurem kui oodatav BAO kera raadius. Töö jätkub, otsime seletust sellele, miks kera raadius just niisugune on.

E. Tempel koos Radu Stoica, E. Saare ja V. Martineziga töötasid välja objekt-punktprotsessidel põhineva meetodi galaktikafilamentide leidmiseks, rakendasid seda SDSS galaktikavalimile ja koostasid filamentide kataloogi. Seda kataloogi on E. Tempel juba kasutanud mitmeks galaktikate ja filamentide vaheliste seoste uurimiseks.

J. Vennik jätkas keskkonnamõjude uurimist lähedastes galaktikagruppides, milles domineerivad hilist tüüpi galaktikad ja mis asuvad kaugustel, kus on nähtavad ka grupi kääbusliikmed. Uurimiseks valitud viie grupi liikmeskonda on täiendatud ca 20 uue kääbusliikmega, mille spektreid vaadeldi Hobby-Eberly teleskoobiga (HET) ja mida fotometreeriti Sloan'i taevaatlase ning Calar Alto teleskoopidega saadud ülesvõtetel. Uued vaatlusandmed on analüüsitud ja tulemused avaldamisele suunatud.

Detailsemalt uuriti kahte suhteliselt rikkama liikmeskonnaga gruppi, vastavalt galaktikate NGC 6962 ja NGC 697 ümber, kaasates erinevatest andmebaasidest kogutud vaatlusandmeid. Valitud grupid on struktuuri ja galaktilise koosluse põhjal otsustades erinevates arengufaasides. NGC 697 grupi heledate liikmete neutraalse vesiniku jaotuses on tugevaid häiritusi ja selle grupi kääbused on aktiivse(ma) tähetekkega kui NGC 6962 grupi liikmed.

B. Deshev jätkas külma gaasi uurimist hillist tüüpi lähisgalaktikates. Koos kolleegidega esitas ta ka vaatlusprogrammi galaktikate spektroskoopiaks põrkuvates galaktikaparvedeks, mis hiljuti edukalt vastu võeti.

U. Haud jätkas tööd Galaktika neutraalse vesiniku (HI) 21-cm raadiojoone ülevaadete andmetega. Ta lõpetas kitsajooneliste HI emissioonipilvede (NHIE) uuringud, lisades kogu taevast haarava Leiden-Argentiina-Bonni (LAB) HI andmetele uue Parkes'i Galaktika ülevaate (GASS) andmed. Koos P.M.W. Kalberlaga Bonni Ülikooli F. W. Argelanderi nim. Astronoomiainstituudist jätkus töö GASS andmestiku kvaliteedi hindamisel. Leiti, et märkimisväärne osa GASS andmestikust on mõjutatud vaadeldud spektrites esinevatest tundmatu päritoluga ebaharilikest signaalikõikumistest vastuvõtja järjestikustes kanalites. On võimalik, et sellised kõikumised viitavad probleemidele GASS vaatlustel kasutatud ühe või mitme vastuvõtja töös, kuid esialgu on probleemi algpõhjuste väljaselgitamine veel pooleli.

Kuna uue GASS ülevaate andmemaht on tunduvalt suurem, kui vanemal LAB andmestikul ja nende kahe ülevaate puhul on kasutatud ka erinevaid vaatlusmeetodeid, siis on GASS andmete kasutamisega pidevalt kaasnenud ka vajadus LAB andmestiku jaoks loodud arvutitarkvara arendamiseks ja täpsustamiseks. Eriti tõsiseks väljakutseks oli NHIE uuringutel kasutatud pilvede leidmise algoritmi kohandamine GASS andmestikule, sest seoses ligi sajakordselt kasvanud Gaussi komponentide arvuga ei olnud vana algoritm enam kasutatav.

V. Maljuto kasutas andmeid tuntud tähdete hajusparvede kohta ja koostas 230-st tähest koosneva kataloogi, mille temperatuurid ja absoluutsed tähesuurused on eriti täpsed ja mis on hädavajalikud Galaktika tähepopulatsioonide uurimisel.

3.1 Search for invisible matter

Most of the matter in the Universe is not seen by telescopes. Dark matter (DM) is the well-known case, but there is also ordinary baryonic matter that is observed at higher redshifts, but cannot be seen in our vicinity. We are searching for both types of hidden matter.

3.1.1 Search for dark matter

Firm evidence for DM is given by various gravitational effects in astrophysics and cosmology. Unfortunately, direct and indirect searches for DM particles have all given either negative or contradictory results. A notable exception to this result is the recent evidence for the gamma-ray excess with the of energy 130 GeV in the Fermi Large Area Telescope (LAT) data. This excess originates predominately from a small region in the Galactic centre and may have a double peak spectral structure. Elmo Tempel with colleagues from the Institute of Chemical and Biological Physics found it last year; this year they studied carefully all the possible instrumental effects and concluded that the case remains open. They also suggested that the cosmic-ray positron excess measured by PAMELA and AMS can be explained by local DM annihilations.

3.1.2 Search for warm-hot intergalactic gas

Simulations suggest that the lost baryonic matter should be in the form of warm-hot tenuous intergalactic gas (WHIM) that should be located in large-scale filaments of galaxies. Jukka Nevalainen is leading a project to detect it in the X-ray absorption spectrum of background sources (blazars, gamma-ray bursts) that shine through the filament gas. L.J. Liivamägi and E. Tempel built luminosity density maps for filaments, where the signal should be expected, and Jukka Nevalainen submitted an observing proposal for the XMM telescope, to use GRB afterglows as beacons. The proposal was considered interesting, but it was rejected. We will submit soon a new proposal for Chandra, and will probably use only blazars as background sources.

E. Saar and L.J. Liivamägi, together with Pekka Heinämäki (Tuorla, Finland), Ricardo Tanausu Genova Santos and José Alberto Rubino Martin (IAC, Spain) and other members of the Planck WG5 were searching for WHIM by the Sunyaev-Zeldovich (SZ) effect, spectral distortions in the cosmic microwave background (CMB) caused by the scattering of the CMB photons by WHIM electrons. Although there are hints for spatially large-scale features in the Planck SZ maps, no local filaments have been detected yet.

3.2 Studies of the structure in the Universe

The properties of the structure of the Universe reflect both the initial conditions (the structure seeds) and the processes that lead to its formation and evolution. These can be examined by different methods – by studying the structure as a whole or concentrating attention on the elements of structure at different scales. Here are our results.

3.2.1 Probing the large scale structure of the Universe

G. Hütsi together with A. Kolodzig, M. Gilfanov, and R. Sunyaev (MPA, Garching) investigated the prospects of using a large sample of active galactic nuclei (AGN) from the upcoming eROSITA all-sky-survey to probe the large-scale structure of the Universe around redshifts $z \sim 1$. Even though the main scientific driver behind eROSITA X-ray survey is to provide a sample of $\sim 10^5$ galaxy clusters, which when complemented with optical follow-up, might potentially become the first Stage IV dark energy probe to be realized, it will also lead to a detection of $\sim$ 3 million AGN in the soft X-ray band ($0.5 - 2.0$ keV). With such a large AGN sample it becomes feasible for the first time to perform detailed studies of AGN clustering as a function of redshift and AGN luminosity. This in combination with our good understanding of the evolution of the underlying large-scale matter distribution, as traced by the dark matter halos, opens up a way to study AGN evolution in the general framework of cold dark matter cosmologies. In particular, one expects to gain substantial insights to AGN triggering mechanisms, their evolution as a function of cosmic environment along with a detailed mapping of the supermassive black hole activity throughout cosmic history.

The above studies do not require detailed redshift information and can already be performed with moderate accuracy photometric redshifts. However, if one has full redshift information available, the AGN sample as provided by eROSITA can be turned to a powerful cosmological probe. In particular, for redshifts between $z = 0.8$ and 2.0, currently uncovered by any of the existing baryonic acoustic oscillation (BAO) surveys, eROSITA AGN sample complemented with redshift information provides a high fidelity BAO measurement: better than $\sim 10\sigma$.

This study has also been generalized to a wider range of possible future X-ray surveys, the results of which will be published during 2014.

As a by-product of the above X-ray-selected AGN studies G. Hütsi together with M. Gilfanov and R. Sunyaev have proposed a simple physically motivated model for the X-ray AGN luminosity function (LF), which turns out to provide a better description for the X-ray LF data than specially tailored analytical forms commonly used in the literature. Since the main assumption of this study is the existence of the scaling relation between the AGN X-ray luminosity and the host halo mass (as hinted by recent observational data), the model makes clear predictions for the X-ray-selected AGN clustering strength. It is interesting that the inferred clustering bias parameters turn out to be in good agreement with AGN two-point function measurements.

G. Hütsi together with A. Mana, T. Giannantonio, J. Weller, B. Hoyle, and B. Sartoris (USM, München) used maxBCG galaxy cluster sample to derive constraints on primordial non-Gaussianity of the local type. The results turned out to be in full agreement with simple Gaussian initial conditions.

G. Hütsi in collaboration with T. Sato, G. Nakamura, and K. Yamamoto (Hiroshima University) investigated the impact of the survey mask on multipole power spectrum measurements (monopole and quadrupole spectrum were considered) and demonstrated how the multipole spectrum from the masked sky is related to the true umasked one. The deconvolution scheme to recover the true underlying spectrum was implemented.

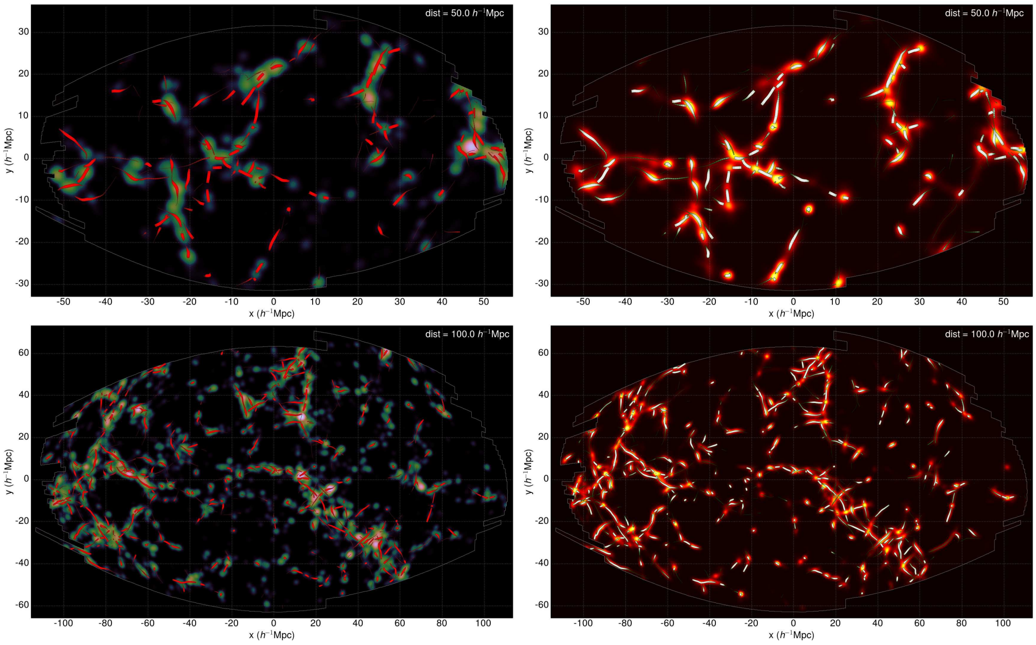
3.2.2 Galaxy filaments

The main feature of the spatial large-scale galaxy distribution is its intricate network of galaxy filaments. This network is delineated by galaxies, and it can be interpreted as a three-dimensional point distribution. E. Tempel in collaboration with R. Stoica (Lille University, France) and E. Saar developed an object point process with interactions (the Bisous model) to trace and extract the filamentary network. This method works directly on the galaxy distribution and does not require any additional smoothing to find the spatial density of galaxies, it only requires fixing the scale of structures. The main advantage of this method is in its probabilistic nature.

The developed filament finder (the Bisous model) is probabilistic in the sense that it gives us the filament detection probability field together with the filament orientation field. Using these two fields, we define the spines of the filaments and extract single filaments from the data. To trace and extract the filamentary network, we applied our model to the presently largest galaxy redshift survey, the Sloan Digital Sky Survey (SDSS). We divided the detected network into single filaments and constructed a catalogue of filaments. The filament catalogue will be made publicly available.

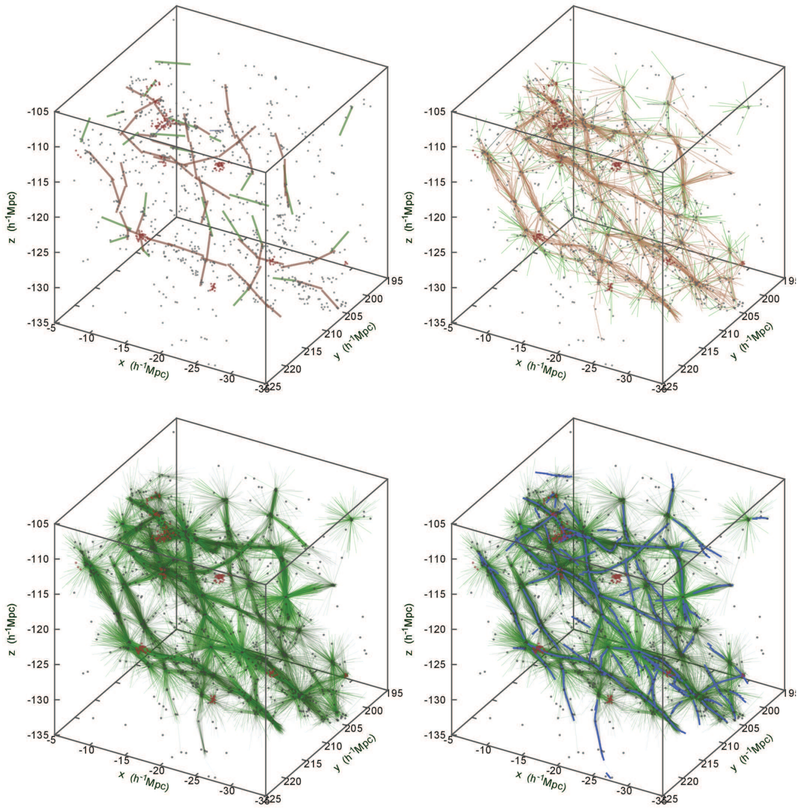
Figure 1 shows an example of detected filaments. Figure 2 gives and example of the filament spines overplotted on a regular luminosity density field.

In collaboration with N. Libeskind (Leibniz Institute for Astrophysics) and Y. Hoffman, E. Tempel showed that the filaments detected with the Bisous model are strongly correlated with the underlying velocity field. This indicates that large-scale filaments defined purely from the distribution of haloes



Joonis 3.1: Sky projections of luminosity density field (left panels) and the visit map (right panels) at distances 50 h^{-1}Mpc (top row) and 100 h^{-1}Mpc (bottom row). Luminosity density field is smoothed with 1 h^{-1}Mpc B_3 spline kernel. For better visualisation, both images are created by summing up projected densities on several planes within range of $-4 \ldots + 4$ h^{-1}Mpc from the indicated distance (using 1 h^{-1}Mpc step) and presented in logarithmic scale. Extracted filaments in the same distance interval are drawn with red and white lines, the width of line denotes the distance between filament and the plane of the image. There is good correspondence between the structures in the luminosity density field and detected filaments. The fly-through movie, showing the full observed volume is available at *http://www.aai.ee/ elmo/sdss-filaments/*.

Heledustihedusvälja (vasakpoolsed paneelid) ja külastuskaardi (parempoolsed paneelid) taevaprojektsioonid kaugustel 50 h^{-1}Mpc (ülemine rida) ja 100 h^{-1}Mpc (alumine rida). Heledustihedusväli on silutud 1 h^{-1}Mpc B_3 splain tuuma kasutades. Parema pildi saamiseks on heledused summeeritud vahemikus $-4 \ldots + 4$ h^{-1}Mpc keskmisest kaugusest ja näidatud logaritmilises skaalas. Leitud filamendid samas kauguste vahemikus on näidatud punaste ja valgete joontega, kusjuures joone laius näitab filamendi kaugust pilditasandist. Heledustihedusvälja struktuurid korreleeruvad kenasti leitud filamentidega. Video, kus me lendame läbi kogu vaatlusruumala, on leitav aadressil *http://www.aai.ee/ elmo/sdss-filaments/*.



Joonis 3.2: Detected filamentary pattern (cylinder axes) in a small sample volume within a pattern of galaxies (points). *Upper left* panel: single MCMC simulation detecting the filamentary pattern; *upper right* panel: the superposition of 25 independent simulations (for visual clarity, we show only half of the simulations). Cylinders are colour-coded as following: 2-connected (red), 1-connected (green), and isolated (grey). Galaxies in groups with 10 or more members are shown with red points; other galaxies are shown with grey points. *Lower* panels show the cylinders from 1000 realisations (it corresponds to the visit map) used to extract the filament spines; in *lower right* panel, the extracted filament spines are also shown with blue lines. The movie, showing the MCMC in action is available at *http://www.aai.ee/ elmo/sdss-filaments/*.
Leitud filamendimuster (baassilindrite teljed) väikeses valimiruumalas koos galaktikatega (punktid). Ülal vasakul paneelil näeme, kuidas üks MCMC simulatsioon leiab filamendimustri, ja ülal paremal näitame 25 sõltumatut simulatsiooni korraga (pool tegelikust 50-st, et pilt selgem oleks). Silindrite värvid on järgmised: 2-seotud (punased), 1-seotud (rohelised), ja isoleeritud (hallid). Galaktikad suuremates kui 10-liikmelistes gruppides on näidatud punaste punktidega, muud galaktikad hallidega. Alumised paneelid näitavad kõiki silindreid 1000-st realisatsioonist (need annavad kokku külastuskaardi), mida kasutati filamendi skeleti leidmiseks. All paremal on see skelett näidatud siniste joontega. Video, mis näitab, kuidas MCMC filamente leiab, on saadaval aadressil *http://www.aai.ee/ elmo/sdss-filaments/*.

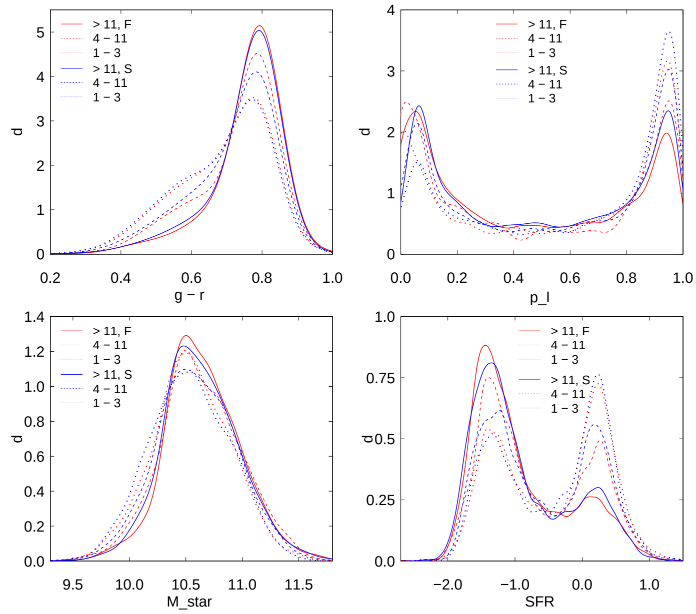
carry more than just morphological information, although the Bisous model does not make any prior assumption on the underlying shear tensor.

E. Tempel and N. Libeskind also used the SDSS filament catalogue to study the correlation between the spin axes of galaxies and the orientation of filaments. The minor axes of ellipticals are found to be preferentially perpendicular to hosting filaments. The spin axes of spiral galaxies are found to be aligned with the host filament. When examined as a function of distance from the filament axis, a much stronger correlation is found for the outer parts of filaments, suggesting that the alignment is driven by the laminar infall of gas from sheets to filaments. When compared with numerical simulations, our results suggest that the connection between the dark matter halo and galaxy spin is not straightforward. Our results provide an important input to the understanding of how galaxies acquire their angular momentum.

3.2.3 Superclusters

M. Einasto together with H. Lietzen and other collaborators studied the morphology and galaxy content of SDSS DR8 superclusters. They found that the fraction of red, early type, low star formation rate (SFR) galaxies in superclusters is higher than among galaxies in a low density global environment. In all environments the fraction of blue, low stellar mass and high star formation rate galaxies in poor groups is larger than in rich groups. According to their morphology, superclusters can be divided into systems of filament and spider type. 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 in 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 a higher density environment than those with small peculiar velocities. There are significant differences between galaxy populations of individual richest superclusters. This study shows the importance of the role of superclusters as a high density environment, which affects the properties of galaxies and galaxy systems in them.

Together with Enn Saar, Vicent Martinez, Jaan Einasto and Juhan Liivamägi Maret Einasto continued the search for shell-like structures in the distribution of nearby rich clusters of galaxies drawn from the SDSS DR8. They found maxima in the distribution of distances from rich galaxy clusters to ot-



Joonis 3.3: Probability density distributions of galaxy $g - r$ colors (upper left panel), probabilities of being of late type (pl, upper right panel), stellar masses (Ms, in log M_{-}), lower left panel), and star formations rates (SFRs, in log M_{-}/yr) for galaxies in groups of different richness in superclusters of filament and spider morphology (red and blue lines). Solid lines show distributions for groups with at least 12 member galaxies, dashed lines correspond to distributions for groups with $4 \leq$ Ngal ≤ 11, and dotted lines to groups with Ngal ≤ 3. Galaktikate värvide, morfoloogiliste tüüpide, täheliste masside ja tähetekkekiiruste jaotused erineva rikkusega galaktikagruppides filament- ja ämblik-tüüpi superparvedes. Punased jooned vastavad galaktikatele filamentides, sinised – ämblikes.

her groups and clusters at distances of about $120h^{-1}$ Mpc suggesting a density enhancement at these distances from rich clusters, and a 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 this distance among our rich cluster sample, and another maximum at a distance of about $240h^{-1}$ Mpc. However, the radius of this shell is larger than expected for a BAO shell ($109h^{-1}$ Mpc), and we do not know yet the cause of that.

3.2.4 Rich clusters of galaxies

Seth Cohen from Dartmouth College (USA), Maret Einasto and Jaan Vennik together with Ryan Hickox and Gary Wegner from Dartmouth College continued the study of the substructure of rich galaxy clusters. They analysed the relationship between the star formation in galaxies, and substructure of galaxy clusters, using data about 109 clusters analysed for substructure by Maret Einasto and her collaborators. This is the first analysis of a large sample of clusters with substructure in which this problem have been studied. Comparing the fraction of star forming galaxies in clusters with several statistical measures of substructure, they found a weak, but significant correlations between the presence of substructure and the fraction of star forming galaxies: multi-component clusters show 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 clustercentric and component-centric distance and decreases with local galaxy number density, being at almost all clustercentric distances and local densities higher in multicomponent clusters than in single-component clusters. These results indicate 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. Relaxed clusters exhibit lower fraction of star forming galaxies due to their more evolved states relative to unrelaxed clusters. This study shows the importance of processes affecting the properties of galaxies during group and cluster mergers.

3.2.5 Groups of galaxies

Pasi Nurmi from Tuorla Observatory (Finland) together with several co-authors from Tartu Observatory continued the comparison of the structure of groups of galaxies from the Sloan Digital Sky Survey seventh data release (SDSS DR7) galaxy and galaxy group catalogues and groups found for the Millennium N-body simulation. They analysed group luminosities, group richnesses, virial radii, sizes of groups and their rms velocities for four volume-limited samples from observations and simulations. Their results showed that the spatial densities of groups agree within one order of magnitude in all samples with a rather good agreement between the mock catalogues and observations.

J. Vennik continued his studies of nearby groups of galaxies, which are dominated by late-type galaxies and in which the faint dwarf galaxies could be detected. About 20 new dwarf members have been found in five selected groups, by means of the long-slit spectroscopy with the Hobby-Eberly telescope, and their surface photometry has been carried out using the frames of the Sloan survey and of our own imaging observations at Calar Alto.

New observational data have been analysed and the results have been submitted for publication. Two relatively rich groups centered on the NGC 697 and NGC 6962 were studied in more detail, using additional data form different databases. According to the structure and galaxy composition those two groups are in different evolutionary states. Bright members of the NGC 697 group show severely disturbed outer HI envelopes and the dwarf satellite galaxies of this group are more actively star-forming than the galaxies of the NGC 6962 group.

3.3 Galaxies

B. Deshev is continuing the investigation of the environmental dependence of the cold gas distribution in late type galaxies in the local universe, based on archival neutral hydrogen interferometric observations and optical data from the SDSS. This work is being done in collaboration with Paolo Serra (CSIRO, Australia). During his visits to IAC, he also continues the work on data processing and analysis of the archival and new data of M33 collected with the INT+WFC at La Palma. As part of a large collaboration including researchers from 5 foreign institutes he is a co-author of a successful proposal for spectroscopy of galaxies in merging clusters at intermediate redshifts.

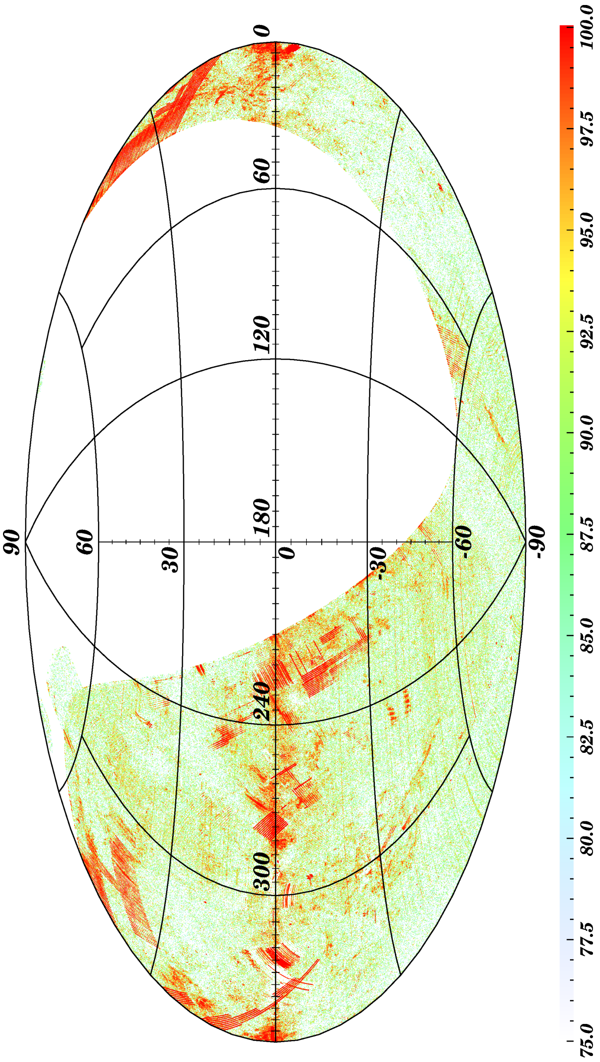
3.4 Our Galaxy

U. Haud continued the studies of the surveys of our Galaxy in the neutral hydrogen (HI) 21-cm radio line. On the one hand, he finished the work on the narrow-lined HI emission clouds (NHIE). These studies were mostly based on the Leiden-Argentina-Bonn (LAB) all-sky database of the 21-cm HI data. In this year the southern sky results were confirmed using the new HI data form the Parkes Galactic all-sky survey (GASS). On the other hand, in collaboration with P. M. W. Kalberla from the Argelander-Institut für Astronomie, Universität Bonn, he continued the study of the quality of the GASS data. For this he used the Gaussian decomposition of the survey data and the statistical analysis of the distributions of the obtained Gaussian parameters. As a result the algorithms for the profile baseline determination and the radio interference mitigation were fine-tuned in Bonn. It was also demonstrated that considerable part of the GASS data contains unusual channel to channel fluctuations of unknown origin. These fluctuations may indicate problems with one or some receivers, used for the observations of the GASS, but the analysis of these features is not finished yet.

As the amount of the new data in GASS is much larger than that of the data from the older LAB database and also the used observation methods are different, the work on the GASS has been accompanied with the continued development and improvement of the computer programs for the analysis of the new data. A serious challenge was the modification of the cloud compilation algorithm, used in the NHIE studies, as with the increase of the number of Gaussians by about two orders of magnitude, compared to the LAB case, the algorithm, used for this analysis so far, was not able to solve the posed task on even the most modern computers in the observatory.

Valeri Malyuto continued development of classification methods for deep surveys of stellar populations in the Galaxy. At the present stage the aim was to create representative sets of templates (the stars with reliable parameters covering the whole HR diagram and metallicity range), which could serve as calibration stars in classification. Special attention was paid to open clusters: the stars from some selected clusters are very suitable for using as homogeneous templates because their well-known ages and metallicities are the same within every cluster, and stellar absolute magnitudes are known too.

In collaboration with S. Zubarev from Ural Federal University (Russia) some selected published stellar catalogues of $B-V$ and V values were analyzed for the open cluster NGC 188, and the errors of these data were estimated from data intercomparisons. The results were used to homogenize the data by their averaging (with the weights inversely proportional to the errors squared). A recently published calibration of Casagrande (2010) with the $B-V$ versus effective temperatures for F-G-K dwarfs and subgiants was then used to produce homogenized effective temperatures for these stars. The homogenized HR diagram (the relationship between the effective temperatures and the absolute magnitudes) was created and analysed.Two lists of about 230 stars with reliable effective temperatures and absolute magnitudes, respectively, were produced. Availability of such stars as templates will help to investigate stellar populations of the Galaxy.



Joonis 3.4: Redder colours indicate stronger channel to channel fluctuations in the HI 21-cm radio line at corresponding sky position. The figure is in galactic coordinates and the numbers at the colour scale are the percentages of the profiles with smaller fluctuations than those, plotted with colours to the right from the corresponding mark on the colour scale. Striped red regions must represent the problems in the observations, whereas the fluctuations in more irregular regions may have more natural causes. Mingi taevapunkti punasem värv viitab tugevamatele signaalikõikumistele antud suunas mõõdetud HI 21-cm raadiojoones. Joonisel on kasutatud galaktilisi koordinaate ja värviskaala juures olevad arvud näitavad, mitu protsenti kõigist vaadeldud vesinikuprofiilidest sisaldavad väiksemaid signaalikõikumisi kui profiilid, mis joonisel on kujutatud värviskaalal vastavast arvust paremale jäävate värvidega. Punasetriibulistes piirkondades on ilmselt tegu mingite vaatluste ajal esinenud tehniliste probleemidega, samas kui korrapäratumad laigud võivad olla tingitud ka looduslikumatest põhjustest.

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

Jahedatest tähtedest jätkati post-AGB, vesinikuvaeste ja punaste ülihiidtähtede uurimist (T. Kipper). Seekord olid vaatluse all RV Tauri tüüpi tähed R Sct ja HD 52961 ning protoplanetaarudu tuum HD 187885. Määrati nende tähtede atmosfääri parameetrid ja keemiline koostis.

T. Nugis koostöös H.J.G.L.M. Lamersiga (Utrechti Ülikool, Holland) alustas suure massiga tähtede optiliselt paksude tuulte tekkepõhjuste väljaselgitamist. Suure massiga tähtede väliskihid muutuvad konvektsiooni ja pulsatsioonide suhtes ebastabiilseiks temperatuuri vahemikus $100000 < T < 250000$ K. Aine väljavool, konvektsioon ja pulsatsioonid on konkureerivad protsessid tähtede väliskihtides ja kõik teoreetilised mudelid peavad neid arvesse võtma. Alustati uute teoreetiliste aine väljavoolu mudelite konstrueerimist, kus aine väljavool formeerub väga sügaval tähe sees vahetult pealpool tuumapõlemistsooni.

A. Aret koostöös kolleegidega Tšehhi Vabariigist, Argentinast ja Brasiiliast uuris massiivsete tähtede massikao erinevaid aspekte. Massiivsed tähed paiskavad oma eluaja jooksul välja tohutu energia ja aine hulga, määrates nõnda galaktikate evolutsiooni. Uuriti vastuolu, mis tekib erinevate meetodite kasutamisel aine väljavoolu määramisel kuumades ülihiidudes: Hα emissiooni modelleerides saadakse reeglina drastiliselt suuremad aineväljavoolu määrad kui küllastamata resonantsjoonte (nt P V ultraviolettjoonte) alusel. Viie O-spektriklassi ülihiiu spektri modelleerimine, kasutades B. Šurlani jt poolt välja töötatud 3-D Monte Carlo kiirguslevi programmi, näitas, et tuule klombilisuse adekvaatne arvestamine lahendab edukalt selle vastuolu.

A. Aret osales hiljuti alanud vaatluskampaanias, mille eesmärgiks on uurida B[e] ülihiidude ümbriseid. Koos kolleegidega Tšehhi Vabariigist, Argentinast, Brasiiliast ja Tšiilist uuris ta viie B[e] ülihiiu optilisi ja lähi-infrapuna spektreid, määrates [Ca II] ja [O I] keelatud joonte ning CO molekulide emissiooniribade abil tähtede ümber pöörlevate ketaste kinemaatika, mis osutus vastavaks Kepleri seadusele. Detailsed ekstsentrilise kaksiktähe GG Car CO-kiirguse uuringud näitasid, et jahe ja tihe ketas ümbritseb kogu süsteemi tervikuna, mitte vaid peatähte.

A. Sapar, R. Poolamäe ja L. Sapar tegelesid põhiliselt uute efektiivsete meetodite väljatöötamisega täheatmosfääride ja tähespektrite mudelarvutuse protsessi kiirendamiseks, eriti tarkvara täiendamisega paralleeltöötluse uute võimaluste väljatöötamisel, kuid ka täheatmosfäärides toimuvate füüsikaliste protsesside uurimisega. Eelmistel aastatel välja töötatud uudne ja väga täpselt kiirgusvoo konstantsust garanteeriv arvutusmeetod baseerub Levenberg-Marquardti vähimruudulisel variatsioonmeetodil järgneva tulemuse parandamisega Broydeni meetodil. Levenberg-Marquardti meetodis arvutatakse jakobiaan lineariseerimismeetodil, kasutades väikesi sobivalt valitud argumentide lõplikke vahesid temperatuuridele mudelatmosfääri standardpunktides. Tarkvara SMART ja Levenberg-Marquardti meetodi teegiversioon (realiseeritud arvutikeeles C) on omavahel seostatud Python skriptiga.

Täheatmosfääride mudelatmosfääride võrgu arvutamisel kasutatakse spektrilahutust 30 000, kusjuures täheatmosfääri kihtide arvuks on 64, spektri arvutusvahemik on kohandatud lainepikkuste vahemikule alates kaugest ultravioletpiirkonnast 11.25 Å kuni kauge infrapunapiirkonnani umbes 48 800 Å, mis on jagatud 144 ühesuguse suhtelise laiusega $2^{1/12}$ spektrilõiguks.

Tähe mudelatmosfääride arvutuste täpsusklassi parandamise meetodiks on rakendamisel nilpotentsed duaalarvud. Nende arvude teine osa, mida nimetatakse infinitesimaalseks osaks, annab automaatselt kasutatud algoritmide täpsed tuletised, mis kõrvaldab vajaduse lõplike vahede meetodi rakendamiseks jakobiaani arvutamisel.

Atomaarseisundite mittetasakaalulise asustatuse arvutamises täheatmosfääri termodünaamilisele tasakaalule mittevastavas kiirgusväljas on välja töötatud relaksatsioonimeetod, mis vastab füüsikalise protsessi toimumisele ajas ja tulenevana sellest asjaolust viib soovitavale lõpplahendile. Arvutusmeetodit testiti ja rakendati iooni CII näitel.

Tarkvara SMART abil jätkati ka valgusindutseeritud triivi tõttu toimuva kaltsiumi isotoopide segregatsiooni uurimisi.

Kosmoseteleskoobi Gaia stardi (19. detsembril 2013) eel valmis ülevaade selle poolt vaadeldavate objektide klassifitseerimise ja astrofüüsikaliste parameetrite määramise süsteemist. Seal sisalduv emissioonijoontega tähti puudutav osa tugineb ka Tartu Observatooriumis projekti „Kiirgusjoontega tähtede klassifitseerimine Gaia kataloogis" raames I. Kolka poolt analüüsitud algoritmidele. Paralleelselt on I. Kolka ja L. Leedjärv näidanud, et kiirgusjoontega sümbiootilised kaksiktähed on parimad objektid kasutamiseks Gaia testimisperioodil madala spektraallahutusega instrumentidega saadavate andmete kvaliteedi hindamisel ja teinud ettepaneku kasutada nimetatud otstarbel 20 välja valitud sümbiootilist tähte.

Täheassotsiatsioonide heledaimate tähtede muutlikkuse uuringu üks eristuv objekt on täht Schulte 12 assotsiatsioonist Cyg OB2. Jätkuvate spektraal- ja heledusvaatluste vahekokkuvõtte põhijäreldusena osutatakse vajadusele arvestada Schulte 12-ga sarnaste tähtede väliskihtide (gaasümbrise) modelleerimisel sfäärilisest sümmeetriast erinevat ainejaotust ja neid kihte iseloomustavate füüsikaliste parameetrite muutlikkust ajas. Jätkus 2011. aastal alanud suure heledusega tähtede heledusmuutuste uurimise projekt (T. Tuvikene, J. Laur, T. Eenmäe, I. Kolka, L. Leedjärv, T. Liimets). New Mexico osariigis, USAs asuva robotteleskoobiga vaadeldi 197 ööl kokku 15 OB assotsiatsiooni ning eriline rõhk pöörati Perseus OB1-le, kattes $5° \times 4°$ suuruse ala.

Uue robotteleskoobiga on 2013. aasta aprilli algusest vaadeldud 58 vaatlusööl, suurem osa nendest öödest olid vaid osaliselt selged. Põhilise osa vaatlustest moodustas eelmainitud täheassotsiatsioonide ja -parvede monitooring, aga ka andmete kogumine bakalaureusetööde jaoks.

A. Puss osales sümbiootiliste kaksiktähtede (CH Cyg, EG And, Z And, AG Dra) ja neile sarnaste objektide (AX Mon, VV Cep) spektraalvaatlustes, samuti LBV tüüpi tähe Cyg OB2 Schulte 12 vaatlustel.

I. Vurm koos kolleegidega Columbia Ülikoolist (USA) uuris gammasähvatuste kiirgust GeV diapasoonis, kasutades detailseteks kiirguslevi arvutusteks välja töötatud Monte Carlo koodi. Leiti, et nimetatud kõrge energiaga kiirguse tekkemehhanism erineb tavapärasest kiirgusest MeV diapasoonis ning pärineb tõenäoliselt lööklainest, mis tekib, kui relativistlik ainevool põrkub gammasähvatuse eellaseks olnud Wolf-Rayet tähe tähetuulega. Tähetuule interaktsioon pehme (MeV) gammakiirgusega rikastab esimese elektronpositron paaridega, mis lööklaine saabudes kuumutatakse relativistlike temperatuurideni ning mis seejärel kiirgavad efektiivselt GeV diapasoonis. Samuti uuris I. Vurm kiirguslikke mehhanisme üliheledates supernoovades (super-luminous supernovae, SLSNe), mille maksimaalne heledus on ~ 100 kõrgem kui harilikes supernoovades.

I. Vurm koos partneritega Oulust modelleeris gammasähvatuste järelhelendust, kasutades välja töötatud numbrilist koodi kiirguslevi arvutusteks relativistlikes lööklainetes. Nimetatud kood suudab ilma lähendusi tegemata käsitleda kõiki antud keskkonnas olulisi kiirguslikke protsesse ja leiab seetõttu kasutust väga erinevates parameetrite piirkondades, võimaldades uurida järelhelendust laias footoni energiate vahemikus (raadiosagedustest teraelektronvoltideni).

J. Pelt jätkas uudsete statistiliste meetodite väljatöötamisega, mida saab kasutada nii astronoomilistes kui ka näiteks meditsiinilistes rakendustes. Algas J. Peldi tihe koostöö Soome teaduse tippkeskusega ReSoLVE Päikese pikaajalise muutlikkuse uuringutes.

A. Sapar jätkas Universumi evolutsiooni alternatiivse stsenaariumi väljatöötamist, mis baseerub võimalikult palju tavafüüsikale. Vaatluslikke põhialuseid on seejuures kolm:

1) Ia tüüpi supernoovade kui kosmoloogiliste standardküünalde vaatlustest leitud vaadeldava tähesuuruse sõltuvus kosmoloogilisest punanihkest.

2) Kosmoloogilise parallaksi määramisest leitud järeldus, et universum on suure tõenäosusega tasaruumiline või vähemalt küllalt lähedane sellele.

3) Graviteeruva aine tihedus universumis, s.o. nähtava barüon-aine ja tu-

meaine summaarne tihedus galaktikates ja nendevahelises aines on tunduvalt väiksem kui tasaruumilise universumi jaoks vajalik kriitiline tihedus umbes 10^{-29} g/cm^3.

A. Sapar on näidanud, et klassikalistest ettekujutustest lähtudes saab tõlgendada tumeenergiat kui tavalist energiaintegraali, millele ei saa omistada mingit lokaliseeritust nagu seda tehakse salapärase tumeenergia kontseptsiooni puhul. Uudse üldistusena on A. Sapar modifitseerinud Friedmanni universumi mudelarvutuste põhivalemit kineetilise energia dominantseks (KED) mudeliks, mis on rakendatav sõltumata 3-ruumi hüperboloidsest, ellipsoidilisest või tasaruumilisest iseloomust.

On uuritud kosmoloogilise neutriinofooni võimalikku rolli tumeainena. Kui eri tüüpi neutriinode keskmine seisuenergia on 1 eV ehk seisumass $1.78{\cdot}10^{-33}$ g, siis selline neutriinofoon annab panuse umbes 7 % kriitilisest tihedusest. A. Sapar tuletas valemid, mis kirjeldavad kosmilisest neutriinofoonist kujuneda võivaid kerasümmeetrilisi neutriinovoogudest moodustuvaid galaktikaid ja koos sfäärilise tihedusjaotusega gaasilise barüonainega kujunevaid mittepöörlevaid galaktikate eellasi.

4.1 Late-type stars

The studies of post-AGB, hydrogen-deficient and luminous red stars were continued by T. Kipper. In 2013 the spectra of the RV Tauri type star R Sct, the extremely metal-poor HD 52961 and a post-AGB star with 21 μm emission feature HD 187885 were analysed.

The spectra of R Sct were analysed in collaboration with V.G. Klochkova (Special Astrophysical Observatory (SAO), Russia). The spectra were obtained with the Nasmyth Echelle Spectrograph of the 6 m telescope of SAO. Some spectra from the NARVAL database (http://tblegacy.bagn.obs-mip.fr/narval.html) were also used.

The fundamental parameters of R Sct were found to be $T_{\rm eff} = 4500\,{\rm K}$, $\log g = 0.0$ and, $\xi_{\rm t} = 4.0\,{\rm km\,s^{-1}}$. The star is metal-poor with [Fe/H]≈ -0.5. The carbon content with respect to that of iron is significantly larger than in the Sun, [C/Fe]=0.84, but there is an evident deficiency of heavy elements. We found no tight correlaton of the chemical abundances to the condensation tempe/-rature of elements. This means that in R Sct the depletion by condensation into dust does not work, with possible exception of Ca and Sc. The lumino/-sity derived from the Hipparcos parallax corresponds to a tip of the red-giant branch or slightly above it. Thus it is possible that R Sct evolved off the early-AGB when it has not yet experienced the third dredge-up, or it is still located on AGB. The peculiarities of spectral features (emissions, line-splitting) and the complicated time-variable radial velocities were also studied.

Another RV Tauri type star, the extremely metal-poor HD 52961 was studied on the basis of the ESPaDOnS spectrograms from the Canada-France-Hawaii Telescope archive. The atmospheric parameters found are: $T_{\rm eff} = 6000\,{\rm K}$, $\log g = 0.5$, $\xi_{\rm t} = 6.8\,{\rm km\,s^{-1}}$, [Fe/H]=$-4.5 \pm 0.2$. The carbon abundance is close to the solar one, [C/H]=-0.17 ± 0.12. At the same time the abundances of heavy refractory elements are very low. The chemical composition and the atmospheric parameters have not changed compared to the first observations of the star about 20 years ago, contrary to expectation of dissolving the peculiarities by mass-loss during a relatively short time. We also found evidence of ongoing mass loss in this post-AGB star with a rate of $\dot{M} \approx 5 \cdot 10^{-6}\,M_{\odot}\,{\rm yr^{-1}}$.

The third post-AGB star analysed, HD 187885, shows an unidentified emission feature at 21 μm in its spectrum. That feature has been observed only in proto-planetary nebulae (PPN) and not in planetary nebulae or in AGB stars. The atmospheric parameters of HD 187885 were found to be: $T_{\rm eff} = 8000\,{\rm K}$, $\log g = 1.0$. The star is metal-poor with [Fe/H]=–0.51. The α-elements, except Ca and Ti, are overabundant as are the elements produced in the s-process. The overabundance of He, found in earlier works, was not

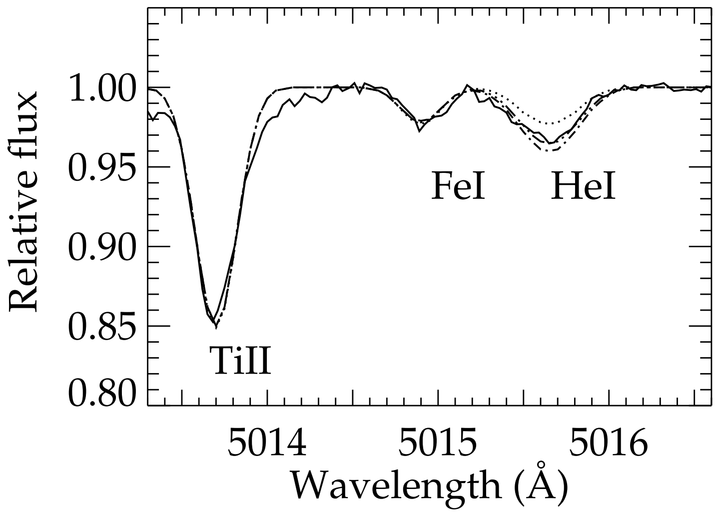


Figure 4.1: The He I $\lambda 5015.7$ line in the spectrum of HD 187885. Solid line – the observed spectrum, other lines correspond to [He/H]=0.0, 0.17 and 0.22. He I $\lambda 5015.7$ joon tähe HD 187885 spektris. Pidev joon – vaatlus, teised jooned vastavad heeliumi ja vesiniku suhtele [He/H]=0.0, 0.17 ja 0.22.

confirmed. The spectrum shows many CS lines forming in multiple expanding shells.

4.2 Hot luminous stars

T. Nugis in collaboration with H.J.G.L.M. Lamers (Utrecht University, the Netherlands) started the studies for clarifying the nature of optically thick (in continuum) winds of massive stars. Previous studies of the authors have been devoted to the study of the structure of optically thick winds and to the uniqueness of solutions.

The massive stars become convectively and pulsationally unstable in the temperature range $100000 < T < 250000$ K (due to the opacity peak). Mass outflow, convection and pulsation are the competitive processes in the outer parts of the stellar envelope and all theoretical models need to take them into account.

T. Nugis and H.J.G.L.M. Lamers started to construct the mass outflow (wind) models where the stellar wind has its origin very deep inside the star, just above the nuclear burning zone. The triggering mechanism of large mass loss of massive stars has many similarities with the superwinds of novae and supernovae.

A. Aret in collaboration with B. Šurlan and other researchers from Czech Republic, Germany and Argentina investigated the previously reported discrepancy between Hα and P V mass-loss diagnostics of hot-star winds – fitting the unsaturated UV resonance lines (e.g. P V) gives drastically lower mass loss rates than those obtained from the Hα emission. Spectra of five O-type Galactic supergiants were modelled using 3-D Monte Carlo radiative transfer code for clumped hot-star winds developed by Šurlan et al. (2012). Obtained good simultaneous fit of the Hα emission (and other Balmer and He II lines) and the unsaturated resonance doublet of P V confirmed that adequate treatment of macroclumping can successfully resolve the problem.

Although several evolved stars fit well to theoretically predicted evolutionary paths, much interest has been paid to the more perplexing transition stages, such as luminous blue variables, B[e] supergiants, and yellow hypergiants, which are still poorly understood. Mass-loss history of the stars is imprinted in the structure and dynamics of their circumstellar material. Recent observations have revealed that the circumstellar material around B[e] supergiants is located in detached disks or rings, sometimes even multiple rings. High variability of density and kinematics of the disks has been reported for several objects. These findings indicate that mass loss happens episodically rather than smoothly via a steady equatorially confined wind as it was suggested earlier. A. Aret was involved in recently initiated observing campaign aimed at the complex diagnostics of circumstellar material around B[e] supergiants to trace the mass-loss history and unveil its possible triggering mechanisms collaborating with researchers from Czech Republic, Argentina and Brazil.

Optical high-resolution spectra of five B[e] supergiants were obtained using the FEROS spectrograph attached to the 2.2m-telescope at ESO in La Silla (Chile), high-resolution near-infrared spectra were obtained with the Phoenix spectrograph attached to the 8m-telescope Gemini-South (Chile) and taken from the ESO archives. Keplerian rotation in the disks of the stars has been traced from inside out using forbidden emission lines to probe inner disk ([Ca II] lines for the innermost regions and [O I] lines at slightly larger radii) and CO emission for the molecular part of the disk. Observations also revealed a strong variability in CO emission in peculiar B[e] supergiants HD 327083 and LHA 115-S 65.

A. Aret together with M. Kraus, M.E. Oksala and D.H. Nickeler (Czech Republic), M. Muratore and L.S. Cidale (Argentina), M. Borges Fernandes (Brazil), and W.J. de Wit (ESO, Chile) studied the kinematics and origin of the disk in the eccentric binary system GG Car, whose primary component is probably a B[e] supergiant, using medium- and high-resolution near-infrared spectra. Analysis of the CO-band emission showed that CO gas forms a cool and dense circumbinary ring in Keplerian rotation with a velocity, projected to the line of sight, of 80 km s^{-1}. Enrichment of ^{13}C confirms a slightly evolved (supergiant) nature of GG Car's primary component. Two possible scenarios of the formation of the circumbinary disk have been discussed: either via non-conservative Roche lobe overflow, which occurred earlier in the evolution of the primary, or the primary of GG Car could have evolved from a classical Be star progenitor. Results of model computations indicated that the second scenario was more likely.

4.3 High-precision modelling of stellar atmospheres and spectra

In 2013 A. Sapar, R. Poolamäe and L. Sapar were predominantly occupied with elaboration of new effective methods for model computations of stellar atmospheres and stellar spectra, especially improving and accommodating the software for new possibilities of parallel processing, but also in study of the physical processes in the stellar atmospheres. The main improvements were made based on the Fortran 90/95 software package SMART. Orienting to the application of the larger set of the multi-core personal computers instead of the local computer network the software has been accommodated for new methods of parallel processing. The Fortran software has been since connected with the Python script for manipulating the core-limited slaves by the host, distributing the model spectral section computation tasks for parallel-processing to them. Now an additional possibility to accomplish the parallel processing also for each variated (a little bit shifted) temperature of model stellar atmosphere layers has been enabled, too.

It deserves to emphasize that Sapar and Poolamäe have elaborated a novel and high-precision method of modelling stellar atmospheres by the use of the non-linear least squares optimization using the Levenberg-Marquardt variational method followed by the loop of single parameter Broyden corrections. In the Levenberg-Marquardt method the Jacobian has been computed using the linearization method for which the small suitably chosen finite differences added to temperatures have been used in the model atmosphere standard points, corresponding to layers. The Broyden method can be accommodated for parallel processing only of spectral sections, but not of the Broyden loop itself.

Switching to the loop of the Levenberg-Marquardt method without the Broyden loop, the parallel-processing of temperature variated model atmosphere layers can also be used in all steps of the loop. Additional parallel processing methods would reduce the time consumption from about an hour per model, including its flux correction loop, to about a minute when applying the computer cluster. Software SMART and the library version of the

Levenberg-Marquardt method (realized in C-language) are connected by the Python script.

In computations of the model stellar atmospheres the spectral resolution 30 000 has been used and the number of model layers has been 64. The spectral interval for model computations has been specified starting from the far ultraviolet spectrum at 11.25 Å and finishing in the far infrared region at about 48 800 Å. The region has been divided into 144 spectral sections, each with relative width $2^{1/12}$ (similarly to 12 octave well-tempered piano). To improve the precision of computation of model stellar atmospheres the nilpotent dual numbers are to be taken into use. The second part of these numbers, named the infinitesimal part, enables to give in it automatically exact derivatives relative to the used algorithms, what removes necessity to apply the method of finite differences in the computations of the Jacobian. Whereas in the SMART software the computations of the absorption coefficients for H and He II have been accomplished using the complex numbers, then in order to apply the dual numbers these must be generalized to dual complex numbers, named by us the duplex numbers. To operate with these, the Fortran module with corresponding data types, operators and functions must be composed for computation of the Jacobian.

Due to non-Planckian stellar radiative field also the populations of the atomic states generally deviate from the local thermodynamic equilibrium values. For computation of these population values, an original relaxation method has been elaborated, which corresponds to the physical scenario of tending to the equilibrated atomic state populations, what is namely the needed final state. As the initial populations of atomic states their local thermodynamic equilibrium values have been used.

In order to accelerate computation procedure of the non-equilibrium state populations by the relaxation method, the double-loop application method has been elaborated. In it the outer loop corresponds to the correction of the radiation field and the inner loop corresponds to application of the relaxation method at fixed radiation field. The algorithm of this method is very compact and the final result has very high precision relative to equality of the electron transitions into and out of each state. The needed initial data for this method is the transition rates due to radiative and collisional transitions of electrons depending on the parameters of each process, or the detailed physical modelling of the atomic species. The relaxation method has been tested and applied for the ion C II.

The light-induced drift in the chemically peculiar Ap and HgMn stellar atmospheres has been studied by the model computations of the calcium spectral lines. The redshifts in its near infrared triplet lines are very interesting. It has been found that the observed isotope anomalies in the chemically peculiar stellar atmospheres can be mainly explicated by the light-induced drift. The list of Ca I, Ca II and Ca III spectral lines, where the isotope splitting, specific mass splitting and the hyperfine splitting for odd isotope ^{43}Ca have been taken into account, has been composed. The model computations with needed very high spectral resolution have been made by the SMART software. In computations of the Ca isotope segregation also the microturbulence has been modelled and applied in iterative computation methods for finding of final equilibrium concentrations of the Ca isotopes. The results of computation demonstrated, that the isotope anomalies of Ca are similar to the anomalies of Hg, including the overabundance of the heaviest isotope ^{48}Ca.

4.4 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" (or VARMAS survey) the spectral and photometric monitoring of the blue hypergiant star Schulte 12 was continued and the preliminary analysis of the time series data was presented by I. Kolka at the conference "Massive stars: From α to Ω". It has been found that: (1) the V/R variability of the Hα emission profile over 6 months points to the essential asymmetry in the gaseous envelope or stellar wind of Schulte 12; (2) the anti-correlated variability of equivalent widths of Si II 6347 and He I 6678 lines indicates that the temperature averaged over the visible stellar disk may be variable; (3) the epochs of maxima of stellar brightness and intensity of He I 6678 absorption line are correlated which can be interpreted as the result of pulsational enlargement of the photosphere. It has been concluded that the common assumptions on the spherically symmetric wind and on the stability of photospheric physical parameters (e.g. $T_{\rm eff}$ may not be justified for modelling of outer layers of Schulte 12, and obviously, of other similar stars.

VARMAS – a time resolved survey of the most luminous stars in selected OB associations was continued by T. Tuvikene, J. Laur, I. Kolka, T. Eenmäe, and L. Leedjärv. In 2013 observations were carried out on 197 nights using the 250-mm T4 telescope of the iTelescope.Net located in New Mexico, USA. From the selected associations the main focus was turned on Perseus OB1 where $5^\circ \times 4^\circ$ field was chosen to cover the whole association. The variability timescales of the OB stars in the survey were analysed with different methods and compared to Hipparcos data.

In 2013, observations for the VARMAS survey were also carried out in twelve nights with Zeiss 600 telescope as part of our long-term monitoring program. In two nights, photometric measurements of variable central star of a newly discovered planetary nebula were done.

The new robotic telescope was used since the beginning of April for 60 ob-

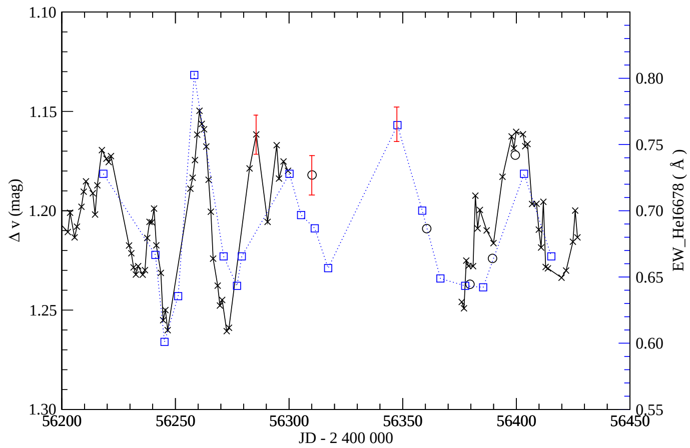


Figure 4.2: *V*-band light variability (crosses denote iTelescope.net T4, New Mexico and circles Zeiss-600, Tartu) of Schulte 12 is qualitatively well correlated with the EW variability of the He I 6678 absorption (blue squares and right-hand y-axis). Heleda ülihiidtähe Schulte 12 heleduse muutlikkus *V*-filtris korreleerub He I 6678 neeldumisjoone ekvivalentlaiusega (sinised ruudud, parempoolne y-telg).

servational nights. Many of those individual nights were clear only for few hours. In majority of nights, observations also covered monitoring areas for the VARMAS survey. In addition, time-resolved observations of hot supergiant stars in the frame of international cooperation and for a bachelor thesis were carried out.

4.5 Preparations for the ESA Gaia mission

The preparations for the Gaia space mission at Tartu Observatory have been continued in the framework of the project "Emission line star classification in the Gaia Catalogue" which is financed by the ESA PECS (Plan for European Cooperating State) programme. The present project contributes to the work of Coordination Unit 8 "Astrophysical Parameters" at the Gaia Data Processing and Analysis Consortium. In 2013, before the launch of Gaia on December 19th, 2013, the comprehensive paper on the Gaia astrophysical parameters inference system was published which includes the paragraph on the special treatment for emission line stars. After the launch, Gaia will soon enter into the period of initial in-orbit commissioning (IIOC). For this period, a dedicated task DPAC-IIOC-250 has been formulated to test on-board the shape of the point spread function and of the dispersion curve in the case of BP and RP spectrophotometric instruments. I. Kolka has demonstrated that for this task emission line objects having the high line intensity contrast over the continuum level and an optimal set of narrow lines are most suitable

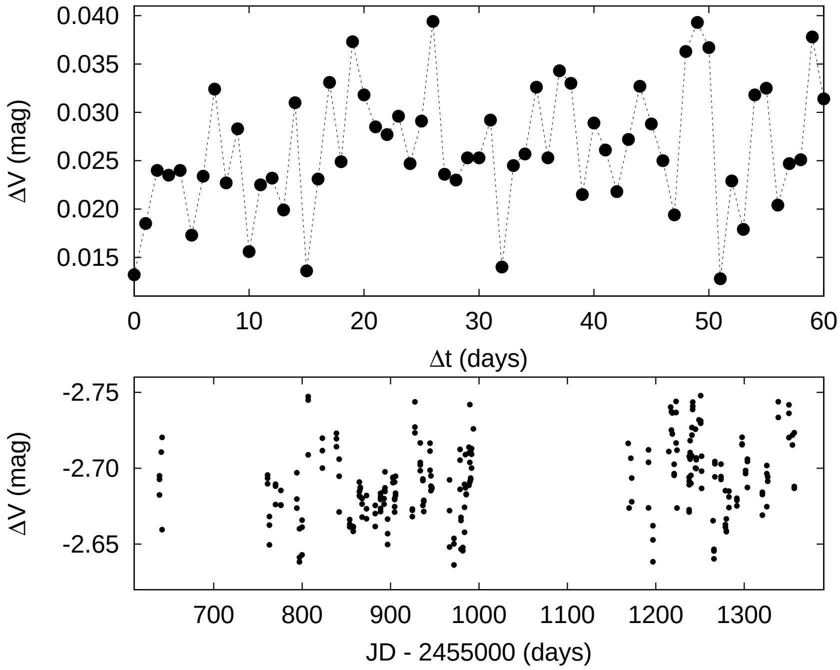


Figure 4.3: Self-correlation graph (upper) and light curve (lower) of HD 14143 (in the open cluster NGC 869). Variability time-scale is found to be 16 days. Tähe HD 14143 heleduskõver (alumine) ja enesekorrelatsiooni graafik (ülemine), millega on tähe muutlikkuses leitud 16-päevane ajaskaala.

ones. He has proposed to use symbiotic stars for that purpose, and selected a list of 20 stars which are of optimal brightness (V = 10...15 mag) and could be observed in April 2014 when Gaia is in the performance verification phase.

4.6 Symbiotic stars and related objects

Analysis of the observations of the yellow symbiotic star AG Draconis was continued by L. Leedjärv and M. Burmeister in cooperation with L. Hric and R. Gális from the Astronomical Institute of the Slovak Academy of Sciences and from the P.J. Šafárik University, Košice. AG Dra undergoes a characteristic symbiotic activity with alternating quiescent and active stages. Periodicity of the outbursts and their relation to the orbital motion in the binary system have been a matter of long-term debate. While there is a general agreement that orbital period of AG Dra is about 550 days, there are variations on shorter time scales (350–380 days) present. Understanding the nature and mechanism of this variability is crucial in order to explain the outburst behaviour of AG Dra and other classical symbiotic stars. A new analysis, involving optical light curve of AG Dra over the last 120 years as well as data on the emission lines over about 15 years has been undertaken by the above named collaboration. Preliminary results indicate that the period around 350 days could be considered as pulsation period of the cool giant. However, it remains unclear whether and which role is played by the magnetic activity as proposed by Formiggini and Leibowitz (MNRAS, 422, 2648, 2012). In particular, their assumption about the retrograde rotation of the cool giant seems to be very artificial, we expect to propose a simpler and more realistic model as a result of our analysis.

A. Puss participated in the observations of symbiotic binary stars (CH Cyg, EG And, Z And, AG Dra) and related objects (AX Mon, VV Cep), and also in the observations of the LBV star Cyg OB2 Schulte 12.

4.7 Peculiar stars

4.7.1 R Aquarii

T. Liimets, K. Verro, I. Kolka together with R. Corradi and M. Santander-Garcia (Spain) continued analysing the wealth of data of the nebulosity and jet complex surrounding the symbiotic star R Aquarii. This is one of the closest stellar jets, which evolution can be studied in great details. Photometric data collection started two decades ago, in 1991, and has continued until present time, with the telescopes in Spain and Chile. Accompanied with the detailed spectroscopical data, recently obtained with the Very Large Telescope, the dataset offers a unique three-dimensional view of the complicated evolution of the clumpy jet. The first results show that the jet structure is constantly changing: loops, spikes, knots are growing, shrinking, braking up, moving non-radially.

4.7.2 V838 Monocerotis

I. Kolka, T. Liimets, T. Kipper together with T. Augusteijn from the Nordic Optical Telescope (NOT) continued photometric and spectroscopic monitoring of the peculiar binary star V838 Mon with the NOT. The peculiar binary still seems to continue with the long-lasting eclipse.

4.7.3 Serpens

T. Liimets together with A.A. Djupvik from NOT carried on the investigation of the dynamical properties of protostellar jets in the active star forming region in Serpens. Multi-epoch near-infrared images (observed with the NOTCam at the NOT) spanning over 10 years are analysed.

4.8 Radiative transfer

I. Vurm together with A.M. Beloborodov and R. Hascoët (Columbia University, USA) studied the origin of GeV emission observed by the Fermi/LAT instrument in a fraction of (usually bright) gamma-ray bursts. The GeV emission typically begins with a delay relative to the main prompt MeV radiation but often while the latter is still going on. Using a detailed Monte-Carlo radiative transfer simulation, they showed that the GeV radiation most likely originates from the forward shock that arises when the relativistic ejecta ploughs into the wind of the Wolf-Rayet progenitor. The wind material ahead of the shock is loaded with electron-positron pairs by the interaction with prompt MeV radiation, making the shock radiatively efficient and highly luminous in the GeV domain via inverse Compton scatterings of the prompt MeV photons by the shocked pairs.

I. Vurm together with B. Metzger, R. Hascoët and A.M. Beloborodov (USA) studied the radiation mechanisms of superluminous supernovae (SLSNe), which exhibit peak luminosities a factor of 100 higher than normal SNe. The spindown power of a newborn strongly magnetized rotating (millisecond) neutron star has been proposed in the literature as a power source for a subclass of hydrogen-poor super-luminous supernovae (SLSNe-I). We have studied this model, in which the pulsar wind of the neutron star inflates a bubble within the supernova ejecta and progressively ionizes it. Under some conditions the ionization front can penetrate the entire ejecta within months of the supernova optical peak, at which time bright X-ray emission should be seen. Such X-ray signature has indeed been observed in at least one SLSNe-I, lending support to the model.

I. Vurm together with T. Pennanen and J. Poutanen (Oulu, Finland) modelled gamma-ray burst afterglow emission, introducing a new kinetic code that calculates broad-band emission from the forward shock. The code self-consistently accounts for all relevant radiative processes, and can be applied to a broad range of parameter regimes and photon energies that span more than 15 orders of magnitude (from radio to TeV).

4.9 Statistical methods in astronomy and climate research

Statistical and computational methods for time series analysis are traditional areas of interest for J. Pelt. The most recent investigations are devoted to breaking of the basic assumptions of analysis – stationarity and linearity. In the context of the sparsely and irregularly measured time series this new level of complexity is a significant challenge.

At first stages of analysis a weak non-stationarity can be taken into account using the so called carrier fit method. This method, developed by J.

Pelt and his collaborators,has found several astronomical and even clinical applications (photometry of the FK Com and II Peg, cross-modulations between lung and heart). Currently we look forward for a new applications in solar physics and geophysics.

To take into account weak non-linearities in time series the recent method of fitting envelopes comes into play. In this method the strict positivity or negativity of certain signal components is taken into account. This allows to study correlations and anti-correlations between two series in coherent ways. Already tried application of this method is the hind casting of total solar irradiance values for these times in the past when satellite observations are not available but some proxies of activity are (sunspot counts, sunspot areas, magnetic measurements etc). Currently the method is used to stitch different satellite observations into compound curves. This allows us to have a homogeneous base data set for further proxy related predictions.

J. Pelt is listed as a key foreign collaborator of the very large project – Centre of Excellence in Research on Solar Long-term Variability and Effects (ReSoLVE) – which got financing and starts its full operation in 2014. This opens an enhanced venue of research where statistical, astronomical, climatological and geophysical expertise of different parties can lead to a new level of synergy. Nigul Olspert got a PhD student position in the Aalto University (Helsinki, Finland) and he will devote himself fully to the ReSoLVE project.

4.10 Physical alternative to the dark energy and dark matter

A. Sapar continued to elaborate the alternative scenario of the universe evolution, avoiding unknown particles and basing on the concepts of traditional physics. There are three important observational foundations:

1) The dependence 'observed stellar magnitude versus the cosmological redshift' of the type Ia supernovae as the cosmological standard candles. To understand better their enormous luminosity, we mention that at the distance of 1 megaparsec their observable visual magnitude is about 6^m.

2) From the cosmological parallax determinations it has been concluded that the universe is flat or very close to flatness. Such conclusion has been made in the Antarctic high-balloon missions BOOMERANG, making high-precision studies of the fine details of the sound-wave structure of the cosmic microwave background, using the power series expansion in spherical functions.

3) The density of the gravitating matter in the universe, i.e. the total mass density of the visible baryonic particles and of the dark matter in the galaxies and in the intergalactic space is considerably less than needed for the flat-space universe, approximately 10^{-29} g $\mathrm{cm}^{-}3$.

A. Sapar has demonstrated, that based on the classical concepts, the dark energy can be treated as the usual energy integral, to which there is no necessity to attribute any localization, as it is done in mysterious dark energy paradigm. He has introduced a novel generalization of the main Friedman equation describing the evolutionary scenario of the universe, constructing the kinetic energy dominated (KED) model universes. The concept is applicable to model universes, which can be hyperboloidal, ellipsoidal or the flat-space ones. In these model universes the characteristic expansion velocity approaches the velocity of light in the future. The present universe is in the transitional stage to this new epoch. The kinetic energy is already dominating in it, and the evolutionary expansion is quicker than it has been usually supposed, but, nevertheless, weakly decelerating.

It has been found, that there is also a possibility to construct a model universe which has ellipsoidal space geometry, but due to its KED nature, is in the eternally expanding state. Such universe can be generated as a strictly local event in the 4-dimensional flat space.

The possible role of the cosmic neutrino background (ν_e, ν_μ, ν_τ neutrinos and antineutrinos) as main contribution to the dark mass has been studied. If their rest-energy is 1 eV or the rest-mass $1.78 \cdot 10^{-33}$ g, then such neutrino background gives contribution about 7 % of the needed critical mass.

In the expanding universe such massive background neutrinos have been cooled down to the non-relativistic velocities and their present velocity is about 50 km s^{-1}. The number density for every neutrino species is about 65 cm^{-3}. The velocity is approximately equal to the Fermi energy of completely degenerate neutrinos at given number density.

A. Sapar derived the equations, which describe the spherically-symmetric neutrino galaxies, formed of the cosmic background neutrinos, and built-up of the radial constant neutrino fluxes. He also derived the equations, describing the non-rotating spherical galaxies with radial neutrino flow added by the baryonic contribution. The differential equation for computation of the radial density in such neutrino dominated galaxies has been derived. The formulae make it evident that due to the neutrino flux contribution radially wide equipotential wells can be formed in such galaxies, which correspond to the observed wide equivelocity plateaus in the galactic virialized stellar velocity curves.

5 Remote sensing Kaugseire

Maismaa kaugseires oli sel aastal pearõhk varem kogutud mõõtmisandmete töötlemisel ja analüüsil ning teoreetilistel uuringutel. Koostöös AS Regioga töötati välja taimkatte primaarproduktsiooni mudel EST_PP. Kasutades ESA MERISe neeldunud fotosünteetiliselt aktiivse kiirguse ja lehepindala hinnanguid hinnati kogu Eesti territooriumi primaarproduktsiooni aastatel 2003–2011. Mudelarvutuste tulemusi võrreldi olemasolevate MODISe GPP/NPP tulemitega ja Eesti riikliku statistika andmetest tuletatud metsade aastaste tüvemassi juurdekasvu ning põllukultuuride saagikuse andmetest tuletatud NPP-ga. Lisaks kasutati võrdlusmaterjalina okas- ja lehtpuude aastarõngaste laiuse andmeid erinevatest maakondadest. Võrdlused näitasid, et erinevate meetoditega hinnatud Eesti keskmised NPP väärtused sobisid omavahel rahuldavalt. Esile tulid probleemid praeguste EST_PP ja MODISe NPP mudelite poolt ennustatud produktiivsuse regionaalse muutlikkusega Eestis ja muutlikkusega aastast aastasse.

Koostöös Slovakkia ja Läti kolleegidega hinnati sealsete metsade lehe- ja okkamassi ning primaarproduktsiooni, kasutades MODISe andmeid. Analüüsi tulemusena järeldati, et Terra MODIS skanneri pildid sobivad pindalalt piisavalt suurte töögipuistute fenoloogia seireks. Vegetatsiooniindeksite ja lehepindala seoses ei esinenud varasemates uurimustes täheldatud asümptootikat suurtel lehepindala indeksi LAI väärtustel. Metsanduslikes rakendustes kasutatava k-lähima naabri klassifitseerimismeetodi kNN abil ennustatud metsa tüvemahu kaardid sisaldavad süstemaatilist tüvemahust funktsionaalselt sõltuvat nihet – nooremate puistute tüvemaht on üle hinnatud ja vanemate puistute tüvemaht on alla hinnatud.

Töötati välja meetod järvede kaldajoone fikseerimiseks keskmise lahutusega satelliidipiltidel. Nii on leitud Euroopa 70 suure järve kaldajoonte asukohad. Kaldajoonte dünaamika annab teavet järvede seisukorra kohta. Hinnangud puistute produktsiooni ning roostike pindala ja fütomassi muutuste kohta veekogude kallastel aastast aastasse pakuvad otsest majanduslikku huvi.

Aastail 2008–2011 helikopterimõõtmistega kogutud metsade peegeldusindikatrissid koos eelmistel aastatel koostatud Järvselja andmebaasiga tegid võimalikuks metsa peegeldusmudeli põhjaliku kontrolli. Ilmnesid probleemid metsa peegeldusindikatrissi modelleerimisel. Mudel ei suutnud reprodutseerida okaspuumetsade peegeldumise tugevat asümmeetriat, mis on ilmselt tingitud puistu struktuuri iseärasustest. Kogu metsa kiirgusrežiimi kujunemisel ja peegeldusindikatrissi kujunemisel on eriti oluline roll koosluse fütomassi grupeerumisel konkreetselt piiritlemata kogumiteks (okaspuu kasvud, puude võrsed, oksad, võrad). Niisuguste taimkatte struktuuri iseärasuste arvestamine kiirgusrežiimi kujundamisel on jätkuvalt suure tähelepanu all. Otsitakse võimalusi metsa struktuuri ja produktsiooni kirjeldamiseks, kasutades selleks nii satelliidi-, lennuki- kui maapealsete optiliste mõõtmiste andmeid. Appi võeti ka Maa-ameti lidarimõõtmised ning mõõdeti Järvselja andmebaasi puistute struktuuri maapealse skaneeriva lidariga.

Väga kõrge ruumilise lahutusega satelliit WorldView-2 mõõtis 29. juulil Järvselja metsi, Peipsit ja Võrtsjärve. Satelliidimõõtmiste toeks ja satelliidisensorite kalibreerimise kontrolliks tegime sünkroonseid valgustatuse ja atmosfääri läbipaistvuse mõõtmisi Järvselja peegeldusetaloni juures ning mõõtsime metsade peegeldusspektreid helikopterilt. Need andmed on alles töötlemisel. Augustis alustas Eesti Keskkonnaobservatooriumi SMEAR-jaama projekti osana spektraalse valgustatuse pidevat registreerimist Järvseljal uus spektromeeter Skyspec. Mitmeid välimõõtmisi tegi veekogude seire töörühm. Koostöös Eesti Mereinstituudiga võeti kasutusele uus spektromeeter Eesti Maa-ameti seirelennukil ja koos Ukraina kolleegidega katsetati Mustal merel uut mõõteseadet multispektraalse ruumhajumise mõõtmiseks vees. *In-situ* mõõtmistega toetati WorldView-2 järvede peegeldusomaduste mõõtmisi. EARLINET ja AERONET mõõtmisvõrkude andmeid kasutades on tuletatud vertikaalselt dünaamilise mitte-merelise aerosooli mudelid satelliidiandmete atmosfäärikorrektsiooniks.

Atmosfääriuuringutes on kesksel kohal projekt "Eesti kiirguskliima". Koostöös Eesti Keskkonnaagentuuriga on koostatud kiirgusvoogude tunnisummade ligi 60-aastane andmekogu. Kui varasemate aastate kohta on olemas ainult andmed integraalsete voogude kohta tollaste sensorite tundlikkuspiirkonnas, siis alates aastast 2004 on mõõdetud ka UV-spektreid. Eriline huvi selle spektripiirkonna vastu on tingitud ultraviolettkiirguse olulisusest biokeemilistes protsessides ja materjalide vananemisel. Koostati andmebaas ultravioletse kiiritustiheduse dooside integreerimiseks registreeritud spektritest päevade ja päeva osade (enne ja pärast keskpäeva, keskpäevased tunnid jne.) ulatuses. On leitud, et rünkpilvede puhul toimub kiirgusvoogude nõrgenemise kõrval sageli nende kuni paarikümne protsendini küündiv võimendamine päikese lähedal paiknevatelt pilvedelt peegeldumise tõttu, mis osalt kompenseerib pilvede varjutavat mõju ja dooside päevast-päeva varieeruvust.

5.1 Remote sensing of vegetation

Within the framework of a common project with AS Regio ESA PECS "Improving the Quality of Greenhouse Gas Inventory in Estonia – Estimating Forest and Wetland Emissions, Removals and Carbon Stocks" T. Nilson together with M. Rennel, M. Hordo, A. Luhamaa, A. Olesk and M. Lang elaborated a model EST_PP to estimate yearly net primary production (NPP) of Estonian vegetation on a 1 km^2 grid. As the main input data to run the model the quantities derived from satellite images (landcover map, fraction of absorbed photosynthetically active radiation (fAPAR) and leaf area index (LAI)), meteorological data (daily air temperature, water vapour pressure, total cloudiness) from the meteodata reanalysis datasets by the HIRLAM were used. The EST_PP model was run for the period from years 2003 to 2011 using the ESA MERIS fAPAR and LAI products. The results of GPP and NPP simulation were compared with the available global MODIS (Moderate Resolution Imaging Spectroradiometer) GPP/NPP product and with the NPP estimates derived from the Estonian statistical data on yearly volume increment in forests and on yield of agricultural crops. The NPP simulation results for coniferous and deciduous forests were also compared with the data from tree ring analyses from different counties. These comparisons showed us that the simulated country average yearly NPP values for Estonian forests agreed satisfactorily with the indirect estimates from other sources, taking into account the rather high uncertainty of the model predictions, uncertainty of forest inventory-based estimates and limited representativity of existing tree ring data. However, problems arise with the ability of present versions of EST_PP and MODIS NPP models to adequately simulate the regional differences of productivity and of variability of productivity in different years. The model needs some modification and the basic light use efficiency principles to be tested in Estonia.

Measurement of spectral reflectance and angular distribution of reflectance over Järvselja forests continued in 2013 with the UAVSpec2 and UAVSpec4SWIR instruments (J. Kuusk, A. Kuusk, M. Lang). On July 29 an airborne campaign was carried out simultaneously with WorldView2 satellite acquisition.

High angular resolution bidirectional reflectance factor (BRF) measurements from flight campaigns carried out in July-August of 2008–2011 over Järvselja forests were processed and georectified. The footprint of a BRF record is calculated using the vector of stand boundaries, the digital surface model (DSM) of 4 m spacial resolution using airborne lidar data provided by Estonian Land Board, and the position and orientation of the sensor. A sample footprint of the BRF-sensor's FOV is shown in Fig. 5.1.

High resolution BRF distribution at several azimuths of the forest stands

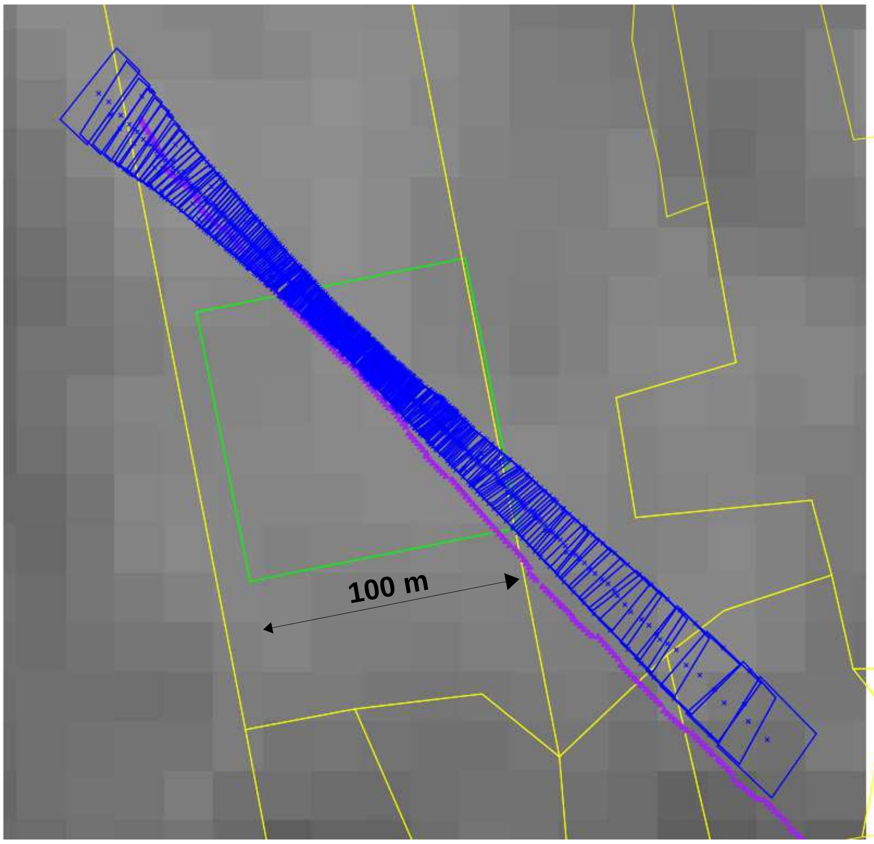


Figure 5.1: A sample footprint of the BRF sensor (blue). The green square is the boundary of the birch stand in the Järvselja data-base, yellow lines are stand boundaries, and red dots are the positions of helicopter during BRF samples. The background is a nadir-looking NIR CHRIS/Proba image. BRF-sensori üks lugem, taustaks CHRIS/Proba lähis-infrapuna pilt. Sinisega on tähistatud BRF sensori pikslid, roheline ruut tähistab Järvselja andmebaasis kirjeldatud kaasikut, kollased on puistute piirid, punased punktid on helikopteri asukohad järjestikuste BRF lugemite ajal.

which are described in the Järvselja database (Kuusk A., Lang M., Kuusk J. 2013). Database of optical and structural data for the validation of forest radiative transfer models. In: Alexander A. Kokhanovsky (Editor), Radiative Transfer and Optical Properties of Atmosphere and Underlying Surface. Light Scattering Reviews 7. Springer, 109–148.) were measured several times. Recorded BRF distributions together with the Järvselja database allow to validate forest reflectance models. A sample BRF distribution of the Järvselja spruce stand in the red spectral band is compared to the model calculations with the FRT model in Fig. 5.2.

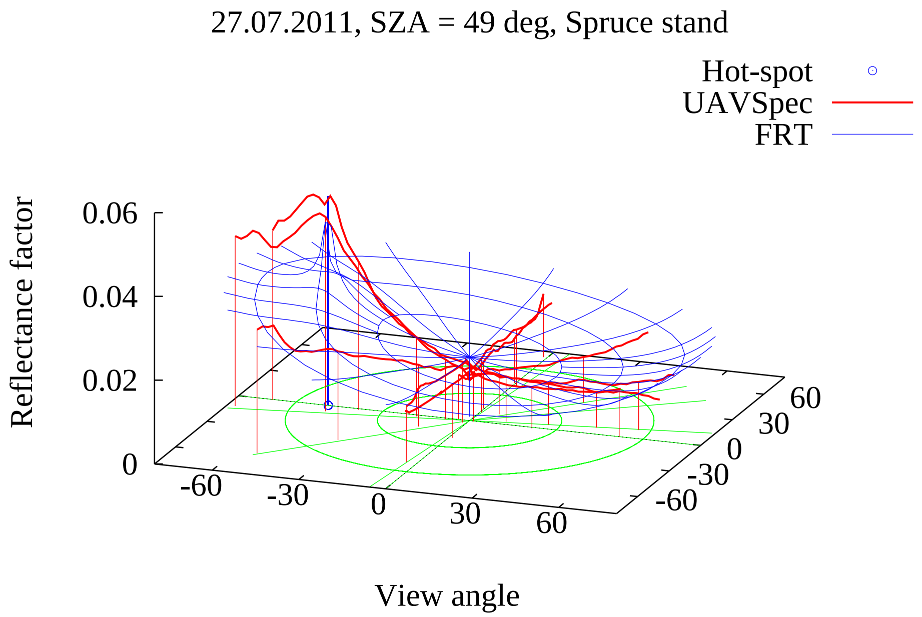


Figure 5.2: BRF of the Järvselja spruce stand in red spectral band; UAVSpec – measurements, FRT – model simulation. Järvselja kuusiku peegeldusindikatriss spektri punases piirkonnas.

For the support of the SMEAR station (Station for Measuring Ecosystem-Atmosphere Relations) of Estonian Environmental Observatory at Järvselja, the special instrument Skyspec was developed in collaboration with Interspectrum OÜ, Estonia. Skyspec is a computer-controlled spectrometer which measures continuously total and diffuse irradiance in the spectral range 300-2200 nm, spectral resolution is 3–15 nm. The Skyspec instrument was installed near the Järvselja reference panel (58^o 16′ 5.98" N, 27^o 18′ 15.43" E) in August and was recording incident fluxes until the end of the vegetation period in late November.

V. Brandýsová (Technical University in Zvolen, Slovakia) and M. Lang studied the options to assess phenology of mature beech forests in Slovakia by using Terra MODIS images based NDVI index. Seasonal change of leaf area index (LAI) of the test stands was measured using below the canopy made digital hemispherical images and using LinearRatio method to calculate canopy transmittance. The analysis revealed that 1) the Terra MODIS images are suitable for phenological observations of sufficiently large beech stands and 2) the relationship between the NDVI and LAI did not indicate the asymptotic shape starting which is reported by many authors for LAI >3.

Figure 5.3: Skyspec spectrometer at Järvselja. Skyspec spektromeetri seadistamine Järvseljal.

M. Lang and M. Mõistus tested the use of airborne lidar data for mapping woody canopy cover in abandoned agricultural fields. Canopy cover (CC) at reference height of 2 m was calculated for 100 m^2 observation units and a raster map of canopy cover was created. The CC is the ratio between the points located higher than the reference height to the total number of points. The boundaries of afforested areas were delineated automatically according to CC > 0.25.

M. Lang studied the applicability of routinely produced global MODIS NPP (primary production of green vegetation) maps for Kurzeme region in Latvia. The MODIS NPP was regressed against two informative variables from forest inventory database – stem volume increment and site fertility. The results showed that the MODIS NPP product has significant systematic errors due to 1) use of coarse resolution meteorological data and 2) classification errors in plant community map which is in the MODIS NPP algorithm used to obtain light use efficiency. It was concluded that the MODIS NPP product is not suitable for regional applications in the Baltic states.

M. Lang, T. Tamm (University of Tartu) ja L. Gulbe (Ventspils University College) analysed k-nearest neighbor classification method (kNN) which is worldwide used in practical applications in forestry. The kNN is based on the in situ measurements in forest and remote sensing data. The study revealed an interesting phenomenon of systematic bias in the predicted stem volume maps. It was found that there exists an underestimation of stem volume in old stands and overestimation of stem volume in young stands. All the used independently developed kNN implementation produces the similar systematic bias. The causes of the systematic bias are not clear yet.

M. Lang in cooperation with company Callista Software OÜ developed a software called HSP Project Manager, which implements the new approach proposed by M. Lang for processing below canopy hemispherical images for canopy gap fraction estimation. The HSP Project Manager is written in Java and does not depend on the computer operating system. The method is based on estimation of the incident radiation above the canopy using the non-obscured sky pixels in canopy gaps. The estimation is carried out with interpolation technique and a sky radiance model. Canopy transmittance image is calculated as the ratio between the below canopy image and the predicted above canopy image. The transmittance data can be used to calculate plant canopy indices e.g. leaf area index and clumpingin other software programmes.

M. Nikopensius tracked seasonal reflectance dynamics of common understory types in RAMI stands, Järvselja, Estonia. K. Raabe tracked seasonal changes in leaf angle distribution as a function of tree height for selected deciduous broadleaf species common to Estonia and Europe.

Clumping index, the measure of foliage grouping relative to a random distribution of leaves in space, is a key structural parameter of plant canopies that influences canopy radiation regimes and controls canopy photosynthesis and other land–atmosphere interactions. Jan Pisek retrieved the clumping index using the original 275 m resolution data of the Multi-angle Imaging SpectroRadiometer (MISR) instrument over a set of sites representing diverse biomes and different canopy structures. For the first time, the MISR derived clumping index values were directly validated with both in-situ vertical profiles and seasonal trajectories of clumping index. Results illustrate that MISR data with 275 m allow clumping index estimates at much more pertinent scales (both spatial and temporal) than previous maps from Polarization and Directionality of Earth Reflectances (POLDER) and Moderate Resolution Imaging Spectroradiometer (MODIS) for modeling local carbon and energy fluxes.

In international collaboration with Miina Rautiainen (University of Helsinki, Finland), Hideki Kobayashi, Rikie Suzuki (JAMSTEC, Japan) and Michael Schaepman (University of Zurich, Switzerland), J. Pisek followed on previous effort at mapping understory reflectance dynamics using multi-angle remote sensing observations. They focused on the validation of their approach against an extended collection of different types of forest sites with

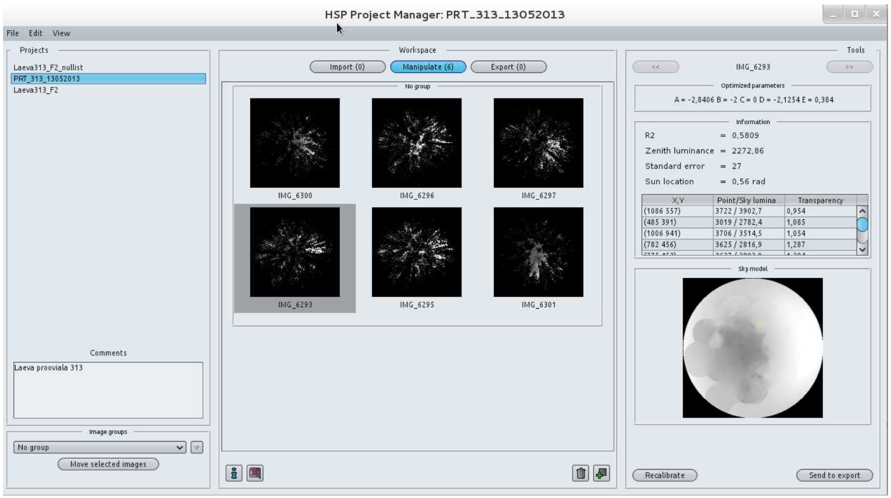


Figure 5.4: The new software HSP Project Manager for processing below canopy digital hemispherical images has been developed. The software implements LinearRatio method for single hemispherical camera. Subjective thresholding is not used. The incident radiation above the canopy is predicted using the clear sky that is visible in the canopy gaps. Tarkvaras HSP Project Manager on realiseeritud maailmas uudne lähenemine taimkatte all tehtud poolsfääripiltidelt taimkatte läbipaistvuse arvutamiseks. Meetodis ei kasutata subjektiivset klassifitseerimist ja samuti piisab vaid ühest kaamerast. Taimkattele pealelangeva kiirguse hulk ennustatakse võrastiku aukudes paistva lageda taeva järgi.

available in-situ understory reflectance measurements distributed along a wide latitudinal gradient: a sparse black spruce forest in Alaska (Poker range; 65.12 N), a northern European boreal forest (Hyytiala; 61.85 N), hemiboreal needleleaf and deciduous stands in Estonia (Järvselja; 58.27 N), a temperate deciduous forest in Switzerland (Laegeren; 47.48 N), and a dense black spruce forest in Canada (Sudbury; 47.16 N).

U. Peterson together with J. Liira from University of Tartu and Liis Kuresoo from Estonian University of Life Sciences tested the methods of shoreline delineation from time series of medium resolution satellite images. The methods were applied to a set of 70 major European lakes spanning a latitudinal distance of 2500 km from the Karelian lakes in the North (60 N) to the lakes in Turkey in the South (37 N). A lake shoreline is a critical line relative to which the expansion or retreat of environmentally sensitive coastal macrophytes can be measured. The shorelines derived with uniform methods for all the lakes of interest support the ongoing study of coastal macrophyte dynamics in the European lakes.

5.2 Remote sensing of atmosphere

The project "Estonian radiation climate" includes a preparation of solar radiation datasets for potential users working in biospheric, health, material and solar energy related applications. Together with the Estonian Environment Agency a dataset of hourly sums of direct, diffuse and global broadband solar irradiance recorded at the Tartu–Tõravere meteorological station in 1955 to 2012 was prepared. The another capacious dataset was prepared on the recorded ultraviolet (UV) spectra since 2004 (K. Eerme, M. Aun, U. Veismann). Spectral UV measurements are still considered the irreplaceable, ultimate reference in a variety of applications. Spectral measurements allow the data to be applied to any biological or chemical photoreaction with a known action spectrum. However, the operation, maintenance, and frequent calibration of spectrometers are costly as well as resource demanding in terms of skilled personnel and laboratory equipment. Such data collecting is difficult to organize as a routine work and needs regular supervision by qualified personnel. The UV spectra in wavelength range 280–400 nm are recorded as separate files in units mW/m^{2}nm with the wavelength resolution of 1 nm after each 15 minutes. The separate spectra are suitable in treating and analysing known situations and studying the cloud, ozone and aerosol effects on the ground-level spectral irradiance. Much of the UV radiation effects are cumulative and depend on the spectral composition of the received irradiance energy. Spectral energy is necessary to integrate over days, parts of days as well as over longer time intervals. For these studies the spectra are needed to present in a relevant way. Thus the project helps particularly address the integration of two global change issues covered by the Montreal and Kyoto Protocols. The database forming procedures are still in progress but close to finishing.

A method as well as the results of reconstruction of UVB (280–315 nm) and UVA (315–400 nm) daily, seasonal and annual doses are described in prepared for publishing manuscript (M. Aun, K. Eerme). The reconstruction results have been compared with these of local reconstruction of erythemally weighted UV doses and with those in other European sites. Covariance and differences in temporal change with broadband solar radiation help to follow the time evolution of UV radiation levels and its spectral composition over decades in past. The total ozone and aerosol contributions and especially the contribution of clouds varies from year to year and is site dependent. Cloud impact on solar radiation shows a strong latitudinal gradient with much less cloud attenuation in southern Europe and more in Northern Europe.

Regular recording of UV spectra in the wavelength range 280–400 nm using Bentham double monochromator DMc150F-U based spectrometric system and collecting their database was continued (U. Veismann). Removing of the measurement system from the meteorological station to the TO main building was prepared.

H. Keernik has investigated GPS-derived water vapour and its calculations. A new database for GPS station in Suurupi is created, which can be used to compare atmospheric water vapour content derived from radiosoundings at the nearby site, Harku. Temperature and humidity trends have been studied at Harku, Jokioinen, Jyväskylä and Sodankylä, using three types of Vaisala radiosondes (RS80, RS90 and RS92).

V. Russak in collaboration with Ingrid Niklus and Anne Jõeveer from the Estonian Environment Agency continued project the analysis of the measured radiation budget components at Tõravere in the frames of "Estonian radiation climate". Due to the shortness of the time series of measurement data of terrestrial and atmospheric infrared radiation the long-wave part of radiation budget remained unexamined in Estonia in former years. At present the amount of collected data is sufficient to start this analysis (e.g. downward long-wave radiation or counterradiation is recorded since 2002). Atmospheric counterradiation is mainly depending on water vapour content in the atmosphere. At Tõravere the relationship between long-wave downward radiation and water vapour pressure on ground can be fitted by a power function. This agrees with the results for different geographical regions analysed by other authors. Nevertheless, the parameters of fitting curves are somewhat different, which is, supposedly, caused by different cloudiness conditions and vertical gradients of water vapour and temperature. Remarkable is the effect of low clouds on counterradiation. Separate analysis of cloudless and overcast hours allowed us to assess the role of clouds in the counterradiation formation process.

Besides the long-wave radiation, attention was continuously paid to the transfer of solar radiation in the atmosphere. Using the elaborated by Martin Kannel and Hanno Ohvril (Tartu University) a method to separate the shares of water vapour and aerosol in the radiation attenuation the corresponding 62-years time series have been created for Tõravere.

5.3 Remote sensing of water bodies

A new method for atmospheric correction has been implemented for remote sensing of coastal and inland water bodies by Olaf Krüger. The work includes the application of a dynamic, vertically resolved non-maritime aerosol models for Europe which have been developed from a synergy of EARLINET and AERONET data. The aerosol models are based on systematic and comprehensive lidar measurements from EARLINET which originally have been exploited to obtain aerosol optical properties and their vertical resolution. These data are available now for improving the significance of interdisciplinary studies. The algorithm includes the creation of a new aerosol database and look up tables (LUTs) of top-of-the-atmosphere (TOA) radiances which are representative for observed aerosol types in Europe. Both the database and the LUT - containing an unprecedented dataset of aerosol measurements - are valuable contributions to the Earth Observation Community. The new aerosol models for atmospheric correction have been developed within the European Project WaterS.

Figure 5.5: New Multi-spectral Volume Scattering Meter which was tested in Ukraine. Uus hajumismõõtmisteks loodud instrument, mida testiti Ukrainas.

First investigations demonstrated that the models are very useful in improving atmospheric correction (AC) of the satellite data for ocean colour. It is the first time that such detailed optical and vertical information from lidars has been applied with the goal to improve the satellite data for ocean colour correction. Besides different types of natural and polluted aerosols the database also includes smoke aerosols originating from forest fires. The analysis with AERONET data confirms that over the Baltic Sea aerosols originating from biomass burning can strongly impact the radiation field.

Group of Remote Sensing of Waters went to several fieldwork campaigns this summer. First a joint campaign over lakes Võrtsjärv and Peipsi was made in July with Estonian Marine Institute where a new spectrometer (mounted on Estonian Land Board airplane) was tested. In the end of July fieldwork data was collected over small Estonian lakes to analyse the capabilities of a high-resolution satellite Worldview-2. In September M. Ligi and A. Reinart

Figure 5.6: Kersti Kangro and Martin Ligi together with Alo Laas (Centre for Limnology) finishing the fieldwork at lake Verevi. Kersti Kangro ja Martin Ligi koos Alo Laasiga (Limnoloogiakeskus) lõpetamas välitöid Verevi järvel.

joined Interspectrum OÜ staff to test a new Multi-spectral Volume Scattering Meter (image) with scientists from Ukrainian Marine Hydrophysical Institute of National Academy of Sciences on the Black Sea.

Participation in Global Lake Ecological Observatories Network (GLEON), The Theory Working Group (TTG) project "Spring Blitz", which is a study of the effects of the onset of stratification after the spring mixing event, involving 16 lakes all over the globe. From Estonia lake Verevi was extensively studied jointly with Centre for Limnology: K. Kangro, E. Asuküll and M. Ligi participated in the fieldwork during 29.04.–11.06.2013. High-frequency measurement of Chl a, oxygen content and temperature from an anchored platform were essential part of the project. The project focuses both on the changes in physical and chemical parameters as well as on the changes in phytoplankton diversity and in the entire food-chain (including zooplankton, bacteria and ciliates).

5.4 Earth atmosphere and climate

The old stationarity treatment for stochastic processes contains a condition about boundedness of the integral for autocorrelation. This opened a convenient way for Box and Jenkins to distinguish between statistical models for stationary time series and those which have stationary increments. Knowing the difference enabled O. Kärner to answer the question T. Mills (2007) asked in his paper ”Time series modeling of two millenia of northern hemisphere temperatures: Long memory or shifting trends?” The answer is simple: The treated series behaves like a nonstationary process with stationary increments. But the approach applied by Mills operates with so called long memory processes. Modern theory of these processes is unable to recognize the processes with stationary increments. This is an example in time series modeling where the older branch of the theory is advantageous in comparison with some new ways of examination. A practical comparison of the corresponding modeling results has been reported by O. Kärner in the workshop ”Economic applications in Climatology” at the University of Guelph in June 2013.

6 Space technology Kosmosetehnoloogia

Eesti tudengisatelliidi programmi algatasid Tartu Ülikooli üliõpilased ja õppejõud 2008. aastal eesmärgiga populariseerida reaal- ja inseneriteadusi, anda tudengitele praktilisi kogemusi ning arendada ettevõtlikkust. Eesti tudengisatelliidi projektis on tööperioodi vältel osalenud ligi sada üliõpilast Tartu Ülikoolist, Tallinna Tehnikaülikoolist, Eesti Lennuakadeemiast ning Eesti Maaülikoolist. Projekti juhendavad Tartu observatooriumi teadlased ja Tartu ülikooli õppejõud.

Projekt jõudis eduka lõpuni 7. mail 2013, kui Prantsuse Guajaanas, Kourous viis kanderakett Vega tudengisatelliidi ESTCube-1 Maa orbiidile. Kuupsatelliidi mõõtmed on 10x10x10 sentimeetrit ja kaal veidi üle kilogrammi. Satelliidi eesmärk on testida soomlase Pekka Janhuneni poolt välja mõeldud päikesepurje komponendi – kümnemeetrise erikujulise traadi väljalaskmist. ESTCube-1 ülesanne on võtta osa elektrilise päikesepurje arendamisest – pildistada väljalastud traati ja mõõta sellele mõjuvat jõudu. Purje traadipool ja kaamera optika valmistati Saksamaal Bremenis, aga sideseadmed ja kaamera elektroonika valmistasid tudengisatelliidi meeskonna liikmed ise.

Students of the University of Tartu Mihkel Pajusalu and Erik Ilbis at the ESA Space Station in Kourou. Tartu Ülikooli tudengid Mihkel Pajusalu ja Erik Ilbis ESA kosmosejaamas Prantsuse Guajaanas Kourous.

The first picture taken by ESTCube-1 at 15th of May. Esimene ESTCube-1 poolt kosmoses tehtud foto, mis on tehtud 15. mail 2013 Horvaatia kohal. Esiplaanil on Vahemeri, kaugemal Tuneesia ja Sahaara kõrb.

Orbiidil töötav satelliit on juba pildistanud Maad ja temaga peetakse pidevalt raadiosidet, sealhulgas ka raadioamatööride jaoks tavalistel, umbes 440 megahertsisel sagedusel. Iga päev lendab satelliit Eestile piisavalt lähedalt üle taeva seitse korda ning keskmiselt saab siis 10 minutit satelliidiga Tõraveres asuvas juhtimiskeskuses sidet pidada, sellest pool aega on võimalik sidet pidada üsna kvaliteetselt, teises osas võib signaali kvaliteet kõikuda. Seda aega kasutatakse satelliidi pealt info allalaadimiseks. Kõik alamsüsteemid on siiani töötanud edukalt.

ESTCube-1 on juba vähemalt kolm korda pääsenud kokkupõrkest kosmoseprügiga, kuid selliseid ohtlikke olukordi võib tulla tulevikuski. On leidnud praktilist kinnitust tõsiasi – meie üliõpilased on suutnud valmistada kosmoses hästi toimiva satelliidi.

Samal ajal valmis Tartu Observatooriumi värskelt renoveeritud peahoones uus laborikompleks, mille tegevused jagunevad kolme põhisuunda: kosmosetehnoloogia arendamine, seadmete katsetamine erinevates keskkonnatingimustes ja optilised mõõtmised. Laborid koosnevad mitmest eritingimusi tagavast ruumist, võimaldades katsetusi elektrostaatiliste lahenduste eest kaitstud keskkonnas, puhasruumis (klass 8, ISO 14644-1) ja elektromagnethäirete eest varjestatud kambris. Kõikides laborites toimib keskkonnatingimuste (õhutemperatuuri ja -niiskuse) automaatne kontrollsüsteem.

Kosmosetehnoloogia laboratoorium pakub võimalust erinevate seadmete (nt elektroonikaskeemide, kontrollerite, raadiosaatjate, -vastuvõtjate, kaamerate jne) projekteerimiseks, ehitamiseks ja katsetamiseks. Kasutusel on kaasaegsed töövahendid – Altium Designer, Labview, jootejaamad ja mikroskoobid. Eesti esimene satelliit ESTCube-1, mis jõudis 2013. a ka edukalt orbiidile, projekteeriti ja ehitati samuti selles laboratooriumis. Koostöös mitmete ülikoolide ja uurimisasutustega suudab kosmosetehnoloogia labor järgnevate projektide käigus pakkuda ka tehnoloogia katsetamist maalähedasel orbiidil tiirlevate nanosatelliitide pardal.

2013. aasta jooksul valmis spetsiaalselt satelliitidega sidepidamiseks mõeldud maajaam, mis koosneb kahest antennisüsteemist ja kaasaaegsetest tarkvaralistest raadiovastuvõtjatest. Antennisüsteemideks on 3-m läbimõõduga paraboolantenn ja Yagi-antennidest koosnev antennirühm 145 MHz ja 435 MHz lainealade jaoks. Mõlemad antennisüsteemid toimivad arvuti juhtimisel automaatselt ja nende abil on võimalik võtta vastu raadiosignaale nii maalähedasel orbiidil tiirlevatelt satelliitidelt kui ka maast tunduvalt kaugemal asuvatelt objektidelt. Maajaam on kasutusel Eesti tudengisatelliidilt ESTCube-1 saadetava telemeetria vastuvõtmiseks, lisaks sellele on maajaam kasutatav ka hariduslikel ja teaduslikel eesmärkidel. Lähiajal on kavas maajaamale lisada ka saatevõimekus.

Laborites on olemas vahendid, mis võimaldavad katsetada seadmete vastupidavust erinevatel keskkonnatingimustel: kliimakapp, vibratsiooni stend, termovaakuumkamber ja puhasruumikeskkonnas asuv optiliste mõõtmiste laboratoorium.

6.1 Testing and calibration laboratories

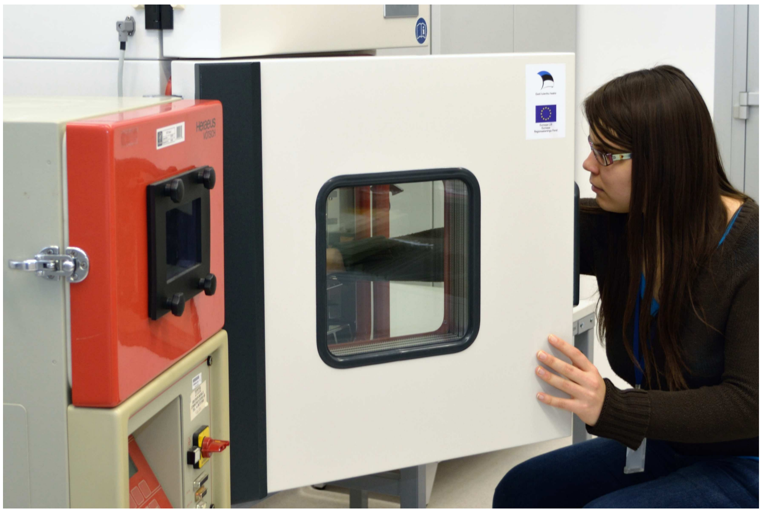
In 2013, a new laboratory complex has been established at the freshly renovated premises of Tartu Observatory. The activities of these laboratories are divided into three branches: development and testing of space technology, environmental testing, and optical measurements. The laboratories include special electrostatic discharge (ESD) safe areas, cleanroom (Class 8, ISO 14644-1) and anechoic environment. All laboratories include automatic control for ambient temperature and humidity conditions.

The laboratory for the development of space technology provides services for designing, assembling, prototyping as well as testing a wide range of different equipment. That includes electronic boards, controllers, radio transmitters, receivers, cameras etc. The available tools involve Altium Designer, Labview, soldering stations and microscopes. The first Estonian nanosatellite ESTCube-1, launched successfully in 2013, was designed and constructed in the laboratories of Tartu Observatory. In cooperation with several universities and research institutes, we can provide in orbit space technology validation service on nanosatellites as a part of our upcoming future missions.

6.2 Ground Station for Satellite Communication

Antenna on the roof of main building. Antenn peahoone katusel.

During year 2013 a dedicated satellite communication ground station was established. Two different antenna systems have been installed on the roof of the main building: one 3.0 m diameter parabolic dish antenna and a yagi antenna array for 145 MHz and 435 MHz frequency ranges. Both antenna systems include computer controlled rotators capable of tracking low earth orbiting satellites and other space objects. The receiving station is based on a solid state high performance software controlled radio (SDR) technology. The ground station is currently used for receiving telemetry data from ESTCube-1 student satellite. Soon the transmitting capability will be implemented. The ground station equipment can be used also for educational and research purposes.



Work with climatic chamber. Töö kliimakambriga.

6.3 Environmental testing

Laboratories for environmental testing include test stations for climatic conditions (temperature and humidity), sinusoidal and random vibration, thermal vacuum, and electromagnetic compatibility in an anechoic chamber.

6.4 Climatic conditions

- climatic chamber
- dimensions of the test space of 400 mm x 470 mm x 345 mm,
- temperature -40 – +150^{o}C,
- humidity 30–90%.

6.5 Vibration

- sinusoidal vibration 5–4000 Hz,
- max acceleration 720 m/s^2,
- max force 1.5 kN,
- random vibration 5–4000 Hz,
- max acceleration 480 m/s^2,
- max force 1 kN.

The figures are depending on the load.

V. Allik with thermal vacuum chamber. V. Allik termovaakuumkambri juures.

6.6 Thermal vacuum chamber

- chamber volume 220 L,
- inner diameter 651 mm,
- inner length 650 mm,
- lowest pressure 5Œ10^{-7} hPa,
- adjustable temperature range -40 – +250^{o}C.

6.7 Electromagnetic compatibility

The anechoic chamber located at the laboratories of Tartu Observatory is based on Frankonia Ultra Compact Chamber with ferrite absorbers on all walls and additional hybrid absorbers on one of the walls. The chamber is suitable for RF immunity and pre-compliance measurements according to the standard IEC/EN 61000-4-3.

- dimensions of the test space 4 m x 3 m x 2.5 m,
- frequency range 30 MHz – 18 GHz,
- distance from the test object 1 m,
- size of uniform field area 0.5 m x 0.5 m.

6.8 Optics

The laboratories for optical measurements are located in the cleanroom environment. The following properties and quantities are being measured:

- spectral responsivity of radiometric sensors
- irradiance and radiance in the wavelength range 340–1500 nm,
- angular responsivity,
- uniformity of the flat-field view,
- inherent stray light effects,
- temperature effects.

6.9 Calibration and characterization of light sources

- spectral irradiance and radiance in the wavelength range 340–1500 nm,
- optical power 5 μW–100 mW in the wavelength range 250–3000 nm. Characterization of materials
- reflectance and transmittance in the wavelength range 340–1500 nm. Ground support for remote sensing measurements
- 10 m x 10 m reference panel in the vicinity of forest remote sensing test site for calibration of air- and spaceborne remote sensing sensors.

6.10 Characterization of materials

- reflectance and transmittance in the wavelength range 340–500 nm.

6.11 Ground support for remote sensing measurements

- 10 m x 10 m reference panel in the vicinity of forest remote sensing test site for calibration of air- and spaceborne remote sensors.

6.12 First Estonian Satellite

The Estonian Student Satellite project started in the summer of 2008 at the University of Tartu with the objectives of promoting space research, being an invaluable educational tool for science, technology, engineering, mathematics subjects and giving students hands-on experience on developing space technologies. The satellite project is expected to have a significant role in educating and inspiring the general public and improving their awareness of space research and to foster the development of Estonian space and high-tech industry by training experts and disseminating knowledge about space technologies. ESTCube-1 is the first Estonian satellite and it was built in Estonia by students from Tartu University, Estonian Aviation Academy, Tallinn University of Technology and University of Life Sciences. The project was supervised by researchers from Tartu Observatory and teaching staff from University of Tartu.

Figure 6.1: Eesti Post issued on May 2, 2013 a stamp and FDC First Estonian satellite designed by Indrek Ilves to celebrate the event. Eesti Post andis välja 2. mail 2013 välja kunstnik Indrek Ilvese kujundatud postmargi ja esimese päeva ümbriku "Eesti esimene satelliit".

On May 7th, 2013 student satellite ESTCube-1 was launched from Kourou, French Guiana aboard a Vega carrier rocket and is actively used since then. The satellite is a cubesat measuring 10x10x10 cm and weighing 1.05 kg.

The main mission of the satellite is to test the electric solar wind sail, a novel space propulsion technology invented by Pekka Janhunen (Finnish Meteorological Institute) that could revolutionize transportation within the solar system. The tasks of ESTCube-1 are to test the deployment of a 10 meter Hoytether as a part of the development work of the Electric solar wind sail, to take a picture of it and to measure the electric sail force, interacting with it. Additionally, to take a picture of the Earth as a secondary mission objective. The coil and camera optics of the sail were developed in Bremen, Germany, however, the communication devices and electronics of the camera the student satellite team members developed themselves.

Communication with the satellite is on-going and by the end of January, 2014 more than 120 pictures of the Earth have been taken. Every day satellite orbits seven times over Estonia and at that time ground station in Tõravere can receive signal from it for 10 minutes in average. This time is used to download data. Since the launch ESTCube-1 has escaped a couple of possible collisions with space debris, however similar dangerous situations can recur. Spaceworthy satellite is a testimony of our student competence to develop space technologies.

7 Publications Publikatsioonid

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7.2 Papers in scientific journals and books Artiklid teadusajakirjades ja -kogumikes

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7.4.1 Astronomy Astronoomia

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8 Meetings Konverentsid ja seminarid

8.1 Astronomy Astronoomia

Nordita Winter School 2013 in High-Energy Astrophysics (Stockholm, Sweden, 06.01.–18.01.2013) – R. Kipper, T. Kuutma.

Isaac Newton Group of Telescopes Seminar (La Palma, Spain, 25.01.2013) – T. Liimets.

Liimets T.: A 3D View of the Nova Remnant of GK Per (oral presentation).

Conference in Memory of Prof. Roman Juszkiewicz (University of Zielona Gó ra, Zielona Gó ra, Poland, 27.01.–31.01.2013) – E. Saar.

Saar E.: Estimating Cosmological Correlations (oral presentation).

Stella Novae: Past and Future Decades (Cape Town, South-Africa, 04.02.–08.02.2013) – T. Liimets.

Liimets T.: A Dynamic Study of the Nova Remnant of GK Per (oral presentation).

49th Winter School of Theoretical Physics (Lądek Zdró j, Poland 10.02.–16.02.2013) – T. Sepp.

Sepp T.: Galaxy Structures (oral presentation).

Horizon 2020 Workshop on Space Science and Exploration (Madrid, Spain, 18.02.–19.02.2013) – L. Leedjärv.

XLIII Eesti Füüsikapäevad (Tõravere, Estonia, 21.03.–22.03.2013) – J. Kuusk, T. Liimets, H. Lätt, M. Noorma, A. Reinart, E. Tempel.

Liimets T.: GK Persei – ilutulestiku noovajäänuk (oral presentation).

Tempel E.: Universumi kaardistamine: erinevad galaktikasüsteemid meie ümber (oral presentation).

Kuusk J.: Kaugseire Tartu Observatooriumis – satelliidilt laborisse ja tagasi (oral presentation).

Noorma M.: Kiired ja ilma kütuseta planeetidevahelised lennud (oral presentation).

Lätt H.: Tartu Observatooriumi külastuskeskus teeb teaduse laste jaoks huvitavaks (oral presentation).

47th ESLAB Symposium "The Universe as Seen by Planck" (ESA/ESTEC, Noordwijk, Holland, 02.04.–05.04.2013) – E. Saar.

Huntsville Gamma Ray Burst Symposium (Nashville, USA, 14.04.–18.04.2013) – I. Vurm.

Vurm I.: Radiative Transfer Models for Prompt GRB Emission (poster).

Gaia DPAC CU 8 Meeting (Brussels, Belgium, 15.04.–16.04.2013) – I. Kolka, L. Leedjärv.

Seminar at Leibniz-Institut für Astrophysik Potsdam (Potsdam, Germany, 15.04.2013) – E. Tempel.

Tempel E.: Detecting Filamentary Pattern in the Universe: a Catalogue of Filaments (oral presentation).

Seminar "The Space Research in Ukraine" (Kiev, Ukraine, 25.04.2013) – T. Viik.

Viik T.: Scientific Life in Updated Tartu Observatory (oral presentation).

Astronomy & Astrophysics Board Meeting (Strasbourg, France, 03.05.2013) – A. Tamm.

IAU Symposium 298 "Setting the Scene for Gaia and LAMOST. The Current and Next Generations of Surveys and Models" (Lijiang, China, 20.05.–24.05.2013) – L. Leedjärv.

Leedjärv L.: Symbiotic Stars as Tracers of Galactic Structures (poster).

Seminar Observatorio Astronomico Nacional (Madrid, Spain, 20.05.2013) – T. Liimets.

Liimets T.: A 3D View of the Nova Remnant of GK Per (oral presentation).

ASTRONET Board Meeting (Madrid, Spain, 28.05.–29.05.2013) – L. Leedjärv.

Workshop "Nordic Science with ALMA" (Göteborg, Sweden, 28.05.–31.05.2013) – A. Tamm.

Tamm A.: From Herschel to ALMA: Mapping Dust Distribution in Galaxies (oral presentation).

Seminar in the Turku University (Turku, Finland, 29.05.2013) – J. Einasto.

Einasto J.: Dark Matter and the Structure of the Universe (oral presentation).

Cosmic Flows – Observations and Simulations (Marseille, France, 03.06.–07.06.2013) – J. Vennik.

Conference "Massive Stars: From α to Ω" (Rhodes, Greece, 10.06.–14.06.2013) – A. Aret, T. Eenmäe, I. Kolka, J. Laur.

Eenmäe T.: Evaluation of B Star Rotation Using Weak Spectral Lines of Metals (poster).

Aret A., Kraus M.: Optical Spectroscopy of Stars with Disks (poster).

Kraus M., Cidale L.S., Arias M.L., Torres A.F., *Aret A.*, Borges Fernandes M., Muratore F., Curé M., Oksala M.E.: Tracing the Mass-Loss History of B[e] Supergiants (poster).

Šurlan B., Hamann W.-R., Kubát J., *Aret A.*, Oskinova L.M.: Macroclumping Resolves Discrepancy Between Hα and P V Mass-loss Diagnostics (oral presentation).

Kolka I., Tuvikene T., Laur J.: The Variabilitu of Schulte 12 (poster).

Laur J., Kolka I., Tuvikene T.: Variability of Time-Scales and Amplitudes of Massive Stars in Selected OB Associations (poster).

75 Years Anniversary of IAP Conference: The Origin of the Hubble Sequence (Paris, France, 24.06.–28.06.2013) – M. Einasto, E. Tempel.

Einasto M.: Superclusters of Galaxies: Morphology and Galaxy Content (poster).

Tempel E.: Evidence for Spin Alignment of Galaxies in Filaments (invited talk).

European Week of Astronomy and Space Science 2013 (Turku, Finland, 08.07.–12.07.2013) – T. Liimets, J. Einasto, M. Einasto, T. Kuutma, V. Malyuto, E. Saar, T. Sepp, A. Tamm, E. Tempel, P. Tenjes.

Malyuto V.: Homogenized HR Diagram for the Open Cluster NGC 188 (poster).

Tempel E.: Evidence for Spin Alignment of Galaxies in Filaments (poster).

Tenjes P.: Star Formation in the Andromeda Galaxy (oral presentation).

Tamm A.: Neighbourhood Cosmology with the Andromeda Galaxy (oral presentation).

ASTRONET Mid-Term Review Meeting at EWASS 2013 (Turku, Finland, 12.07.–13.07.2013) – L. Leedjärv.

The 11th NEON Observing School (La Palma Observatory, Spain, 14.07.–27.07.2013) – J. Laur.

Conference "Ripples in the Cosmos" (Durham University, United Kingdom, 22.07.–26.07.2013) – G. Hütsi.

Hütsi G.: Clustering of AGN in eROSITA All-Sky Survey (contributed talk).

Workshop on Symbiotic Stars, Binary Post-AGB and Related Objects (Wierzba, Poland, 18.08.–23.08.2013) – T. Liimets.

Liimets T.: New Insights into the Jet of R Aquarii (oral presentation).

13th Odessa International Astronomical Gamow Conference-School (19.08.–25.08.2013, Odessa, Ukraine) – V. Malyuto.

Zubarev S., *Malyuto V.*: Homogenized Effective Temperatures for the Open Cluster NGC 188 (poster).

Halo Mass Recovery Comparison (Nottingham, United Kingdom, 02.09.–06.09.2013) – E. Tempel, T. Sepp.

Tempel E.: Description of TAR: Cluster Mass Estimation (oral presentation).

Observing Techniques, Instrumentation and Science for Metre-Class Telescopes (Tatranská Lomnica, Slovakia, 23.09.–26.09.2013) – L. Leedjärv.

Leedjärv L.: Cataclysmic Variables and Symbiotic Stars – Challenging Targets for Small Telescopes (invited review talk).

The annual meeting 2013 of the Astronomische Gesellschaft (Tübingen, Germany, 23.09.–27.09.2013) – T. Tuvikene.

Tuvikene T.: High-Mass Stars in the Digital Archive of Photographic Plates (oral presentation).

Tartu-Tuorla Annual Meeting (Seminar on Cosmology) (Villa Greete, Estonia, 25.09.–27.09.2013) – J. Einasto, M. Einasto, M. Gramann, U. Haud, R. Kipper, T. Kuutma, J. Laur, H. Lietzen, T. Liimets, L.J. Liivamägi, E. Saar, T. Sepp, I. Suhhonenko, E. Tempel, O. Tihhonova, J. Vennik, K. Verro, T. Viik.
Deshev B.: Abell 520 (oral presentation).
Einasto J.: Formation of the Cosmic Web (oral presentation).
Einasto M.: Nearby BAO Shells (oral presentation).
Kipper R.: Gaseous Discs of Distant Galaxies(oral presentation).
Kuutma T.: Dust Distribution in Nearby Galaxies (oral presentation).
Lietzen H.: Does it take a Supercluster to Raise a Galaxy? (oral presentation).
Liimets T.: Structure and Kinematics of Circumstellar Matter in Real Time: GK Persei, R Aquarii (oral presentation).
Liivamägi L.J.: Delineating Probable WHIM Locations in LSS (oral presentation).
Saar E.: Cosmology after Planck (oral presentation).
Sepp T: Halo Mass Recovery Comparison Workshop (oral presentation).
Tempel E.: Estimating Group/Custer Masses: Comparison of 22 Nearby BAO Shells (oral presentation).
Tempel E.: Filaments for the SDSS: Connection with Galaxy Groups (oral presentation).
Tenjes P.: Star Formation in the Andromeda Galaxy (oral presentation).
Vennik J.: Observations of Dwarf Galaxies in Nearby Groups of Galaxies (oral presentation).
Verro K.: Various Structures in the Universe (oral presentation).
Viik T.: The Great Finn Karl Fritiof Sundman (oral presentation).

Gesellschaft für Kultur, Ingenieurwesen und Wissenschaft e.V., Wissenschaftliche Seminare (Dresden, Germany, 28.09.2013) – V. Malyuto.
Malyuto V.: Stellar Clusters (oral presentation).

Humboldt Kolleg "Digitization of Heritage in Science" (Sofia, Bulgaria, 01.10.–05.10.2013) – T. Tuvikene.
Tuvikene T.: Bringing Data in Photographic Plates to Modern Scientific Use (oral presentation).

Seminar at Aalto University (Helsinki, Finland, 07.10.2013) – J. Pelt.
Pelt J.: Nyquist Barrier – Not for All (oral presentation).

2nd Extreme Universe Laboratory Workshop on Gamma-Ray Bursts (Moscow, Russia, 07.10.–11.10.2013) – I. Vurm.
Vurm I.: Radiative Transfer and Photospheric Emission in GRB Jets (invited talk).

ASTRONET Joint Call Workshop (Hamburg, Germany, 22.10.–23.10.2013) – L. Leedjärv.

Conference "Excellence in Research" (Tallinn, Estonia, 22.10.–23.10.2013) – E. Saar, J. Nevalainen.
Saar E.: Dark Matter in (Astro)particle Physics and Cosmology (oral presentation).
Seminar "ALMA Radio Observatory" (Tuorla, Finland, 11.11.–15.11.2013) – A. Tamm
ASTRONET WG3 and Executive Committee Meeting (Prague, Czech Republic, 25.11.–26.11.2013) – L. Leedjärv.
"Multi-Scale and Multi-Field Representations of Condensed Matter Behavior" (Pisa, Italy, 24.11.–30.11.2013) – L.J. Liivamägi.
Seminar at Valencia University (Valencia, Spain, 29.11.2013) – E. Tempel.
Tempel E.: Detecting Filamentary Pattern in the Universe: a Catalogue and Applications (oral presentation).
International Francqui Symposium "What Asteroseismology has to Offer to Astrophysics" (Brussels, Belgium, 02.12.–04.12.2013) – I. Kolka, L. Leedjärv.
Seminar at Oulu University (Oulu, Finland, 05.12.2013) – J. Pelt.
Pelt J.: Use of Envelopes in Time Series Analysis (oral presentation).

8.2 Remote Sensing Kaugseire

Workshop of FORMIT Project WP1+WP2 (Vienna, Austria, 08.01.–10.01.2013) – M. Lang.
GMES seminar (Tallinn, Estonia, 10.01.2013) – M. Lang, U. Peterson, A. Reinart.
Lang M.: Metsade kaugseirest (oral presentation).
HELCOM Meeting (Stettin, Poland, 30.01.–18.02.2013) – O. Krüger.
Reed as a Renewable Resource – International Conference on the Utilization of Wetland Plants (Greifswald, Germany 14.02.–16.02.2013) – U. Peterson.
Peterson U., Liira J., Kuresoo L.: Remote Monitoring of Reed Expansion on the Coasts of the Baltic Sea and on the Shores of Large Shallow Lakes (oral presentation).
GlaSS Kickoff Meeting (Wageningen, The Netherlands, 13.03.–15.03.2013) – K. Alikas, P. Grötsch.
Alikas K.: Water Remote Sensing Group in Tartu Observatory (oral presentation).
Finnish-Estonian Remote Sensing Seminar (Helsinki, Finland,13.03.2013) – T. Arumäe, A. Kodar, A. Kuusk, J. Kuusk, M. Lang, M. Nikopensius, T. Nilson, J. Pisek, K. Raabe.
Arumäe T: Using LIDAR Data to Assess Forest Characteristics in Estonia (oral presentation).
Kodar A.: Leaf Area Index Mapping with Airborne Lidar, Satellite Images and Ground Measurements in Järvselja VALERI Test Site (oral presentation).

Kuusk A.: Directional Properties of Forest Reflectance: Measurements and modeling (oral presentation).
Lang M.:, Brandýsová V.: Observation of Phenophases in Beech Forest using MODIS NDVI (oral presentation).
Pisek J.: My Personal Journey Through Leaf Angles (oral presentation).
Pisek J.: What can Multi-Angle MISR Observations at 275 m Resolution Tell us About Foliage Clumping? (oral presentation).

Blue Photonics (Texel, The Netherlands, 18.03.–20.03.2013) – P. Grötsch.
Grötsch P., Simis S., Eleveld M., Peters S.: Spatial Variability of Chlorophyll a in the Baltic Sea as a Proxy for Validation Suitability (poster).

European Geosciences Union – General Assembly (Vienna, Austria, 07.04.–12.04.2013) – H. Keernik.
Keernik H., Ohvril H., *Jakobson E.*, Rannat K., Luhamaa A.: Column Water Vapour: An Intertechnique Comparison of Estimation Methods in Estonia (poster).

The Arctic Science Summit Week 2013 (Krakow, Poland, 16.04.–19.04.2013) – E. Jakobson.

Ferrybox Meeting (Helsinki, Finland, 24.04.–25.04.2013) – P. Grötsch.
Grötsch P.M.M., Simis S., Eleveld M., Peters S.: Spatial Coherence between Ferrybox Fluorescence Measurements (oral presentation).

Joint Seminar for ENVIRON PhD Students and Postdocs (Intsu village, Viljandi county, Estonia, 30.04.–01.05.2013) – J. Kuusk.

1st International Workshop "Econometric Applications in Climatology" (University of Guelph, Canada, 05.06.–07.06.2013) – O. Kärner.
O. Kärner: Stationary Long Memory or Non-stationary with Stationary Increments? (oral presentation).

Satelliitseire infopäev (Tartu Observatoorium, Tõravere, Estonia, 06.06.2013) – M. Lang.
Lang M.: Aerolidari rakendustest Eesti metsade ja põllumaa kaugseires (oral presentation).

7th Study Conference on BALTEX (Borgholm, Sweden, 10.06.–14.06.2013) – E. Jakobson, H. Keernik, O. Krüger.
Keernik H., Jakobson E., Ohvril H.: Trends in Tropospheric Humidity and Temperature over Estonia and Finland Derived from Radiosonde Measurements (poster).

GlaSS WP3 Kickoff Meeting (IVM, Amsterdam, The Netherlands, 19.06.2013) – K. Alikas, K. Kangro.

Seminar "Aerosols Baltic Region" (Szczecin, Poland, 27.06.–30.06.2013) – O. Krüger.

4th Advanced Training Course in Land Remote Sensing (Athens, Greece, 01.07.–05.07.2013 – E. Asuküll, K. Alikas.
Asuküll E., Reinart A., Ligi M., Alikas K.: Measuring Dissolved Organic Matter from MERIS/Envisat Satellite (poster).

2013 IGARSS Symposium (Melbourne, Australia, 21.07.–26.07.2013) – J. Pisek.
Pisek J.: Estimation of Vegetation Clumping Index Using Multi-angle Imaging SpectroRadiometer (MISR) Data (oral presentation).

32nd Congress of the International Society of Limnology (Budapest, Hungary, 04.08.–09.08.2013) – U. Peterson.
Peterson U., Liira J.: Changes of Macrophyte Area in Lakes Along a Latitudinal Gradient in Eastern Europe (oral presentation).

Baltic Sea Science Congress (Klaipeda, Lithuania 26.08.–30.08.2013) – P. Grötsch.
Grötsch P., Simis S., Eleveld M., Peters S.: Bloom Detection with Coherence between Ferrybox Measurements (oral presentation).

NordBaltRemS Meeting (Klaipeda, Lithuania 30.08.–31.08.2013) – P. Grötsch.
Grötsch P., Simis S., Eleveld M., Peters S.: Bloom Detection with Coherence between Ferrybox Measurements (oral presentation).

The 2013 European Space Agency Living Planet Symposium (Edinburgh, UK, 09.09.–13.09.2013) – K. Alikas, E. Asuküll, A. Reinart, A. Olesk, K. Kangro, M. Ligi, P. Grötch.
Olesk A., Voormansik K., Zālite K., Reinart A., Noorma M., Desnosving Y.: Forest Biomass Estimation Methodology in Estonia Using Spaceborne SAR Imagery (poster).
Alikas K., Kangro K., Randoja R., *Asuküll E.*, Philipson P., *Reinart A.*: Monitoring Optically Complex Inland Waters in the Context of EU WFD by Means of Satellite Derived Products (oral presentation).
Ligi M., Grötsch P., Simis S.G.H., *Ansko I., Reinart A.*: Testing an Algorithm to Automatically Quality-Control Reflectance Data Over Turbid Lakes (poster).
Asuküll E., Reinart A., Ligi M., Alikas K.: Measuring Dissolved Organic Matter from MERIS/Envisat Satellite (poster).
Reinart Anu, Alikas K., Ansko I., Vendt R., Kuusk J., Kuuste H., Envall J., Reinart Aivo, Tõnnisson T.: Prototype for Multispectral Volume Scattering Meter – MVSM (poster).

Workshop on Metrology for Meteorology (Helsinki, Finland, 09.09.–10.09.2013) – E. Jakobson.

64th International Astronautical Congress (Beijing, China, 19.09.–28.09.2013) – A. Reinart, M. Noorma, E. Kulu.

Asia-Pacific Conference on Synthetic Aperture Radar "Overcoming the Hardships: Responding to Disasters with SAR" (Tsukuba, Japan, 23.09.–27.09.2013) – A. Olesk.

Intensive Course on Spatial Statistics (Tõravere, Estonia, 30.09.–04.10.2013) – J. Pisek, K. Kangro, K. Alikas, E. Asuküll, P. Grötsch.

European Space Expo (Tallinn, Estonia, 01.10.–06.10.2013) – A. Olesk.
Olesk A.: Biomassi kaardistus ja innovaatiline metsamajandamine (oral presentation).

GMES Meeting (Brussels, Belgium, 21.10.–24.10.2013) – A. Reinart.
FORMIT Meeting (Warsaw, Poland, 22.10.–25.10.2013) – M. Lang.
Finnish Remote Sensing Days (Helsinki, Finland 23.10.–24.10.2013) – P. Grötsch, J. Kuusk, M. Nikopensius, K. Raabe.
Nikopensius M.: Seasonal Reflectance Dynamics of Common Understory Types in Hemi-Boreal Forests, Järvselja, Estonia (poster).
Raabe K.: Does Leaf Angle Distribution Change as a Function of Height and Season for Broadleaf Tree Species Common to Estonia and Finland? (poster).
INCREASE Meeting (Copenhagen, Denmark, 28.10.–31.10.2013) – J. Kuusk.
XII Ökoloogiakonverents (Tartu, Estonia, 18.11.2013) – M. Lang, T. Arumäe, A. Kodar, J. Kuusk.
Alikas K., Kangro K., Randoja R., Asuküll E., Philipson P., *Reinart A.*: Possibilities of Using Satellite Data to Determine the Status of Water Bodies (oral presentation).
Lang M.: Aerolidari andmete kasutamine puittaimestiku seireks (oral presentation).
RMK ja EMU metsakorralduse osakonna ühisseminar (Tallinn, Riigimetsade Majandamise Keskus, Estonia, 15.11.2013) – U. Peterson.
Peterson U.: Eesti Maaülikooli ja Tartu Observatooriumi võimekus metsaga alade kaugseireks spektri optilises piirkonnas Eestis ja lähivälismaal (oral presentation).
GLaSS meeting (Frascati, Italy, 25.11.2013) – A. Reinart, K. Alikas.
Reinart A., Alikas K.: WP3 and WP4 – Data Collection and Analyses for Lake Case Studies (oral presentation).
Alikas K.: Task 5.7 – WFD Reporting Based on Results from Estonian Lakes (oral presentation).
Sentinel-3 Validation Team 1st Meeting (Frascati, Italy, 26.11.–29.11.2013) – A. Reinart, K. Alikas.
Reinart A.: European Field Instrument Calibration Facility (oral presentation).
Alikas K.: Quality of Above Water Measurements in Lakes/Turbids Waters (oral presentation).
Final Conference of INTERREG IV A project: Potential and Competitiveness of Biomass as Energy Source in Central Baltic Sea Region / Pure Biomass (CB56) (Ventspils, Latvia, 05.12.2013) – M. Lang.
Lang M., Traskovs A.: Remote Sensing Technologies for Biomass Assessment and Forest Growth Predictions in Kurzeme (oral presentation).
AGU Fall Meeting (San Francisco, USA, 09.12.–13.12.2012) – J. Pisek.
Pisek J.: Retrieval of Seasonal Dynamics of Forest Understory Reflectance Over a Set of Boreal, Sub-Boreal and Temperate Forests Using MODIS BRDF Data (oral presentation).

8.3 Space Technology Kosmosetehnoloogia

2nd Advanced Course on Radar Polarimetry (ESA ESRIN, Frascati, Italy, 21.01.–25.01.2013) – A. Olesk.

6th International Workshop on Science and Applications of SAR Polarimetry and Polarimetric Interferometry (POLinSAR) 2013 (ESRIN, Frascati, Italy, 28.01.–01.02.2013) – A. Olesk.

Olesk A., Voormansik K., Luud A., Rennel M., *Zālite K., Noorma M., Reinart A.*: Countrywide Forest Biomass Estimates from PALSAR L-Band Backscatter to Improve GHG Inventory in Estonia (poster).

European Space Agency POLinSAR 2013 Workshop "Effects of Inundated Vegetation Parameters on X-band HH-VV Backscatter" (Frascati, Italy, 28.01.–01.02.2013) – K. Zālite.

ESAIL Project Meeting (Helsinki, Finland, 14.03.–16.03.2013) – U. Kvell.

Finnish Physics Days 2013 "Low-Power Custom-Built Sun Sensors For Nanosatellite" (Espoo, Finland, 14.03.–16.03.2013) – R. Valner, A. Slavinskis, R. Vendt, I. Ansko, U. Kvell, H. Ehrpais, E. Kulu.

Member of Preliminary Design Review Panel of Aalto-2 Satellite (Espoo, Finland, 21.03.2013 and 28.03.2013) – A. Slavinskis.

NANOSAT Meeting (Brussels, Belgium, 11.04.–12.04.2013) – M. Noorma.

2nd International Scientific Conference "Baltic Applied Astroinformatics and Space Data Processing" (Ventspils, Latvia, 15.05.–16.05.2013) – A. Slavinskis, E. Kulu, R. Valner, J. Viru, U. Kvell, S. Lätt, M. Noorma.

Slavinskis A., Kulu E., Valner R., Viru J., Kvell U., Lätt S., Noorma M.: Attitude Determination and Control of ESTCube-1 (oral presentation).

Slavinskis A., Kulu E., Valner R., Viru J., Kvell U., Lätt S., Noorma M.: Solar Wind Electric Sail Testing CubeSat: Mission Concept (oral presentation).

ESA 4th Trainees and Fellows Meeting (ESA ESRIN, Frascati, Italy, 25.05.2013) – A. Olesk.

Olesk A.: Improving Forest Biomass Estimation Methodology in Estonia Using Spaceborne SAR Imagery (oral presentation and report on the activities).

NANOSAT Meeting (Brussels, Belgium, 02.06.–06.06.2013) – M. Noorma, E. Kulu, U. Kvell.

Space Technology Department International Meeting (Nelijärve, Estonia, 01.07.–03.07.2013) – V. Allik, T. Eenmäe, E. Kulu, H. Kuuste, U. Kvell, K. Laizans, S. Lätt, M. Noorma, A. Slavinskis, I. Sünter, K. Voormansik, K. Zālite.

Bring your Own Boards Day at the Surrey Space Centre (Guildford, United Kingdom, 19.07.2013) – I. Sünter, J. Kalde.

AMSAT-UK International Space Colloquium 2013 "ESTCube-1 Mission and Lessons Learned" (Guildford, United Kingdom, 19.07.–21.07.2013) – I. Sünter.

9th International Summer Space School "Future Space Technologies and Experiments in Space" (Samara, Russia, 18.08.–31.08.2013) — A. Slavinskis.

22nd Baltic Sea Parliamentary Conference (Pärnu, Estonia, 25.08.–27.08.2013) – A. Olesk.

Olesk A.: Innovative Use of Space Technologies in the Energy, Environment and Environmental Monitoring, Meteorology, Agriculture and Forestry Sectors (oral presentation).

The 1st ALOS-2 PI Workshop 2013 (Tsukuba, Japan, 19.09.–20.09.2013) – A. Olesk.

Olesk A., Voormansik K., Zālite K., Nilson T., Desnos Y-L.: Countrywide Forest Biomass Estimates Using ALOS PALSAR Data (oral presentation).

European Space Expo (Tallinn, Estonia, 01.10.–06.10.2013) – A. Olesk.

Olesk A.: Biomassi kaardistus ja innovaatiline metsamajandamine (oral presentation).

Study Trip to Thales Alenia Space (Torino, Italy, 29.10.–01.11.2013) – R. Vendt.

Space Technology Department International Meeting (Voore, Estonia, 01.11.–03.11.2013) – V. Allik, T. Eenmäe, E. Kulu, H. Kuuste, U. Kvell, K. Laizans, S. Lätt, M. Noorma, A. Slavinskis, K. Zālite.

Seminar "European Space Solutions 2013" (Munich, Germany, 05.11.–07.11.2013) – K. Zālite.

Keskkonnafüüsika seminar (Tartu, 06.11.2013) – M. Aun.

Aun M.: Rekonstrueeritud UVB ja UVA kiirgus Tõraveres aastatel 1955–2003 (oral presentation).

Elektromagnetilise ühilduvuse seminar (Tõravere, Estonia, 13.11.2013) – V. Allik, S. Lätt.

8.4 Miscellaneous Muud koosolekud ja ettevõtmised

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

Rahvusvahelise astronoomiaolümpiaadi treeninglaager (Tõravere, Estonia, 26.08.–28.08.2013) – T. Eenmäe, R. Kipper, T. Sepp.

Eesti koolinoorte võistkonna juhtimine Rahvusvahelisel Astronoomiaolümpiaadil (Dubingiai, Lithuania, 06.10.–14.10.2013) – T. Sepp, T. Eenmäe, R. Kipper.

8.5 Meetings at Tartu Observatory Tartu Observatooriumis korraldatud konverentsid

8.5.1 Strategy day of Tartu Observatory, Tõravere, 22 February Tartu Observatooriumi strateegiapäev, 22. veebruaril Tõraveres

The strategy day 2013 of the Tartu Observatory was held on February 22. The aim of this meeting was to discuss the status of the implementation of the development plan in Tartu Observatory together with the personnel and students who are supervised by our researchers, to target the goals for the end of 2013 and to set the strategic aims up to 2020. The topics considered were:

- research,
- teaching,
- popularization,
- management.

Every fellow has to publish at least one paper per year, advisably 1.5–2.

Tartu Observatooriumi 2013. aasta strateegiaseminar toimus 22. veebruaril Tõraveres. Kokkusaamise eesmärgiks oli arutada kõigi töötajate ja nende poolt juhendatavate üliõpilastega läbi Tartu Observatooriumi arengukava täitmise hetkeolukord, seada konkreetsed sihid 2013. aasta lõpuks ning püstitada strateegilised eesmärgid kuni aastani 2020. Teemad, mida käsitleti, olid järgmised:

- teadustöö,
- õppetöö,
- populariseerimine,
- administreerimine.

Ühiselt leiti, et teadlastelt peab ilmuma vähemalt 1 artikkel aastas, soovitavalt 1,5–2 artiklit.

8.5.2 Estonian Physics Days and Days of Physics Teachers Tõravere, 21.–22.March 2013 Eesti Füüsika päevad ja füüsikaõpetajate päev Tõravere, 21.–22.märtsil 2013

This year's XLIII Estonian Physics Days and XXXV Days of Physics Teachers were held in Tõravere, 21st and 22nd of March.

Presentations were given by the representatives of the Estonian Physical Society (EFS) workgroups, among them also the editorial board of the news portal fyysika.ee and the organizers of the Science Bus "Suur Vanker" (Ursa Major). Presenters explained the last year's greatest achivements. During the physics days also awards were granted. The EFS Award of the Year was given to the organizing team of the International Physics Olympiad (IPhO), held in Tartu and Tallinn 15.–24. of July. The award was received by the director of the Institute of Physics at the University of Tartu Prof. Jaak Kikas and the senior researcher of the Institute of Cybernetics at the Tallinn University of Technology Jaan Kalda. Kikas stated that the organizing team managed their task well, as the feedback was mostly positive. Especially when considering that several prominent countries have had to cancel the organizing agreement or fail with the organization. The student stipend was given to Morten Piibeleht (UT), Joosep Pata (UT), and Jakob Jõgi (UT).

Among others, specific thematic talks were given. It was pleasing to note that more than half of the participants were students. In the evening a general meeting of the EFS was held, during what the statute of the Estonian Physics Students Society (FÜS) was unanimously approved. In addition, a second year physics student and the coordinator of the mentoring programme Madis Ollikainen was chosen to be part of the board of EFS.

Seekordsed, XLIII Eesti füüsikapäevad ja XXXV füüsikaõpetajate päev toimusid Tõraveres 21. ja 22. märtsil. Esinesid EFS töörühmade esindajad, nende hulgas ka fyysika.ee uudisteportaali toimetus ning Teadusbussi tegijad, kes selgitasid viimase aasta suuremaid tegusid. Jagati ka preemiaid. EFS aastapreemia pälvis 15.–24. juulil Tartus ja Tallinnas toimunud rahvusvahelise füüsikaolümpiaadi (IPhO) korraldusmeeskond. Preemia võtsid vastu Tartu Ülikooli Füüsika Instituudi direktor prof. Jaak Kikas ning Tallinna Tehnikaülikooli Küberneetika Instituudi vanemteadur Jaan Kalda. Kikase sõnul sai olümpiaadi korraldusmeekond ülesandega hästi hakkama, tagasiside oli valdavalt positiivne. Seda enam, et nii mõnigi nimekas riik on korraldamisnõusolekust pidanud ära ütlema või ettevõtmisega sootuks läbi kukkunud. Tudengistipendiumi pälvisid Morten Piibeleht (TÜ), Joosep Pata (TÜ) ning Jakob Jõgi (TÜ).

Olid ka temaatilised ettekanded. Meeldiv oli tõdeda, et pooled kohalolnutest olid tudengid. Õhtusel EFS üldkogul sai üksmeelse kinnituse Eesti Füüsikaüliõpilaste Seltsi (FÜS) põhikiri. Lisaks valiti EFS juhatusse teise aasta füüsikatudeng ja FÜS mentoriprogrammi koordinaator Madis Ollikainen.

8.5.3 Intensive Course on Spatial Statistics (30.09.–04.10.2013, Tõravere, Estonia) Ruumilise statistika intensiivkursus (30.09.–04.10.2013, Tõravere, Estonia)

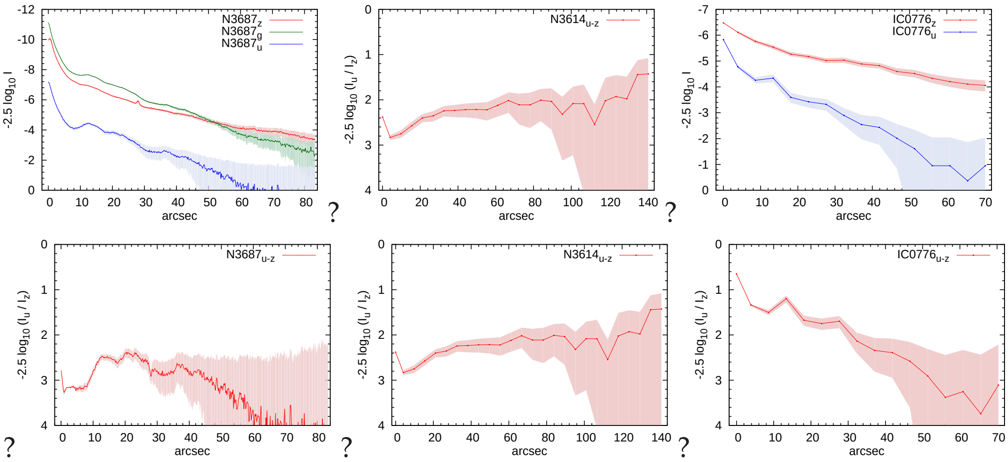
Prof. John E. Lewis gave a five day intensive course on spatial statistics from September 30 to October 4 in Tartu Observatory. The analysis and modeling of spatial data was the focus of the course with a strong emphasis on the "hands-on" application of data utilizing spatial statistical techniques, which were discussed in class. Each of the essential topics within the realm of spatial statistics was introduced with a lecture highlighting the pertinent statistical concepts for understanding the spatial theory. After each lecture there was a demonstration where applications and problem solving procedures in spatial statistics using the material of that lecture session was presented. Also there were seven tutorials, which took place in the form of in-class exercises where the students were working on different spatial data sets in order to provide them with the hands-on experience of the real world problems. Additionally, students were presenting their ongoing research and received useful feedback. Participants from Tartu Observatory: J. Pisek, K. Kangro, K. Alikas, E. Asuküll, P. Grötsch. Altogether there were 15 participants.

Prof. John E. Lewis viis läbi ruumiliste andmete statistilise analüüsi kursuse Tartu Observatooriumis ajavahemikul 30.09.–04.10. 2013. Kursuse eesmärgiks oli kaugseire andmete analüüs ja modelleerimine. Loengutele järgnesid praktilised demonstratsioonid ning praktikumid loengus läbitud teemade kohta. Lisaks tutvustasid tudengid enda uurimistöid ning said tagasisidet statistilise andmetöötluse metoodika kohta.

Kursusel oli 15 osalejat, kellest viis olid Tartu Observatooriumist: J. Pisek, K. Kangro, K. Alikas, E. Asuküll, P. Grötsch

8.5.4 Practical Astronomy: Observations (30. April 2013, Tõravere/Tartu, Estonia) Praktiline astronoomia: vaatlused (30. aprillil 2013, Tõravere/Tartu, Estonia

T. Liimets, T. Eenmäe, U. Veismann organized a Practical Astronomy course. The students leared all the main topics of the observational astronomy in classical lectures by means of practical works. In the 2013 course, for the first time students got an opportunity to gain experience in observing with the modern world-class medium-size telescope. Remote observations were carried out using the 2.6-meter Nordic Optical Telescope (NOT) on La Palma, Spain. In the classroom a remote telescope and instrument control system was set up, which allowed students to observe with the NOT via internet without the expenses of travelling to the site. Students were divided into 3–4 person groups which were led by researchers from Tartu Observatory. The project topics were: kinematic studies of disks around young stars (led by A. Aret), spectro-astrometry of κ Draconis (led by I. Kolka, T. Liimets), galaxy imaging survey for students (led by A. Tamm). In addition to observing skills, students learned how to perform data reduction and analysis. During the galaxy group observations, a Target of Opportunity observation was requested and students had to observe newly discovered very energetic gamma-ray burst GRB 130427A for another scientific group. The NOT observations, accompanied with the observations from the Gran Telescopio Canarias, led to a associated supernova discovery (Xu, D. et al. 2013, ApJ, 776, 98) which gave hint on the long debated origin of the gamma-ray bursts to be related to supernova explosions. The organizers of the course as well as the students



Joonis 8.1: Luminosity distributions of the observed galaxies in u, z and g filters (upper panels). Colour profiles ($u - z$) of the observed galaxies (lower panels). Vaadeldud galaktikate heledusjaotused u, z ja g filtrites (ülal) ja $u - z$ värvusindeksid (all).

thank the NOT Council for the generous offer of full night observing time and T. Augusteijn for the support at the telescope.

Praktilise astronoomia kursuse raames õpivad üliõpilased vaatlusliku astronoomia põhitõdesid klassikaliste loengute ja praktiliste tööde kaudu. 2013. aasta kursusel oli üliõpilastel esmakordselt võimalus vaadelda kaasaegse maailmatasemel teleskoobiga. Kaugvaatlused teostati 2,6 meetrise Põhjamaade Optilise Teleskoopiga (NOT) La Palmal, Hispaanias. Klassiruumis oli üles seatud teleskoobi ja instrumentide kaugjuhtimistarkvara, mis võimaldas tudengitel vaadelda interneti vahendusel, ilma Kanaaridele sõidu kuludeta. Loengukursusel osalejad olid jagatud 3–4 liikmelistesse gruppidesse, mida juhendasid Tartu Observatooriumi teadlased ja mille teemad olid: noori tähti ümbritsevate ketaste kinemaatika (juhendaja A. Aret), κ Draconise spektroastromeetria (juhendajad I. Kolka, T. Liimets), galaktikate fotomeetria uuring (juhendaja A. Tamm). Lisaks vaatlemisele said tudengid astronoomiliste andmete töötluse ja analüüsi kogemuse. Galaktikate fotomeetriliste vaatluste ajal pidid tudengid plaaniväliselt vaatlema ka gammasähvatust GRB 130427A "Target of Opportunity" (kiireloomulised vaatlused, mida peab teostama otsekohe). Konkreetne gammasähvatus oli eriline oma väga suure energia poolest. Lisaks avastati NOT-i vaatluste kaasabil gammasähvatusega seotud supernoova (Xu, D. et al. 2013, ApJ, 776, 98), mis aitab lahendada küsimust, mil viisil gammasähvatused võivad olla seotud supernoova plahvatustega. Kursuse organiseerijad ja osalejad tänavad NOT-i nõukogu (NOTSA) suurepärase võimaluse eest vaadelda terve öö mahus ning T. Augusteijni vaatlustel assisteerimise eest.

8.5.5 Tartu – Tuorla Annual Meeting 2013: Various Structures in the Universe (25–27 September, Estonia, Villa Greete) Tartu – Tuorla ühisseminar 2013: "Universumi erinevad struktuurid" (25.–27. september, Greete motell, Valgamaa)

The annual cosmology meeting was held in South Estonia this time, in the cosy environment of Villa Greete. It was the longest and most popular meeting of this series so far. Over 50 people from Tartu Observatory, Tuorla Observatory, FINCA (Finnish Centre for Astronomy with ESO), University of Tartu, National Institute of Chemical Physics and Biophysics, University of Helsinki, and even Dartmouth (USA) discussed a variety of topics extending from stellar physics and galaxy evolution to particle physics and theoretical cosmology. During three days, 40 talks and 2 poster presentations were made. Also the traditional Estonian-Finnish football match took place.

Igaaastane kosmoloogiaseminar peeti seekord Lõuna-Eestis, hubases Greete motellis. Osales üle 50 teadlase Tartu ja Tuorla observatooriumitest, FINCA-st (Soome keskus astronoomilisteks uuringuteks ESOs), KBFI-st, Helsingi ülikoolist ja koguni USA-st Dartmouthist. Kolme päeva jooksul peeti 40 suulist ja 2 posterettekannet, mille temaatika ulatus tähefüüsikast ja galaktikate evolutsioonist osakestefüüsika ja teoreetilise kosmoloogiani. Peeti ka traditsiooniline Eesti-Soome maavõistlus jalgpallis.

Ühisseminarist osavõtjad. Participants of the Meeting.

8.5.6 Seminar on the Electromagnetic Compatibility (EMC), Tartu Observatory, Rohde & Schwarz Danmark A/S, (13 November 2013, Tõravere) Seminar elektromagnetilise ühilduvuse (EMÜ) teemal, Tartu Observatoorium, Rohde & Schwarz Danmark A/S, (13. november 2013, Tõravere)

On November 13th Tartu Observatory arranged a seminar about electromagnetic compatibility. The seminar was organized in cooperation with Rohde & Schwarz GmbH Estonian representation and Estonian Technical Surveillance Authority. The seminar had over 60 participants from various academic and educational institutions and also from several private companies. The feedback given by the participants was very positive.

Tartu Observatoorium korraldas 13-ndal novembril elektroonika ja raadioside valdkonna spetsialistidele ühepäevase seminari, milles käsitleti elektromagnetilise ühilduvuse (EMÜ) problemaatika olemust, anti ülevaade selles valdkonnas kehtivatest standarditest ja kasutatavatest mõõtemeetoditest ning jagati praktilisi nõuandeid EMÜ nõuetele vastava elektroonikaaparatuuri konstrueerimiseks. Koostöös ettevõttega Rohde & Schwarz Danmark A/S demonstreeriti kohapeal kaasaaegset EMÜ-ga seotud mõõtmisteks kasutatavat mõõteaparatuuri. Seminarist võttis osa üle 60 inimese erinevatest eluvaldkondadest.

9 Visits and guests Visiidid ja külalised

9.1 Astronomy Astronoomia

B.Z. Deshev – Centro de Astrofisico en La Palma, La Palma (Spain); 01.01.–30.01.2013.
T. Liimets – Centro de Astrofisico en La Palma, La Palma (Spain); 01.01.–30.01.2013.
G. Hütsi – Max Planck Institute for Astrophysics (Garching, Germany); 08.01.–01.02.2013.
G. Hütsi – Max Planck Institute for Astrophysics (Garching, Germany); 11.03.–05.04.2013.
E. Tempel – Leibniz-Institut für Astrophysik Potsdam, Potsdam (Germany); 10.04.–20.04.2013.
T. Viik – Ukraina Rahvusliku TA Astronoomiaobservatoorium, Kiiev (Ukraina); 24.04.–28.04.2013.
T. Liimets – Observatorio Astronómico Nacional, Madrid, (Spain); 11.05.–23.05.2013
G. Hütsi – Max Planck Institute for Astrophysics (Garching, Germany); 16.05.–21.06.2013.
J. Einasto, M. Einasto – Tuorla Observatory, Turku (Finland); 28.05.–02.06.2013.
E. Tempel – Leibniz-Institut für Astrophysik Potsdam, Potsdam (Germany); 27.07.–05.08.2013.
G. Hütsi – Max Planck Institute for Astrophysics (Garching, Germany); 11.08.–30.08.2013, 05.09.–04.10.2013.
A. Aret – Astronomical Institute of the Academy of Sciences of the Czech Republic (Ondřejov, Czech Republic); 01.09.–14.09.2013.
L. Leedjärv – Astronomical Institute of the Slovak Academy of Sciences, Tatranská Lomnica (Slovakia); 26.09.–29.09.2013.
L. Leedjärv – Institute of Astronomy, University of Vienna (Austria); 30.09.–01.10.2013.
J. Pelt – Aalto University, Helsinki (Finland); 06.10.–12.10.2013.
K. Verro – Observatorio del Roque de los Muchachos, La Palma (Spain); 07.10.–21.10.2013.
B.Z. Deshev – Centro de Astrofisico en La Palma, La Palma (Spain); 07.10.–31.12.2013.
T. Liimets – Centro de Astrofisico en La Palma, La Palma (Spain); 07.10.–31.12.2013.
T. Liimets – Observatorio del Roque de los Muchachos, La Palma (Spain); 07.10.–21.10.2013.

E. Tempel, L.J. Liivamägi – Leibniz-Institut für Astrophysik Potsdam, Potsdam (Germany); 28.10.–08.11.2013.

A. Tamm – Tuorla Observatory (Finland); 11.11.–15.11.2013.

E. Tempel – Observatori Astronómic, Universitat de Valéncia, Valéncia (Spain); 24.11–30.11.2013

J. Pelt – Oulu University, Oulu (Finland); 04.12.–06.12.2013.

9.2 Remote sensing and Space Technology Kaugseire ja Kosmosetehnoloogia

A. Olesk – ESA ESRIN, Frascati (Italy); 30.12.2012.–28.03.2013.

O. Krüger – Finnish Meteorological Institute, University of Helsinki (Finland); 21.03.–01.04.2013.

O. Krüger – Helmholtz-Zentrum Geesthacht, Max Planck Institute for Meteorology (Germany); 02.04.–09.04.2013.

V. Allik – Guiana Space Centre, Kourou (French Guiana); 29.04.–06.05.2013.

O. Krüger – Finnish Meteorological Institute, University of Helsinki (Finland); 06.06.–09.06.2013.

P. Grötsch – SYKE (Finland); 24.06.–28.06.2013.

O. Krüger – Max Planck Institute for Meteorology, Hamburg (Germany); 29.07.–03.08.2013.

E. Kangro – Plymouth Marine Laboratory (PML)-RSG Group, (Plymouth, UK); 09.09.–09.12.2013.

J. Kuusk – University of Copenhagen (Denmark); 28.10.–31.10.2013.

R. Vendt – Thales Alenia, Space, Cannes (France) and Torino (Italy); 29.10.–01.11.2013.

O. Krüger – Max Planck Institute for Meteorology, Hamburg (Germany); 06.11.–10.12.2013.

9.3 Guests of the observatory Observatooriumi külalised

Salvis Roga – Business Incubator at Ventspils High Technology Park (Latvia); 08.01.–09.01.2013.

Jouni Envall – Finnish Meteorological Institute (Finland); 20.01.2013.

Pekka Janhunen – Finnish Meteorological Institute (Finland); 20.01.2013.

Petri Toivanen – Finnish Meteorological Institute (Finland); 20.01.2013.

Paolo Serra – ASTRON (The Netherlands); 09.03.2013–10.03.2013.

Franz Kaminski – University of Applied Science Aachen (Germany); 08.04.–10.11.2013.

Jakiv Pavlenko – Main Observatory of the Academy of Sciences of Ukraine (Ukraine); 16.04.–18.04.2013.

Changbom Park – Korea Institute for Advanced Study, Seoul (Korea); 29.04.–30.04.2013.
Michaela Kraus – Astronomical Institute of the Academy of Sciences of the Czech Republic (Czech Republic); 13.05.–24.05.2013.
Thomas Schneider – TU München (Germany); 16.05.2013.
Yara Jaffe – Astronomy Department of Universidad de Concepcion (Chile); 17.06.–21.06.2013.
Speaker of the Parliament of Estonian Republic Ene Ergma with Delegation of Vlaams Parliament (Belgium); 06.06.2013.
Endija Briede – Ventspils University College (Latvia); 15.06.–15.09.2013.
Raivis Paberzs – Ventspils University College (Latvia); 15.06.–15.09.2013.
Robers Trops – Ventspils University College (Latvia); 15.06.–15.09.2013.
Gatis Steinbergs – Ventspils University College (Latvia); 15.06.–15.09.2013.
Gatis Spudins – Ventspils University College (Latvia); 15.06.–15.09.2013.
Martti Heinonen – MIKES (Finland); 20.06.2013.
Valdis Avotins – Ventspils University College (Latvia); 11.07.2013.
Juris Polevskis – Ventspils University College (Latvia); 11.07.2013.
Gabriele Fantoni – Alta S.p.A. (Italy); 03.07.–04.07.2013.
Tiziano Fiore – Alta S.p.A. (Italy); 03.07.–04.07.2013.
Petra Ammenberg Philipson – Brockmann Geomatics, Sweden AB (Sweden); 07.07.–06.09.2013.
Radu S. Stoica – Université Lille 1 (France); 15.07.–27.07.2013.
Lucia Ayala – University of California, Berkeley (USA); 04.09.–06.09.2013.
Frank Schulze – University of Applied Science Aachen (Germany); 19.09.–31.12.2013.
Seth Cohen – Dartmouth (USA); 25.09.–27.09.2013.
Alexis Finoguenov – University of Helsinki (Finland); 25.09.–27.09.2013.
Pekka Heinämäki – Tuorla Observatory, University of Turku (Finland); 25.09.–27.09.2013.
Pasi Nurmi – Tuorla Observatory, University of Turku (Finland); 25.09.–27.09.2013.
Mauri Valtonen – Tuorla Observatory, University of Turku (Finland); 25.09.–27.09.2013.
Leo Takalo – Tuorla Observatory, University of Turku (Finland); 25.09.–27.09.2013.
Anu Poudel – Tuorla Observatory, University of Turku (Finland); 25.09.–27.09.2013.
Juliet Datson – Tuorla Observatory, University of Turku (Finland); 25.09.–27.09.2013.
Kalle Karhunen – Tuorla Observatory, University of Turku (Finland); 25.09.–27.09.2013.
Toni Tuominen – Tuorla Observatory, University of Turku (Finland); 25.09.–27.09.2013.

Harry Lehto – Tuorla Observatory, University of Turku (Finland); 25.09.–27.09.2013.

Samuli Kotiranta – Tuorla Observatory, University of Turku (Finland); 25.09.–27.09.2013.

Pauli Pihlajoki – Aalto University, University of Turku (Finland); 25.09.–27.09.2013.

Ghassem Gozaliasl – University of Helsinki (Finland); 25.09.–27.09.2013.

John Lewis – Emeritius(Canada); 30.09.–04.10.2013.

Stefan Simis – SYKE (Finland); 07.11.–08.11.2013.

Areg Mickaelian – Byurakan Astrophysical Observatory (Armenia); 29.11.–05.12.2013.

10 Seminars at the Observatory Observatooriumis toimunud seminarid

10.1 Astronomy Astronoomia

16.01.2013 – Elmo Tempel: Fermi 130 GeV piik: tõend tumeaine annihilatsioonist?

23.01.2013 – Maret Einasto: Suurim struktuur Universumis lõpuks ometi avastatud.

13.02.2013 – Arutelu teemal "Institutsionaalsed grandid ja meie".

08.03.2013 – Paolo Serra (ASTRON, The Netherlands): The Atlas3D Survey: a Changing View of Early-Type Galaxies.

03.04.2013 – Elmo Tempel: Kas galaktikad ja filamendid on korrelleeritud? Vana asi uues kuues.

16.04.2013 – Jakiv Pavlenko (Ukraina Teaduste Akadeemia Astronoomia Peaobservatoorium): Brown Dwarfs.

24.04.2013 – Tiina Liimets, Indrek Kolka: Spektroastromeetria võimalustest mitmiktähtede ja täheümbriste uurimisel.

15.05.2013 – Enn Saar: Plancki maailm.

22.05.2013 – Olavi Kärner: Statsionaarsuse definitsiooni erinevate tõlgenduste mõjust statistilisele modelleerimisele.

29.05.2013 – Tõnu Viik: Viktor Sobolev - teoreetilise astrofüüsika patriarh.

05.06.2013 – Maret Einasto: Superparved: morfoloogia ja galaktikate koostis.

12.06.2013 – Mihkel Kama (Leideni Ülikool, Holland): Astrokeemia ja astrobioloogia: keemiliste elementide rännak tähtede vahelt elusorganismidesse.

19.06.2013 – Yara Jaffe (Astronomy Department of Universidad de Concepcion, Chile): The Effect of Environment on the Gas and the Stars of Distant Galaxies.

26.06.2013 – Heidi Lietzen: Galaxies in the Cosmic Web.

04.09.2013 – Lucia Ayala (California): Large-Scale Structure of the Universe Before the 20th Century.

02.10.2013 – Laur Järv (TÜ FI): Tumeenergia ja universumi tulevikustsenaariumid.

23.10.2013 – Tiit Sepp: Uue põlvkonna teleskoobid, astronoomilised vaatlused kosmosest.

30.10.2013 – Tõnis Eenmäe: RAITS – uusim teleskoop Tõraveres.

06.11.2013 – Urmas Haud: Arvutikasutuse algus Tõraveres.

03.12.2013 – Areg Mickaelian (Byurakan Astrophysical Observatory): Multiwavelength Studies of Active Galaxies.

10.2 Remote sensing Kaugseire

07.02.2013 – Andres Kuusk: Veelkord metsa peegeldumisindikatriss.
25.04.2013 – Sebastian Traud: The Origin of High Alkane/CO Ratios at Cruise Altitude over Central Asia Measured by the CARIBIC Observatory in 2006.
16.05.2013 – Thomas Schneider (TU München): Activities and Concepts of the RS Working Group of the Center of Life and Food Sciences Weihenstephan of the TU München (TS).
16.05.2013 – Philipp Grötsch: Spatial Coherence between Ferrybox Fluorescence measurements.
27.05.2013 – Elar Asuküll: Vees lahustunud värvunud orgaanilise aine määramine satelliidipiltidelt.
28.10.2013 – Jan Pisek: Tracking Seasonal Dynamics of Forest Understory Reflectance Over a Set of Boreal, Sub-Boreal and Temperate Forests Using MODIS BRDF Data.
04.11.2013 – Tiit Nilson: An Application of NPP Model: Optimal Seasonal Course of fAPAR/LAI.
08.11.2013 – Stefan Simis (Finnish Environment Institute, Marine Research Center): Hyperspectral Ship-Borne Remote Sensing.
11.11.2013 – Urmas Peterson: Brief Insights Into Remote Sensing of Coastal Macrophytes.
18.11.2013 – Kalju Eerme: Projekti Eesti kiirguskliima ideoloogiast ja loodetavatest tulemustest.
02.12.2013 – Hannes Keernik: Õhusamba niiskussisaldus: määramisviiside võrdlus Eesti andmetel.
09.12.2013 – Marta Mõistus: Puittaimestiku kaardistamine aeroLiDARi andmete põhjal metsana lisanduvatel ja taastuvatel aladel.
16.12.2013 – Evelin Kangro: Practice in Plymouth Marine Laboratory.

10.3 Joint Seminar of the Observatory Observatooriumi ühisseminarid

29.04.2013 – Prof. Changbom Park (Korea Institute for Advanced Study, Seoul): The Largest Structures in the Universe.
20.05.2013 – Michaela Kraus (Astronomical Institute of the Academy of Sciences of the Czech Republic, Czech Republic): Puzzling Phases in the Post-Main Sequence Evolution of Massive Stars.
05.09.2013 – Uno Veismann: Raamatu ”Ilmaruumi künnisel” pidulik esitlus.

11 Membership in scientific organizations
Teadusorganisatsioonide liikmed

Academia Europaea – J. Einasto
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 Member Countries Representatives of COST 726 Action – K. Eerme
Board of the Tartu Astronomy Club – E. Tago
British Interplanetary Society – U. Veismann
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, L. Sapar, 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 Kosmosepoliitika Töögrupp / Estonian Space Policy Working Group – L. Leedjärv (Vice-Chair), A. Reinart, M. Noorma
Eesti Looduseuurijate Selts – K. Eerme, V. Russak, A. Sapar, U. Veismann, T. Viik (president)
Eesti Teaduste Akadeemia / Estonian Academy of Sciences – J. Einasto, E. Saar, A. Sapar
EUFAR (EUropean Fleet for Airborne Research): Education and Training – S. Lätt
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, V. Malyuto, T. Nugis, E. Saar, A. Sapar, L. 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, V. Malyuto, 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, V. Malyuto

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, V. Malyuto, T. Nugis, J. Pelt, E. Saar, A. Sapar, L. Sapar, I. Suhhonenko, E. Tago, A. Tamm, E. Tempel, P. Tenjes, U. Veismann, J. Vennik, T. Viik

International Astrostatistics Association – E. Saar.

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

Nordic Network on Physically-based Remote Sensing of Forests – T. Nilson (director), M. Lang (member of steering committee)

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

Working Group 4 of COST 726 Action – S. Lätt

12 Teaching and Popularizing Õppetöö ja populariseerimine

12.1 Lecture courses and seminars Loengukursused ja seminarid

12.1.1 Astronomy Astronoomia

The Equations of Mathematical Physics Matemaatilise füüsika võrrandid – T. Viik, University of Tartu.

Astronomy Astronoomia – R. Kipper together with P. Tenjes, University of Tartu.

Cosmology Master Course Kosmoloogia magistrikursus – E. Saar, University of Tartu.

Global Physics, Globaalfüüsika – M. Gramann together with H. Ohvril, K. Tarkpea and O. Tihhonova, University of Tartu.

Hydrodynamics I Hüdrodünaamika I – P. Tenjes, University of Tartu.

Hydrodynamics II Hüdrodünaamika II – P. Tenjes, University of Tartu.

Seminar in Astrophysics Astrofüüsika seminar – J. Laur, R. Kipper together with T. Liimets and P. Tenjes, University of Tartu.

Practical Astronomy: Observations Praktiline astronoomia: vaatlused – T. Liimets, T. Eenmäe, U. Veismann.

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

12.1.2 Remote sensing Kaugseire

Introduction to Geophysics Sissejuhatus geofüüsikasse – K. Eerme, University of Tartu.

Environmental Science Keskkonnaõpetus – K. Eerme, University of Tartu.

Measurements and Measurement Uncertainty Mõõtmised ja mõõtemääramatused – E. Jakobson, University of Tartu.

Measurement Data Processing Mõõtmistulemuste töötlemine – E. Jakobson, University of Tartu.

Probability and Statistics Tõenäosusteooria ja statistika – E. Jakobson, University of Tartu.

Environmental Remote Sensing I Keskkonnakaugseire I – K. Alikas, T. Nilson, J. Pisek, A. Kodar, O. Krüger, M. Ligi, University of Tartu.

Environmental Remote Sensing II Keskkonnakaugseire II – K. Alikas, T. Nilson, J. Pisek, O. Krüger, J Kuusk, M. Lang, A. Reinart, University of Tartu.

In the frame of a course "PK.1055 Methods of investigation of water bodies" a lecture "Methods of phytoplankton investigation". Loengukursuse "PK.1055 Veekogude uurimise meetodid" raames loeng "Fütoplanktoni uurimise meetodid" – K. Kangro, Estonian University of Life Sciences.

In the frame of a course "LOOM 01.094 Technology of ecosystems" a lecture "Restoration methods for water bodies". Loengukursuse"LOOM 01.094 Ökosüsteemide tehnoloogia" raames loeng "Veekogude taastamine" – K. Kangro, University of Tartu.

In the frame of a course "LOOM.01.058 Bioindication" a lecture "Algoindication". Loengukursuse "LOOM.01.058 Bioindikatsioon" raames loeng "Algoindikatsioon" – K. Kangro, University of Tartu.

Fundamentals of Remote Sensing Kaugseire alused – U. Peterson, University of Tartu.

Environmental Monitoring Keskkonnaseire – U. Peterson, Estonian University of Life Sciences.

Geographic Information Systems Geograafilised Informatsioonisüsteemid – U. Peterson and M. Lang, 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.

Remote Sensing in Nature Looduse kaugseire – M. Lang, Estonian University of Life Sciences.

Databases of Nature Resources Loodusressursside andmebaasid – M. Lang, Estonian University of Life Sciences.

Programming in C# and Pascal Programmeerimine C# ja Pascal keeles – M. Lang, Estonian University of Life Sciences.

Image Processing in Remote Sensing Pilditöötlus kaugseires – U. Veismann together with A. Luts, University of Tartu.

Space Technology Kosmosetehnoloogia – A. Olesk, University of Tartu.

Seminar on Space and Military Technologies Kosmose- ja militaartehnoloogia seminar – M. Noorma together with U. Kvell, A. Olesk, University of Tartu.

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

Remote Sensing II, one lecture Keskkonnafüüsika alused II, 1 loeng ja ühe eksamivooru läbiviimine – M. Aun, University of Tartu.

Fundamentals of Signals and Systems I Signaalitöötluse alused I - K. Zālite together with K. Voormansik, University of Tartu.

Microwave remote sensing Radarkaugseire - K. Zālite together with K. Voormansik, Ventspils University College.

Space Technology Kosmosetehnoloogia alused – A. Slavinskis, University of Tartu.

Amateur radio Amatöörraadioside – T. Eenmäe, V. Allik, University of Tartu.

12.2 Popular lectures Populaarteaduslikud loengud ja esinemised

12 intervjuud raadiole ja televisioonile – T. Viik.
1 intervjuu Vikerraadiole – E. Tempel.
18 avalikku vaatlusõhtut Tartu Tähetornis – A. Puss.
147 planetaariumietendust Tartu Tähetornis – A. Puss.
Kohtumisõhtu astronoomidega (Tartu Tähetorni Astronoomiaring, 15.01.2013) – J. Pelt, A. Tamm, E. Tempel, T. Tuvikene.
Taevane ilutulestik (Labor, Vikerraadio, 06.01.2013) – T. Liimets.
Kosmoloogia elik algusesse ja tagasi (Koidula Gümnaasium, Pärnu, 18.01.2013) – T. Sepp.
Kosmoloogia elik algusesse ja tagasi (Sütevaka Gümnaasium, Pärnu, 18.01.2013) – T. Sepp.
Kosmoloogia elik algusesse ja tagasi (Ülejõe Gümnaasium, Pärnu, 18.01.2013) – T. Sepp.
Katastroofid Päikesesüsteemis (Pärnu Hansagümnaasium, 18.01.2013) – T. Viik.
National Geographicu filmi "Päikese saladused" kommenteerimine (ETV2, 29.01.2013) – T. Liimets.
Astronoomia probleemidest (Vikerraadio, 06.02.2013) – J. Einasto.
Teekond Kehrast tähtedeni (Kehra Gümnaasium, 08.02.2013) – L. Leedjärv.
Satelliitside – mis, kuidas, milleks? (Eesti Raadioamatööride Ühingu tehnikapäev, Tõravere, 09.02.2013) – T. Eenmäe.
200 aastat Universumi uurimist Eestis (Eesti Raadioamatööride Ühingu tehnikapäev, Tõravere, 09.02.2013) – L. Leedjärv.
Kas asteroid 2012 DA14 ohustab Maad? (Raadio 2, Kuulderaadius, 14.02.2013) – L. Leedjärv.
Tšeljabinski meteoriit ja asteroid 2012 DA14 (ETV, otseintervjuu Aktuaalsele Kaamerale, 15.02.2013) – L. Leedjärv.
Kosmoseprügi – asteroidid, komeedid, meteoriidid! ("Puust ja Punaseks", Raadio 2, 22.02.2013) – T. Eenmäe.
Eesti kosmoseuuringud (Rakvere Reaalgümnaasiumi keskkonnateemaliste loengute sari, Tõravere, 01.03.2013) – T. Eenmäe, S. Lätt.
Galileo Galilei – Euroopa teenäitaja (Eesti Geodeetide Ühingu kevadkonverents, Pärnu, 01.03.2013) – L. Leedjärv.
Silmad, mis jälgivad maad (Tartu Tähetorni Astronoomiaring, 05.03.2013) – T. Sepp.
Miks Pluuto enam planeet ei ole. 73 aastat Pluuto avastamisest (intervjuu Vikerraadio saatele "Stuudios on Madis Kimmel", 13.03.2013) – L. Leedjärv.
Avalik vaatlusõhtu (Kamari lasteaed, 16.03.2013) – A. Hirv.
Avalik vaatlusõhtu (Kamari lasteaed, 18.03.2013) – A. Hirv.
Täheparvedest keskkütte radiaatorini (Tartu Tähetorni Astronoomiaring, 19.03.2013) – J.Pelt.

Eestimaa nähtuna kosmosest (Looduskaitse Seltsi Tartu osakonna aastakoosolek, 20.03.2013) – U. Peterson.

Miks maailma lõpp ära jäi? (Tähtvere päevakeskus, Tartu, 21.03.2013) – T. Viik.

Globe at Night (Teaduslaager "Astronoomiakool Tartu Tähetornis", Tartu Tähetorn, 21.03.2013) – T. Eenmäe.

Kuidas pildistada taevakehi (Teaduslaager "Astronoomiakool Tartu Tähetornis", Tartu Tähetorn, 21.03.2013) – T. Eenmäe.

Kiirpilved (Vikerraadio saade "Labor", 07.04.2013) – U. Haud.

Kosmoloogia elik algusesse ja tagasi (Inglise kolledž, 11.04.2013) – T. Sepp.

Kosmoloogia elik algusesse ja tagasi (Tallinna Reaalkool, 11.04.2013) – T. Sepp.

Astronoomia Eestis (Teaduskeskus "AHHAA", 12.04.2013) – J. Einasto.

Külmad tähetekkepilved (Vikerraadio saade "Labor", 21.04.2013) – U. Haud.

Eesti osalus Nõukogude Liidu kosmoseprogrammis (Raadio2, 21.04.2013) – U. Veismann, T. Viik.

Universumi struktuuri mõistmise arengulugu (Tartu Ülikooli Pärnu kolledž, 25.04.2013) – J. Einasto.

The Universe and its content (TEDx seminar, Tallinn, 03.05.2013) – J. Einasto.

Viktor Sobolev – teoreetilise astrofüüsika patriarh (Tartu Tähetorni Astronoomiaring, 07.05.2013) – T. Viik

Kosmoloogia – kellele ja milleks? (Nõo Reaalgümnaasium, 07.05.2013) – T. Sepp.

Tudengisatelliit saadeti orbiidile ("Päevakaja nr 19000", Vikerraadio, 07.05.2013) – T. Eenmäe, M. Noorma, A. Reinart, K. Voormansik.

ESTCube-1 tiirutab ja peab sidet ("Labor", Vikerraadio, 12.05.2013) – T. Eenmäe, K. Voormansik.

Intervjuu Õhtulehele artikli "Multiversumi teooria: meie universum pole midagi erakordset" (18.05.2013) jaoks – T. Sepp.

Jaan Eilarti publikatsioonid (Jaan Eilarti mälestuskonverents Tartu Ülikoolis, 21.06.2013) – U. Peterson.

ESTCube-1 täna – senised tulemused ja mis edasi? (Eesti Raadioamatööride Ühingu suvine kokkutulek, Vaibla, 05.07.2013) – T. Eenmäe.

Astronoomiahuvilised kosmoseriigis (Labor, Vikerraadio, 04.08.2013) – T. Eenmäe, K. Verro, T. Liimets.

Igakülgselt Eesti tudengisatelliidist (Astronoomiahuviliste XVIII Üle-Eestiline kokkutulek, Tõravere, 10.08.2013) – T. Eenmäe, E. Kulu, M. Noorma.

Filamentide kurb saatus (Astronoomiahuviliste XVIII Üle-Eestiline kokkutulek, Tõravere, 10.08.2013) – E. Tempel.

Universumi evolutsioon (Astronoomiahuviliste XVIII Üle-Eestiline kokkutulek, Tõravere, 10.08.2013) – J. Einasto.

Astronoomia uudised (Astronoomiahuviliste XVIII Üle-Eestiline kokkutulek, Tõravere, 11.08.2013) – J. Laur.

Maad taevast ähvardavad ohud (Lodjafestival, Emajõe Suursoo keskus, 22.08.2013) – T. Viik.

F.G.W. Struve elu ja tegevus (Simuna - Võivere matk, 24.08.2013) – T. Viik.
Meenutades Gunnar Kangrot kui õpetajat (Prof. Gunnar Kangro mälestuskonverents, Tartu, 02.09.2013) – J. Einasto.
Meie ohtlikud naabrid ("Teadlaste Öö", Tartu Linnaraamatukogu, 27.09.2013) – T. Viik.
Meie ohtlikud naabrid ("Teadlaste Öö", Tartu Observatoorium, 27.09.2013) – T. Viik.
Tõravere robotteleskoop (Ettekanne ja vaatlus Teadlaste Öö raames, Tõravere, 27.09.2013) – T. Eenmäe.
Kohtumistest Ernst Öpikuga (Teadlaste Öö Kunda muuseumis, Kunda, 27.09.2013) – J. Einasto.
Muusika ja teadus (Eesti Televisioon, Tallinn, 30.09.2013) – J. Einasto.
Karl Fritiof Sundman – kolme keha probleemi lahendaja (Tartu Tähetorni Astronoomiaring, 01.10.2013) – T. Viik.
Miks maailma lõpp ära jäi? (Tallinna Vanalinna Rotary klubi, 02.10.2013) – T. Viik.
Tähtede, galaktikate, Universumi teke (Miina Härma Gümnaasium, 02.10.2013) – E. Tempel.
Aeg enne ja pärast geoloogiat (IX Geoloogia sügiskool, Voore, 12.10.2013) – L. Leedjärv.
Universumi kiireimad ja aeglaseimad protsessid (IX Geoloogia sügiskool, Voore, 12.10.2013) – T. Sepp.
Moodsad teleskoobid (Tartu Tähetorni Astronoomiaring, 15.10.2013) – T. Sepp.
Lugu F.G.W. Struvest ja tema kaarest (Väike-Maarja valla õpilased ja õpetajad, 22.10.2013) – T. Viik.
Teleskoobid: ehitus, konstruktsioon, optikasüsteemid (Astronoomiliste vaatluste juhendajate koolitus, Tõravere, 22.10.2013) – T. Eenmäe.
Digitaalfotograafia: seebikarbist CCD-kaamerani (Astronoomiliste vaatluste juhendajate koolitus, Tõravere, 23.10.2013) – T. Eenmäe.
Praktikum: Astrofotode töötlemine (Astronoomiliste vaatluste juhendajate koolitus, Tõravere, 23.10.2013) – T. Eenmäe.
Stellaariumi lugu (Astronoomiliste vaatluste juhendajate koolitus, Tõravere, 24.10.2013) – M. Ruusalepp.
Maismaa kaugseire Eesti keskkonnaseire programmis (Eesti Geoinformaatika Seltsi aastakonverents, 25.10.2013) – U. Peterson.
Miks tähed tähtsad on? (24 Tundi Eestimaa Rahvamajas, Konguta Rahvamaja, 26.10.2013) – L. Leedjärv.
Täheteke Andromeeda galaktikas (Tartu Tähetorni Astronoomiaring, 05.11.2013) – P. Tenjes.
Universumi struktuur (Buddha Ühing, Tallinn, 07.11.2013) – J. Einasto.
Universumi evolutsioon ja struktuur (Teatriühing, Tallinn, 07.11.2013) – J. Einasto.

Avalik vaatlusõhtu (Kamari lasteaed, 08.11.2013) – A. Hirv.

TEDx Youth Tallinn "Estonian Students at the Frontier of Scientific and Technological Development", (Tallinn, Estonia, 16.11.2013) – A. Slavinskis.

Tumedad jõud: aine ja energia (Tartu Rotary Klubi, 22.11.2013) – E. Tempel.

Raamatu "Dark Matter and Cosmic Web Story" esitlus (Tartu Ülikooli Ajaloo Muuseum, Tartu, 02.12.2013) – J. Einasto.

Päikese ultraviolettkiirgus: head ja halvad küljed, mõõtmine (TÜ ajaloomuuseumi teeõhtu, 05.12.2013) – U. Veismann.

Maa-alused teleskoobid (Tartu Tähetorni Astronoomiaring, 17.12.2013) – J.Pelt.

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

12.3.1 Ph.D. theses Doktoritööd

R. Vendt: Combined Method for Establishment and Dissemination of the International Temperature Scale. Rahvusvahelise temperatuuriskaala esitamine ja edastamine kombineeritud meetodil. Ph.D. Thesis, University of Tartu.
Defence Kaitsmine: 19.06.2013.
Supervisors Juhendajad: D.Sc. Mart Noorma (University of Tartu), D.Sc. Toomas Kübarsepp (Central Office of Metrology, Tallinn University of Technology, Tallinn, Estonia).
Opponents Oponendid: DSc Martti Heinonen, Centre for Metrology and Accreditation (MIKES), Espoo, Finland,
DrEng Mart Tamre, Tallinn University of Technology, Tallinn, Estonia.

Juhendajad, Supervisors: DSc M. Noorma, DSc Toomas Kübarsepp, Central Office of Metrology, Tallinn University of Technology – *Viktor Vabson*: Measurement Uncertainty in Estonian Standard Laboratory for Mass. Mõõtemääramatuse hindamine Eesti massi riigietaloni laboratooriumis PhD Thesis, University of Tartu.

12.3.2 M.Sc. theses Magistritööd

A. Reinart, M. Ligi – *E. Asuküll*: The determination of the coloured organic matter solved in water by satellite photos. Vees lahustunud orgaanilise aine määramine satelliitidelt (M. Sc), University of Tartu.

M. Noorma, V. Allik, R. Vendt – *M. Tverdokhlib*: Sun Sensors Angle Testing for ESTCube-1 Satellite. Päikese sensorite nurga testimine ESTCube-1 satelliidi jaoks (M.Sc.), University of Tartu.

U. Peterson – *T. Lätti*: Mapping Coastal Vegetation on Lakes with Medium Resolution Satellite Images. Järvede kaldaveetaimestiku kaardistamine keskmise ruumilise lahutusega satelliidipiltidelt (M. Sc.), Estonian University of Life Sciences.

U. Peterson – *H. Gross*: Remote Sensing of Coastal Reeds in the Optical Spectral Region at Estonian Western Coastal Areas. Eesti lääneranniku roostike satelliitseire spektri optilises piirkonnas (M. Sc.), Estonian University of Life Sciences.

U. Peterson – *K. Erik*: Changes in the Towns of Ida-Virumaa County Detected with Spectral Mixture Analysis. Ida-Virumaa linnades toimunud muutused spektraalse segu lahutamise meetodil (M. Sc.), University of Tartu.

12.3.3 B.Sc. theses Bakalaureusetööd

V. Allik – *J. Kalde*: Piezoelectric Motor Driver for Nanosatellite Piesoelektrilise mootori juhtseade kuupsatelliidile (B.Sc.), University of Tartu.
– *J. Viru*: Design and testing of Attitude Determination Sensors for ESTCube-1. ESTCube-1 satelliidi asendi määramise ja juhtimise alamsüsteemi disainimine ja testimine (B.Sc.), University of Tartu.

R. Vendt – *R. Valner*: Characterization of Custom Built Sun Sensors for ESTCube-1. ESTCube-1 päikesepatareide karakteriseerimine (B.Sc.), University of Tartu.

J. Kuusk – *R. Kena*: Automated Sun Shade for Sky Imager. Automatiseeritud päikesevari taevakaamerale (B.Sc.), University of Tartu.

M. Lang – *S. Lapitski*: Tree Species Composition Mapping from Medium Resolution Multispectral Satellite Images. Puistute liigilise koosseisu määramine satelliidipildilt (B. Sc.), Estonian University of Life Sciences.

T. Eenmäe, U. Kvell – *I. Mahhonin*: Satellite Tracking Optimizations for Ground Stations Satelliitide jälgimise optimeerimine maajaamades (B.Sc.), University of Tartu.

T. Eenmäe, U. Kvell – *M. Vellak*: Using Space-Dynamics Library OREKIT for Optimal Satellite Contacts Planning Orbitaaldünaamika teegi OREKIT kasutamine satelliitside kontaktide optimaalseks planeerimiseks (B.Sc.), University of Tartu.

E. Tempel – *E. Kuiv*: Morphology of Galaxies in Superclusters Void Network Galaktikagruppide morfoloogia superparvedes ja tühikutes (B.Sc.), University of Tartu.

12.3.4 Diplomitööd Diplomitööd

V. Allik – *J. Subitidze*: Student Satellite ESTCube-1 Vibration Testing Tudengisatelliidi ESTCube-1 vibratsiooni testimine, Eesti Lennuakadeemia.

12.3.5 Refereeing of theses Oponeerimine

J. Kuusk – *H. Lillmaa*: Designing, Building, Programming and Testing Solar Cell Simulator for ESTCube-1. ESTCube-1 päikeseelemendi simulaatori arendus ja testimine (B.Sc.), University of Tartu.

M. Lang – *A. Makarjev*: Geodetic Network Foundation in Järvselja Primeval Forest. Geodeetilise võrgu rajamine Järvselja ürgmetsas (B. Sc.), Estonian University of Life Sciences.

M. Lang – *H. Gross*: Remote Sensing of Coastal Reeds in the Optical Spectral Region at Estonian Western Coastal Areas. Eesti lääneranniku roostike satelliitseire spektri optilises piirkonnas (M. Sc.), Estonian University of Life Sciences.

M. Lang – *S. Sisask*: Effect of Drainage on the Development of an Oligo-Ombrotrophic Pine (*P. sylvestris L.*) Stand in Järvselja. Kuivenduse mõju rabamänniku arengule metsakvartali JS115 näitel (M. Sc.), Estonian University of Life Sciences.

13 Staff Koosseis (31.12.2013)

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	Tõnu Kipper (D.Sc.)
Senior research associate / Vanemteadur	Indrek Kolka (Ph.D.)
Senior research associate / Vanemteadur (0.50)	Tiit Nugis (Ph.D.)
Research associate / Teadur	Mari Burmeister (Ph.D.)
Research associate / Teadur	Anti Hirv (Ph.D.)
Research associate / Teadur	Alar Puss (M.Sc.)
Research associate / Teadur	Taavi Tuvikene (Ph.D.)
Research associate / Teadur	Tõnis Eenmäe (M.Sc.)
Research associate / Teadur	Tiina Liimets (M.Sc.)
Junior research associate / Nooremteadur (0.25)	Jaan Laur (M. Sc.)
Technician / Tehnik (0.25)	Kristiina Verro

Group of theoretical astrophysics Teoreetilise astrofüüsika töörühm

Senior research associate / Vanemteadur (0.75)	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	Raivo Poolamäe (M.Sc.)
Research associate / Teadur	Lili Sapar (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	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 (M.Sc.)
Research associate / Teadur	Ivan Suhhonenko (Ph.D.)
Research associate / Teadur	Lauri J. Liivamägi (M.Sc.)
Research associate / Teadur	Boris Zhivkov Deshev (M.Sc.)
Post doctoral associate / Järeldoktor	Gert Hütsi (Ph.D.)
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Technician / Tehnik (0.70)	Peeter Einasto
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Group of physics of galaxies Galaktikate füüsika töörühm

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