Discussion on the possible merging of Space Climate, Ionospheric Physics and Astronomy Research Units

Working group report
20.4.2018

UNIVERSITY OF OULU

Table of Contents

1. Introduction

The dean Maarit Järvenpää appointed a working group to discuss the drawbacks and benefits for research, education and personnel policy associated with the possible merging of Ionospheric Physics, Space Climate and Astronomy Research Units.

The working group had three meetings on 6.2., 22.2. and 19.4.2018.

This report was prepared by the working group in response to the nomination document from the Dean added in Appendix 1.

Members of the working group were

Education dean Saana-Maija Huttula, chair of the group
Professor Anita Aikio, Ionospheric Physics Research Unit
Professor Kalevi Mursula, Space Climate Research Unit
Professor Jürgen Schmidt, Astronomy Research Unit
University teacher Seppo Alanko, responsible person of Degree program of Physics
Postdoctoral researcher Ilkka Virtanen, Ionospheric Physics Research Unit
Postdoctoral researcher Ilpo Virtanen, Space Climate Research Unit
Student Katja Matilainen, Astronomy Research Unit
Student Juhani Pieskä, Space Climate Research Unit

2. Research units and their personnel plans

2.1. Ionospheric Physics Research Unit

The Ionospheric Physics Research Unit studies ionospheric physics and the geospace environment by utilizing different ground-based and satellite measurements. The terrestrial high-latitude ionosphere is coupled to the magnetosphere and to the solar wind, and one of the key questions is to understand how space weather phenomena affect the coupled magnetosphere-ionosphere-thermosphere system. The electrical currents and electric fields in the ionosphere result from this interaction. Particle precipitation from the near-Earth space to the ionosphere produces visible aurora (northern lights), increases ionospheric ionization and may disturb radio communications. Rapid changes in electric currents produce ionospheric heating and induced currents on the ground and in technological systems like transformers and pipelines. In addition, there is a coupling between the ionized and neutral part of the atmosphere, which is poorly understood.

One of the most important research infrastructures used in our research is the international EISCAT incoherent scatter (IS) radar facility. With these radars, located on the mainland of Scandinavia and on Svalbard, researchers can study the Earth's ionosphere up to 1000 kilometers. The mainland radars will be replaced by 2022 with the volumetric EISCAT_3D radar facility, with stations distributed in Norway, Sweden and Finland. This will be a world-leading IS radar facility. In addition, the unit utilizes several other ground-based equipment such as all-sky cameras, magnetometers, riometers etc. which are operated by the Sodankylä Geophysical Observatory (SGO, independent department of Oulu University) and the Finnish Meteorological Institute (FMI). Satellite missions, e.g. SWARM and Cluster by ESA, play also an important role in our research. Our unit has developed several advanced analysis methods for ground-based and satellite measurements and participated in related international projects. Professor Anita Aikio leads the Ionospheric Physics Research Unit.

Table 1 outlines the personnel plan for the Ionospheric Physics Research Unit for the next three years. The unit is led by one professor, who also leads the overall science planning and ensures coherence, so that critical mass is preserved in the research. Her salary comes mainly from the basic funding. In experimental science, each instrument requires specific expertise and hence the unit must maintain the critical knowledge for key measurements and their state-of the art analysis. The most important instrument is the incoherent scatter radar, because University of Oulu is the coordinator for Finnish EISCAT research and Finland has made the large investment (12.8 M€) in the EISCAT_3D radar facility. University of Oulu/ Ionospheric Physics Unit and SGO have leading expertise in incoherent scatter radar data analysis within the international EISCAT community, and their aim is to keep that position. The research unit has developed also unique satellite analysis tools, in specific for the ESA's Swarm mission magnetometer measurements, as well as for versatile ground-based instruments. The three senior researchers (stages 2-3) in the group have expertise in the above-mentioned fields. At the moment, their funding comes from the Academy and ESA projects as well as from basic funding. One post-doc position will end in August 2018, if there is no success in the 2017 Academy call. The number of seniors will however remain as 3, since the tenure position will be filled by autumn 2018 (see below).

Profi-2 funding (Academy + matching funds from the university) is used to hire a visiting professor (3 months/year for 2018-2020) and to open a tenure position at assistant or associate professor level (not yet filled). With the faculty of Science funding, the tenure funding is secured for 5 years. After that, a continuation period may be granted, or the position may be made permanent if the tenure holder has been successful in the research work. In that case, the tenure holder will get his/her salary from the basic funding and from the overheads of external projects.

Funding for PhD students comes from UniOGS and Kvantum. The group has 2 PhD students in 2018 and we actively seek funding to increase the number of PhD students for later years (+1 increase assumed for 2020, but it can be larger).

After 2020, the aim is to stabilize the funding for seniors and to increase the number of persons at stages 1-2 (PhD students and post-docs). This will require success in different calls, including Academy, EU Horizon, MSCA, ERC and others.

Stage	2018	2019	2020
Professor (stage 4)	1	1	1
Visiting Professor (stage 4)	0.25	0.25	0.25
Researchers, incl. tenure (stages 2-3)	3	3	3
PhD student (stage 1)	2	2	3
Total	6.25	6.25	7.25

Table 1. Person years in Ionospheric Physics Research Unit.

2.2. Space Climate Research Unit

Space climate is an emerging, interdisciplinary science that concentrates on the long-term change (years to thousands of years) in the Sun and its effects in the heliosphere (region of space dominated by solar magnetic field), including the near-Earth space, atmosphere and climate. Space climate has, during the last 10 years, grown to a central focus area in space physics, a topic of collaboration at the widest international level, e.g., within the VarSITI (Variability of the Sun and Its Terrestrial Impact) program of SCOSTEP (Scientific Committee on Solar-Terrestrial Physics). Space Climate Research Unit (SCRU) of the University of Oulu is one of the main originators of Space climate and has had a leading role from the start of this field. SCRU has one of the widest research programs in Space climate research in the world, and SCRU is also one of the first University units dedicated to Space climate.

Space Climate Research Unit concentrates on one of the most important open questions of Space climate research: the unknown long-term (centennial) evolution of the solar poloidal magnetic field and its important role for the long-term variability of solar activity, for the structure of solar magnetic fields, solar corona and solar wind. Poloidal magnetic fields are important because they modulate the amount of high-speed solar wind streams (HSS) that cause magnetic storms and vary the flux of energetic particles in the Earth's magnetosphere, which can also seriously affect the Earth's atmosphere and climate.

One key question is how the solar magnetic field and solar wind changed in the past. The Sun experienced a dramatic burst of activity during the early 20th century, from a low level of 100 years ago to an all-time maximum (so called Grand Modern Maximum; GMM) around 1960, and a recent, rapid decline back to a low level. SCRU uses all ground-based (WSO, MWO, SOLIS) and satellite (SOHO/MDI, SDO/HMI) measurements of the solar magnetic field and historical spectral line observations at several observatories in order to study this exceptional period of the Sun. SCRU has also launched an international team working on this topic within the International Space Science Institute. SCRU is also involved in the future satellite programs measuring the solar magnetic field, in particular in ESA L5 satellite program. Long-term (centennial to millennial) solar activity is being studied using cosmogenic isotopes produced by cosmic rays. University of Oulu hosts one of the most stable and longest-operating cosmic ray stations, which serves as a reference station for the research community.

SCRU studies the occurrence of magnetic storms and substorms, the largest solar disturbances in the near-Earth space that are mainly caused by the coronal mass ejections (CME) or high-speed solar wind streams (HSS). CMEs are related to active magnetic regions like sunspots, HSSs to solar coronal holes (CH). Solar poloidal fields relate to the evolution of coronal holes and, thereby, to high-speed streams. The early disturbances caused by CMEs and HSSs can also be used to study the historical evolution of solar wind and coronal holes. SCRU uses magnetic field measurements from a large number (typically 100) of stations over the last 200 years to study the long-term evolution of the solar wind and coronal holes beyond the time of satellite observations. SCRU maintains a related database of validated, homogeneous long-term measurements that is unique in the world. SCRU also operates a web-based service of monitoring magnetic storms, which is the most extensive and accurate both in space and time.

HSS-related storms are most effective in accelerating energetic particles (EP) in the Earth's magnetosphere. The most severe space weather effects on technology, the "killer electrons" that are known to be responsible for the loss of several satellites, are caused by HSS storms. Energetic particles also affect atmospheric and climatic effects, by causing significant ozone loss in the stratosphere during winter, leading to changes in the polar vortex and air circulation systems. The longest measurements of energetic particles have been made by the MEPED (Medium Energy Proton and Electron Detector) instruments onboard the polar orbiting NOAA (National Oceanic and Atmospheric Administration) satellites. Due to radiation, the instruments degrade in time, but SCRU has corrected the EP measurements of all the 18 NOAA/POES satellites. The corrected dataset now forms the longest calibrated, homogeneous dataset of energetic particles spanning almost 40 years. This dataset is interesting also for atmospheric and climate community and will be used in the future for IPCC-related climate modeling. SCRU has a leading role in the modelling of atmospheric impacts of cosmic rays, including atmospheric ionization, related chemical effects and the production of cosmogenic isotopes. SCRU is also a pioneering team in accurate simulations of terrestrial effects caused by galactic and solar cosmic rays.

The pinnacle of Space climate research is the Centre of Excellence on Research on Solar Long-term Variability and Effects (ReSoLVE) funded by the Academy of Finland in 2014-2019. ReSoLVE consists of three teams in Oulu University and two teams in Aalto University. SCRU leads the ReSoLVE Centre of Excellence and the two professors of SCRU are the chair and vice-chair of ReSoLVE. In addition to ReSoLVE, SCRU has been and continues to be actively involved in several international projects, like in the EU 7th Framework Programme and Horizon 2020 Collaborative and Infrastructure projects (SOTERIA, eHeroes, ESPAS, STORM, SEPServer) and ESF/COST networks (TOSCA, ELECTRONET). Moreover, we have also national funding from the Academy of Finland, Kvantum Institute and different Finnish Foundations.

Stage	2018	2019	2020
Professors (stage 4)	1.5	1.5	1.5
Researchers, incl. tenure (stages 2-3)	6.25	5.75	4
PhD students (stage 1)	5.5	6.5	4
Total	13.25	13.75	9.5

Table 2. Person years in Space Climate Research Unit.

Table 2 depicts the distribution the current personnel of SCRU in the four stages in 2018, and the planned personnel in 2019-2020, based on a realistic estimate of future funding. SCRU includes two full professors, Kalevi Mursula, the Head of the SCRU, and professor Ilya Usoskin, whose funding is currently shared with Sodankylä Geophysical Observatory (SGO) by 50%-50% cost division. Their funding mainly comes from the basic budget. Two postdoc researchers have also shared funding between SCRU and SGO. One senior researcher, who is also a ReSoLVE team leader, one postdoc and one part-time senior are funded from the basic budget. One postdoc is funded by the Kvantum Institute. Other senior (stage 2-3) positions are funded by ReSoLVE CoE funding of the Academy and the related “matching” funding of the University. Additional funding for PhD students comes from UniOGS/Exactus and Kvantum Institute.

As Table 2 shows, it is likely, although not certain, that there will be a considerable reduction in the funding of SCRU in 2020, as the funding of the Academy to ReSoLVE CoE ends. The amount of person years is estimated to reduce by about 30% from 2019 to 2020. However, this will not paralyze SCRU. On the contrary, most of the reduced positions will be recent PhDs, for whom it is only natural to move to their first postdoc position outside Oulu. All key personnel are able to stay within SCRU. SCRU will continue having a strong basic budget, thanks to the very effective outcome of the ReSoLVE period, whose effect will continue until 2023. The unit plans to open a tenure track position at a senior researcher level in 2019. This can be sustained by basic budget until 2021 and thereafter from the savings of the retirement of the unit Head. The matching funding will continue, although at a decreasing level, until 2021, and Kvantum funded positions continue until 2020 and 2021. SCRU will also continue its active policy in seeking external funding from several sources (e.g., Academy of Finland, EU, ESA, ERC, Nordic Council, Foundations etc.), and is expected, judging from the very successful past, to continue having an essential fraction of its total budget from external sources.

Concluding, SCRU will remain fully functional even after the end of ReSoLVE. Although there will be some reduction in personnel, mainly at postdoc (stage 2) level, there will be no loss of critical assets or crucial information, and the SCRU will retain a critical mass for effective operation, as well as for future developments and openings. This is true based on already known sources of funding, but it is also very likely that SCRU will continue being successful in obtaining external funding that will further strengthen the unit.

2.3. Astronomy Research Unit

Astronomy is a well-established independent discipline of Natural Sciences, belonging to the curriculum of most science-oriented universities in the world, including the university of Oulu. The Astronomy Research Unit concentrates on investigating dynamical and physical processes at many different scales, starting from the Solar System and extending to our Milky Way Galaxy and nearby galaxies in general.

The extragalactic research focuses on galaxy formation and evolution. We are particularly interested in the morphology and mass distributions of local redshift-zero galaxies, representing the endpoints of diverse evolutionary pathways starting from primordial dark matter fluctuations. This approach, called galactic archeology, is capable of answering the question in which level the galaxies formed in mergers of dark matter halos at high redshifts, and to what extent they formed due to slower processes related to internal galaxy evolution, or to interactions with the galaxy environment. Our research covers galaxies in the whole range of masses, starting from the Ultra Diffuse Galaxies to the most massive early-type disk galaxies. These extreme galaxy types have turned out to be the hardest to explain in the framework of standard cosmological galaxy evolutionary models.

The Milky Way Galaxy is a point of reference for our extragalactic work. In order to understand the dynamical and star formation processes in other galaxies, knowledge is needed also of our own Galaxy. In our unit, there is an ongoing research of dynamics of binary stars, in particular Cataclysmic Variables, which provides an excellent way to study how stellar evolution is affected due to accretion of gas onto compact objects.

Our research unit plays a leading role in the field of galaxy morphology and has a strong background in dynamical N-body modeling, using codes developed in the unit.

As a direct consequence, we have been invited to several international networks, i.e. the Spitzer Survey of Stellar Structure (S4G), the Fornax Deep Survey (FDS), the DAGAL Marie Curie ITN-network, and currently to SUNDIAL, a H2020 Innovative training network (typically, only 1-2% of such network applications receive EU funding). S4G, a legacy Spitzer survey of about 3000 galaxies observed at infrared, is currently the most complete survey of the nearby universe. The ultimate goal of SUNDIAL is to train astronomy/computer science PhD-students to use EUCLID satellite data (totaling several petabytes), which will be the largest extragalactic database in the coming years. Preparing PhD students for working with such a database will keep the extragalactic astronomy of Oulu in the frontline.

Another focus of the unit's research are small particles found in the environment of the planets of the solar system (circumplanetary dust), which are detected by in-situ instruments on spacecraft. The grains carry information on the physical and chemical conditions at their points of origin, like the surfaces or even the interiors of the moons of the giant planets. For instance, the identification of salts in water ice particles, with the Cosmic Dust Analyzer instrument on board the Cassini mission at Saturn, revealed that the icy moon Enceladus harbors a subsurface water ocean. This finding makes Enceladus a prime target for future spacecraft exploration, because it may support astrobiological processes and the habitability of the moons of the giant planets is a central theme of the ESA Cosmic Vision programme and the NASA Decadal Survey. Also, because their motion is affected by the planetary magnetic fields and the presence of ions and neutral gas, the analysis of the paths of the grains yields information about the environment of the planets. Another motivation for the study of dust around the planets is spacecraft hazard: Impacts of larger particles tend to degrade the hardware of spacecraft and in extreme cases may lead to fatal damage. In this vein, the unit has developed the Jovian Meteoroid Environment Model (JMEM) for the European Space Agency (ESA), which is used in preparation of the ESA mission JUICE that will explore the Jupiter system.

The astronomy research unit uses both ground- and space-based international telescopes with modern instruments attached to them. The most important ground-based facilities are the 2.5-10 m telescopes at the European Southern Observatory (ESO, see section 3) in Chile. During the last three proposal periods the Oulu research unit has obtained 40% of the projects allocated to Finland-based Principal Investigators (observing time is granted based on international competition). We act also as Co-Investigators (Co-Is) in several ESO-proposals every year. Other important facilities are the 10 m Grantecan telescope (five successful runs as a Co-Is during the last three periods) and the Nordic Optical Telescope (NOT, 2.5 m, seven successful proposals during the last three periods) in Canary Islands. Our research unit belongs also to the MAGIC-consortium, which uses the two 17m Cherenkov Telescopes located in La Palma to monitor gamma-ray bursts. Of the space telescopes we have extensively used Spitzer (as S4G core team members; 900 hours allocated since 2009), and also the Hubble Space Telescope, Swift and XMM-newton. In summary, the unit has established a level that makes it capable of winning ample observing time at the most-competed international world class telescopes. The unit is also involved in the future exploration of the solar system with scientific instruments on space missions, as a Co-Investigator of the dust analyzer instrument SUDA on the NASA Europa-Clipper mission that will explore the habitability of the Jupiter moon Europa, the JANUS camera on the ESA mission JUICE to Jupiter, and the mission Destiny+ by the Japanese agency JAXA that will explore a Near Earth asteroid.

Table 3 outlines the personnel plan for Astronomy Research Unit for the next three years. The background of the numbers in the Table 3 is briefly discussed below, followed by an estimate of the future development.

Stage	2018	2019	2020
Professor (stage 4)	2	2	2
Senior researcher (stage3)	1.2	1.2	1
Postdocs (stage 2)	4	4	3
PhD student (stage 1)	6	5	5
Total	13.2	12.2	11

Table 3. Person years in Astronomy Research Unit.

At the moment, the unit consists of two professors, two senior researchers, four post-docs, and six PhD students. One professorship is permanent and one is temporal. It is planned to make the temporal position permanent in course of 2019. The salary of the senior researchers comes from the Astronomy basic funding. One senior researcher is working part time (20%) in 2018 and 2019 and will retire at the beginning of 2020. The second senior researcher position is filled until mid 2018 and it is currently in the process of being filled for a period of five years with an open call. As to the post-doc positions, one is paid from the Astronomy budget (contract until 31.12.2020 that can potentially be renewed), one is funded by the academy project of prof. H. Salo (until mid 2020), one holds a position funded by FINCA (until mid of 2020), and one is funded (for 2018 and 2019) by the Academy of Finland in course of the profiling measure (profi2) to the University of Oulu.

Two PhD students will defend in 2018. One PhD student is funded until 2021 from the Academy project of prof. J. Schmidt and one PhD student is funded through a Horizon 2020 European innovative training network also until 2021. One PhD student is a double degree student with the University of Cordoba in Argentina, which provides funding for 2018. For forthcoming years funding will be applied from foundations that provide research grants. One PhD student is a double degree student with the University of Groningen, funded partially by the Academy of Finland and currently by a grant from the Väisälä foundation. At the moment, there are three promising masters candidates in the unit who will finish their master's thesis soon. For these students the unit is seeking funding in terms of applications to the Academy of Finland and applications for research grants by private foundations.

The unit has long been successful in obtaining external funding, currently two four-year academy research projects (until 2020), and H2020 innovative training network funding (SUNDIAL, 2017-2021). In course of the years 2018-2020 the unit will maintain its activity in writing proposals to external funding agencies. Because of new recruitments (two new post docs in 2017), the research output of the unit is expected to increase, and the overall perspective for submission of selectable research proposals is good. Due to retirements in the unit (one senior researcher 2019 and one professor 2023) the unit plans to open a tenure track position in 2020. The financial support for this position will come in 2020 from the retirement of the senior researcher, the savings of the unit (currently 150 000 €) and the income from the research output of the unit and from 2023 onward from the retirement of the professor.

3. European Southern Observatory membership fee

Finland joined ESO (European Southern Observatory, founded in 1962, belongs to ESFRI roadmap) in 2004. The joining fee was 13 M€ and the annual fee paid by the Academy of Finland is about 2 M€. The membership opened up opportunities for Finnish astronomers to apply for observation time and to participate in other ESO activities. Current and future ESO's VLT telescopes (including the ALMA radio telescope and the forthcoming ELT 39m telescope) are the most important ground-based infrastructure in the European astronomy, including Finnish astronomy.

A national ESO center (Finnish Center for Astronomy with ESO, FINCA) was established in Finland in 2010, operated at the Turku University Tuorla Observatory. FINCA consists of the astronomy units in the Universities of Turku, Helsinki, Oulu, and Aalto. The funding of FINCA consists of the contributions of the University of Turku (600 000 €; including the special funding from the Ministry of Education and Culture), and smaller contributions of the other universities (each 60 000 €). On behalf of Oulu the FINCA agreement was made by the Board of the University. However, the 60 000 € membership fee was paid from the Physics Department budget, and later divided by Astronomy and the Faculty of sciences, and since 2018 completely from the astronomy research unit budget. If the Space Physics and Astronomy units were merged, the fee would be paid by the new unit.

The Astronomy research unit in Oulu has been successful in getting funding from FINCA to such a level that so far it has fully compensated for the FINCA payment. This includes one senior research position (5 years in 2010-2015), funding for developing instrument software (1.5 years in 2016-2017), and three post-doc positions (4 years in 2011-2015; 3 years in 2018-2020). The publications from these FINCA funded positions have earned the University of Oulu about 200 JUFO points (approx. 30 per year), so that in total the University gained back significantly more than the invested 60000 € per year. The Oulu Astronomy unit has also been very successful in getting the highly competitive observing time at ESO: during the last three observing periods Oulu has gained 40% of all accepted PI (principal investigator) proposals from Finland, which fraction is clearly more than expected for the size of the unit.

4. Education

4.1. General about bachelor's education in physics

Physics is the major subject for students of Space Physics and Astronomy. A bachelor's degree with physics as the major subject in the degree program of Mathematics and Physics has the structure shown in Table 4. Courses that are included in the 70 credit points of mandatory physics studies in a bachelor's degree are shown in Table 5, together with the responsible research unit. The total amount of completed credit points for each individual course in 2017 are also shown in Table 5. The same courses (without the bachelor's thesis) comprise the 60 credit points package of minor studies in physics, and some of these courses are also mandatory for students from the Faculty of Technology, and the Faculty of Information Technology and Electrical Engineering.

General and language studies	10 cp
Physics (mandatory for all)	70 cp
Physics, mandatory 25 cr ”minor subject”	25 cp
Mathematics	45 cp
Programming	5 cp
Other studies	25 cp
Total	180 cp

Table 4. General structure of the bachelor's degree in Mathematical and Physical Sciences, when physics is the major subject.

Course	cp	2017	Responsible unit from 2018 onwards
Fysiikan maailmankuva	5	600	Nanomo/Space climate
Fysiikan laboratoriotyöt 1	5	252	Part-time teacher
Mekaniikka 1	5	325	NMR, including labs (credits from “Perusmekaniikka”)
Mekaniikka 2	5	686	Ionospheric physics (credits from ”Mekaniikka”)
Aaltoliike ja optiikka	5	777	Nanomo/Seppo including labs
Fysiikan laboratoriotyöt 2	5	203	Part-time teacher
Sähkömagnetismi 1	5	934	Space climate (credits from ”Sähkö- ja magnetismioppi”) including labs
Sähkömagnetismi 2	5	819	Ionospheric physics (credits from ”Sähkömagnetismi”)
Atomifysiikka 1	5	480	Nanomo
Ydin- ja hiukkasfysiikka	5	192	Nanomo
Kiinteän aineen fysiikka	5	295	Nanomo
Termofysiikka	5	360	NMR
Luk-tutkielma ja seminaari	10		All the physics research groups.
Kypsyysnäyte	0		

Table 5. Mandatory physics courses for all the physics major students, and the 60 credit points package of minor studies in physics (excluding “LuK-tutkielma ja seminaari”).

4.2. Space physics oriented bachelor's degree

Students, who orient to space physics, currently select the 25 cp package (Physics "minor") shown in Table 4. All the courses in Table 6 are lectured in every year. The course “Avaruusfysiikan perusteet” (Basics of space physics) is scheduled in the degree program to the spring semester of the second year. Thus, the Advanced courses of space physics can be started already in the 3rd year.

	25	2017	Responsible unit
Säteilyfysiikka, -biologia ja turvallisuus	5	218	Nanomo, including labs
Fysiikan laboratoriotyöt 3	5	116	Part-time teacher
Avaruusfysiikan perusteet	5	20	Space climate
Kvanttimekaniikka 1	10	154	Nanomo

Table 6: Currently required minor subject package of general physics for the students orienting to space physics.

The same 25 cp package is currently valid also for students, who will orient to molecular and material physics, except that the course “Avaruusfysiikan perusteet” is replaced by the course “Spektroskooppiset menetelmät”. However, there is a clear need to modify this 25 cp package more suited for students interested in space physics by replacing the current courses by courses better dedicated to space physics. The newly planned 25 cp package for space physics students is depicted in Table 7. Similarly, a new dedicated 25 cp package will be planned for molecular and material physics students.

Uusi Avaruusfysiikan paketti	25	2017	Responsible unit
Avaruusfysiikan perusteet	5	20	Space climate
Tähtitieteen perusteet 1	5	24	Astronomy
Data-analyysin perusmenetelmät	10	?	Mathematics
Avaruusfysiikan tutkimusprojekti	5	-	Space climate / Ionospheric physics

Table 7: Newly planned minor subject package for space physics students.

The numbers of completed bachelor's degrees in space physics is shown in the Table 8 for the last four years. Table 8 shows also the proportion of space physics degrees of all bachelor's degrees of physics.

	2014	2015	2016	2017	Average	
Space climate	2	1	2	1	1.50	7.3%
Ionospheric physics	1	0	0	0	0.25	1.2%

Table 8. Numbers of completed bachelor's degrees in space physics.

4.3. Astronomy oriented bachelor's degree

4.3.1 The current structure of bachelor level studies in astronomy

Astronomy minor in a B.Sc. degree consists of 40 cp of studies, 25 cp of which are mandatory for all students. These mandatory courses are listed below.

765114P Tähtitieteen perusteet 1
765115P Tähtitieteen perusteet 2
765307A Tähtitieteen tutkimusprojekti
765309A Galaxies
765384A Physics of the solar system 1

The first-year introductory courses "Fundamentals of astronomy I" and "Fundamentals of astronomy II" are lectured annually in periods 3 and 4. In their second year, students who plan on choosing astronomy as the major subject in their master's degree will complete the course "Research project in astronomy", which gives the students the necessary introduction to using astronomical software and tools in a Linux environment, and reporting their work. The course is offered annually, and its workload is split into periods 3-4. The content of this course is largely independent work for the students. Students that only wish to do a 25 cp minor in astronomy can replace this research project course with "History of astronomy", which is generally suitable for any physicist, including subject teachers, and does not require any prior studies. This course is offered every second year, and on request it can be offered as a book exam if needed.
In their second and third year of studies the students will take the courses "Galaxies" and "Physics of the solar system I", which represent two of the major branches of research at the Astronomy research unit of the University of Oulu. These courses are lectured in a two-year cycle in second period so that either "Galaxies" is taken as a second-year course and "Physics of the solar system I" is taken in their third year of studies, or the other way around. Both of these courses are equally suitable for either second or third year students, so offering them in this kind of cyclical manner saves some resources.

Students that plan on continuing with astronomy as the major subject in their master's studies, will additionally pick at least 15 cp (15-25 cp is recommended) of free-choice intermediate astronomy studies for their bachelor's degree from this list, depending on their interests:

765304A Taivaanmekaniikka I
765386A Interstellar matter
765358A Cosmology
765301A Introduction to nonlinear dynamics
767303A Observational astronomy I
767302A Physics of the solar system II

767301A Time series analysis in astronomy
765308A Tähtitieteen historia

These courses can be taken during the second or third year of studies, and they are lectured in a 2-3-year cycle. The offered teaching is split evenly into four periods during the year. All of the above courses (except "Tähtitieteen historia") can be done later as advanced versions in the master's degree instead by doing additional projects/exercises during the course. This makes the system very flexible and makes it possible to offer a wide selection of different courses without having to lecture them annually. If a student misses an important course in the bachelor phase of their studies, they can include it later as an advanced version in their M.Sc. degree instead. An additional benefit of offering astronomy courses with a 2-3-year time interval is that the lectures will attract a wider audience of students between their second and fifth year of studies. All the other astronomy courses are scheduled in such a manner that a student can collect enough credit points for both their bachelor's and master's degrees within the ideal times of 3+2 years.

		2015		2016		2017		
Course name	CP	Passed credits	Passed students	Passed credits	Passed students	Passed credits	Passed students	Responsible unit
Tähtitieteen perusteet I	5	65P	13	100P	20	120P	24	Astronomy
Tähtitieteen perusteet II	5	45P	9	60P	12	10P	2	Astronomy
Johdatus tähtitieteeseen	2-3	76P	38	65P	32	14P	7	Astronomy
Tähtitieteen historia	3-4	69P	22	42P	14	57P	19	Astronomy
Tähtitieteen maailmankuva	5	65P	13	40P	8	60P	12	Astronomy
Tähtitieteen tutkimusprojekti 1	6-7	13A	2	0A	0	17A	3	Astronomy
Galaksit	6	78A/6S	14	48A/6S	9	6A	1	Astronomy
Physics of the solar system 1	7	28A/35S	9	35A/43S	11	52A	10	Astronomy
Taivaanmekaniikka I	5	15A/0S	3	10A/0S	2	25A/15S	8	Astronomy
Celestial mechanics II – Special topics	7	21A/28S	7	-	-	-	-	Astronomy
Introduction to nonlinear dynamics	6	6A/36S	7	6A/30S	6	0A/6S	1	Astronomy
Interstellar matter	5	-	-	-	-	35A/10S	9	Astronomy
Observational astrophysics and data analysis	6	0A/12S	2	6A/30S	6	-	-	Astronomy
Time series analysis in astronomy	6	-	-	0A/12S	2	-	-	Astronomy
Stellar structure and evolution	7	42A/28S	10	56A/0S	8	35A/7S	6	Astronomy
Cosmology	5	55A/5S	12	40A/5S	9	30A/15S	9	Astronomy

Table 9. Completed credits for basic (P) and intermediate (A) level astronomy courses in the years 2015-2017. The amount of completed credits for the advanced (S) version of the same course is

included for reference as well. Before 2017 only the Fundamentals of Astronomy I & II –courses were mandatory, and the rest of the 40 cp of bachelor-level astronomy studies could be chosen freely. The amount of credits in individual astronomy courses also changed from a range of 2-8 to strict multiples of 5 cp from 2017 onward. A dash signifies that the course was not offered that year.

For the above Table 9 it is important to note a few historical and technical things in order to fully understand its contents. The course "Johdatus tähtitieteeseen" is an older version of the first introductory course in astronomy. Previously the credits for the first two introductory courses in astronomy were divided in a different manner (at first 3cp+8cp, and later on 2cp+8cp), and the first introductory course was a part of mandatory introductory studies in physics.

The timing of the two introductory courses "Tähtitieteen perusteet 1" and "Tähtitieteen perusteet 2" has changed recently, as the University started using a 4-period system instead of just dividing the academic year into spring and fall semesters. In the old schedule the first introductory course was planned to be taken by first year students in their first spring semester, and the second introductory course would then follow in the next fall semester in their second year of studies. In the current period system, the introductory courses are scheduled into periods 3 and 4 in the first year of studies. This change resulted in a unique situation where the second introductory course would have been lectured twice in a row within a very narrow time window, so the lecturer decided to skip holding the course in 2017 and arranged it for the first time in its new time slot in 2018 instead. The 10 credit points logged in for "Tähtitieteen perusteet 2" in 2017 come from two students re-taking a previously failed exam, or re-scheduling the exam to a later time.

The course "Galaksit" used to be lectured annually before 2017. Currently the courses "Galaxies" and "Physics of the solar system 1" are lectured in a two-year cycle so that in 2017 "Galaxies" was not lectured at all. The 6 credits for this course in 2017 come from a student re-taking a previously failed exam.

It should also be noted that the credits logged in for "Introduction to nonlinear dynamics" course in 2015 were actually completed in 2014, but since the date of the final exam was close to the end of the year, the credits were marked in the year 2015. Similarly, the 6 cp logged in the year 2017 come from a student re-scheduling the 2016 exam to a later time.

In the Table 9 there are also two exceptions in the way that the correct timing of the completed credits are presented. The actual number of credits for "Interstellar matter" logged in the year 2017 is 25 credits, by 5 students. There were 4 students who had to take the course exam at a later date, so their 20 credits were actually logged in the year 2018. Because this course was lectured for the first time in 2017, it would be misleading to only list the credits in the year 2017. Similarly, for the course "Taivaanmekaniikka I" there were 0 cp by 0 students logged in the official records during the year 2017 because of the late return date for computer exercises and reports in that course. To leave all the 8 students and 40 credits logged in for this course in 2018 out of this table would also be misleading, as it would look like no one passed the course held in 2017.

The number of completed bachelor's degrees in astronomy is shown in the Table 10 for the last four years. The table also shows the percentage of astronomy degrees from all of the bachelor's degrees in physics.

Major subject	2014	2015	2016	2017	Degrees/year	% from all BSc degrees in physics
Astronomy	5	2	2	2	2.75	13.4 %

Table 10. The number of completed bachelor's degrees in astronomy.

4.4. Master's education in space physics

In Master's studies, the student can specialize in space physics, molecule and materials physics, biomedical physics or astronomy. Students orienting to space physics have to select at least three of the five courses listed in Table 11: Plasmafysiikka, Ionosfäärifysiikka, Heliosfäärifysiikka, Magnetosfäärifysiikka and Kosmiset säteet. These courses are lectured typically every second year. The number of passed students and credit points obtained from these courses during the last three years together with the responsible unit are also given in Table 11.

		2015		2016		2017		
		cp	st	cp	st	cp	st	
Plasmafysiikka	8	40	5	40	5	-	-	Space climate
Ionosfäärifysiikka	8	56	7	-	-	32	4	Ionospheric phys.
Heliosfäärifysiikka	8	-	-	48	6	56	7	Space climate
Magnetosfäärifysiikka	8	32	4	-	-	-	-	Space climate
Kosmiset säteet	8	-	-	16	2	8	1	Space climate

Table 11. Courses organized by space physics units and numbers of passed student from the last three years.

In addition, space physics students have to include at least 16 credit points from those courses listed in Table 12 (or from the rest of the courses of Table 11) to their Master's degree.

		2015		2016		2017		
		cp	st	cp	st	cp	st	
Aurinkofysiikka	8	-	-	80	10	-	-	Space climate
Auringon ilmastovaikutukset	6	36	6	-	-	24	4	Space climate
Revontulifysiikka	6	-	-	54	9	12	2	Ionospheric phys.
Sähkömagneettiset aallot	5	48	8	-	-	-	-	NMR
Hydrodynamiikka	6	-	-	18	3	-	-	Nanomo
Epäkoherentin sirontatutkan perusteet/Radioaallot ionosfäärissä	8	-	-	-	-	-	-	Ionospheric phys.

Table 12. Freely elective courses organized by the two space physics units and the number of passed students during the last three years.

The courses of Table 12 are lectured every second or third year, so that all students can have all the courses of Table 12 in the degree. Therefore, e.g. the 2 students that got the credits for Revontulifysiikka from an exam in 2017 are actually students that participated in the course in 2016 when it was lectured. A new course "Radioaallot ionosfäärissä" will replace the course "Epäkoherentin sirontatutkan perusteet", which will no longer be lectured, since the core information of that course will be included in the new course, and more detailed information on that topic will be given in international Incoherent Scatter Radar Schools. "Hydrodynamiikka" and

"Sähkömagneettiset aallot" are not special courses for space physics but are related closely to the research in space physics. "Hydrodynamiikka" course has been previous lectured by Erkki Thuneberg (theoretical physics) and NMR research group is responsible for the course of "Sähkömagneettiset aallot". The teaching plan of space physics courses for the next four years is shown in Table 13.

Autumn 2018			Spring 2019		
Radioaallot ionosfäärissä	8	Anita Aikio, Ilkka Virtanen	Aurinkofysiikka	8	Ilya Usoskin & Alexander Mishev
Heliosfäärifysiikka	8	Kalevi Mursula	Magnetosfäärifysiikka	8	Timo Asikainen
			Avaruusfysiikan perusteet	5	Kalevi Mursula
Autumn 2019			Spring 2020		
Plasmafysiikka	8	Timo Asikainen	Kosmiset säteet	8	Ilya Usoskin
Ionosfäärifysiikka	8	Anita Aikio	Auringon ilmastovaikutukset	6	Ville Maliniemi
			Avaruusfysiikan perusteet	5	Kalevi Mursula
Autumn 2020			Spring 2021		
Heliosfäärifysiikka	8	Kalevi Mursula	Avaruusfysiikan perusteet	5	Kalevi Mursula
Radioaallot ionosfäärissä	8	Anita Aikio	Aurinkofysiikka	8	Ilya Usoskin

Table 13. Teaching plan of space physics courses for the next four years.

Number of graduated Master students in space physics is given in Table 14. The yearly average of the graduated Master students in Space Climate Research Unit is 1.25 and Ionospheric physics Research Unit 0.50.

	2014	2015	2016	2017	Average	
Space Climate	3	0	1	1	1.25	7.2%
Ionospheric physics	0	0	2	0	0.50	2.9%

Table 14. Number of completed master's degrees in space physics.

4.5. Master's education in astronomy

4.5.1 Current structure of master's level studies in astronomy

Master's studies in astronomy consist of 80 credits: 35 cp master's thesis and at least 45 cp of advanced studies that are chosen freely from the offered courses listed below.

Courses that can be done as either intermediate or advanced versions:

765304S Taivaanmekaniikka 1
765686S Interstellar matter
765658S Cosmology
765601S Introduction to nonlinear dynamics
767603S Observational astronomy 1
767600S Physics of the solar system 2

767601S Time series analysis in astronomy

Courses that are only offered as advanced versions:

765669S Astrophysics of interacting binary stars
765606S Taivaanmekaniikka 2
765661S Galactic astronomy
765608S Galactic dynamics
767600S Observational astronomy 2
765629S Stellar atmospheres
765626S Stellar structure and evolution
765656S Topics of modern astrophysics
765641S Tähtitieteen tutkimusprojekti 2
765692S Tähtitieteen erikoiskurssi

All of these courses are offered in a 2-3-year cycle, with the exception of the 'Special course in astronomy'. The content and lecturer of this course varies, and it can include courses done in other universities. With the current variety of courses, and the provided flexibility, it is definitely possible to graduate in goal time from both bachelor's and master's degrees, with a specialization of your choice.

The teaching plan for astronomy courses is shown in Table 15. The astronomy research unit currently has two new postdocs who are willing to gain teaching experience. This is considered an advantage in their future grant or work applications, and enhances their career opportunities. The contract of one lecturer (yliopistotutkija) will terminate in mid-2018, but the position is currently in the process of being filled for a period of five years with an open call. The research unit is continuing its efforts to keep a Finnish speaking lecturer (yliopisto-opettaja) as a part of the teaching personnel. As an alternative, fallback solution, the teaching can be provided partly in English and partly in Finnish, by providing the written teaching material in Finnish and offering the exam in Finnish as well. The course "Tähtitieteen tutkimusprojekti 1" consists of research projects of smaller scope. The direct supervision can be done by a PhD student while the topic and the project evaluation are made by senior researchers of the unit.

Autumn 2018			Spring 2019		
Tähtitieteen historia	5	Pertti Rautiainen	Tähtitieteen perusteet I	5	Rautiainen/Salo/ Schmidt/Comeron
Galaxies (Galaksit)	5	Joachim Janz	Tähtitieteen perusteet II	5	Rautiainen/Salo/ Schmidt/Comeron
Observational astronomy I	5	Vitaly Neustroev	Tähtitieteen tutkimusprojekti I	5	PhD Student / Salo/Schmidt/Comereon
Celestial mechanics II	10	Juergen Schmidt	Stellar structure and evolution	10	Sebastien Comeron
Tähtitieteen erikoiskurssi (Planetaariset renkaat)	5	Heikki Salo	Observational astronomy II	5	Vitaly Neustroev
			Physics of the solar system II	5	Juergen Schmidt

Autumn 2019			Spring 2020		
Physics of the Solar System I	5	Juergen Schmidt	Tähtitieteen perusteet I	5	Rautiainen/Salo/ Schmidt/Comeron
Interstellar matter	5	Sebastien Comeron	Tähtitieteen perusteet II	5	Rautiainen/Salo/ Schmidt/Comeron
Celestial mechanics I	5	post doc	Tähtitieteen tutkimusprojekti I	5	PhD Student / Salo/Schmidt/Comereon
Stellar atmospheres	10	Vitaly Neustroev	Introduction to nonlinear dynamics	5	Juergen Schmidt
Tähtitieteen historia (book exam)	5	Heikki Salo / Rautiainen	Cosmology	5	Sebastien Comeron
Autumn 2020			Spring 2021		
Galaxies (Galaksit)	5	post doc or Comeron	Tähtitieteen perusteet I	5	Rautiainen/Salo/ Schmidt/Comeron
New course	5	post doc	Tähtitieteen perusteet II	5	Rautiainen/Salo/ Schmidt/Comeron
Galactic dynamics	10	Heikki Salo	Tähtitieteen tutkimusprojekti I	5	PhD Student / Salo/Schmidt/Comereon
Tähtitieteen historia (book exam)	5	Heikki Salo / Rautiainen	Stellar structure and evolution	10	Sebastien Comeron
Astrophysics of Interacting binary stars	5	Vitaly Neustroev	Time-series analysis in astronomy	5	Vitaly Neustroev
			Physics of the solar system II	5	Juergen Schmidt

Table 15. Three-year teaching plan for astronomy

4.5.2 Amount of completed master's level studies in the years 2015-2017

		2015		2016		2017		
Course name	CP	Passed credits	Passed students	Passed credits	Passed students	Passed credits	Passed students	Responsible unit
Galaxies	6	78A/6S	14	48A/6S	9	6A/0S	1	Astronomy
Physics of the solar system 1	7	28A/35S	9	35A/43S	11	52A	10	Astronomy
Physics of the solar system 2	7	-	-	-	-	21S	3	Astronomy
Tähtitieteen tutkimusprojekti 2	6	0S	0	0S	0	6S	1	Astronomy
Taivaanmekaniikka I		15A/0S	3	10A/0S	2	25A/15S	8	Astronomy
Celestial mechanics II – Special topics	7	21A/28S	7	-	-	-	-	Astronomy
Interstellar matter	5	-	-	-	-	35A/10S	9	Astronomy
Cosmology	5	55A/5S	12	40A/5S	9	30A/15S	9	Astronomy
Introduction to nonlinear dynamics	6	6A/36S	7	6A/30S	6	0A/6S	1	Astronomy
Observational astrophysics and data analysis	6	12S	2	6A/30S	6	-	-	Astronomy
Time series analysis in astronomy	6	-	-	12S	2	-	-	Astronomy
Astrophysics of interacting binary stars	5	-	-	-	-	10S	2	Astronomy

Stellar structure and evolution	7	42A/28S	10	56A	8	35A/7S	6	Astronomy
Special course in astronomy	x	-	-	-	-	40S	7	Astronomy
Advanced astronomy studies at other universities	x	12S	2	14S	3	18S	3	Astronomy
Dark matter	5	-	-	25S	5	-	-	Astronomy
Stellar dynamics	7	-	-	-	-	28S	4	Astronomy

Table 16. Completed credits for advanced (S) level astronomy courses in the years 2015-2017. The amount of completed credits for the intermediate (A) version of the same course is included for reference as well. A dash signifies that the course was not offered that year.

In the above Table 16 there are a couple of exceptions in the way that the correct timing of the completed credits is presented. Because the course "Astrophysics of interacting binary stars" was only offered in 2017 and not during the years 2015-2016, the credits marked in the year 2018 from the course exam done in late 2017 or re-scheduled course exam in the very early 2018 were included here. The actual records for this course during the year 2017 was 0cp from 0 students. The course exam was held late in the year 2017, so all of the course credits were marked in the year 2018. It would be misleading to leave these credits completely out of the table, so they were included here as an exception. For any exceptions in the courses that can be done as either intermediate or advanced versions, see explanations below Table 9.

The number of master's degrees completed in astronomy in the years 2014-2017 is shown in the table below.

Major subject	2014	2015	2016	2017	Degrees/year	% from all MSc degrees in physics
Astronomy	1	1	0	2	1.00	5.8%

Table 17. The number of completed master's degrees in astronomy in the years 2014-2017.

4.6. Scope of astronomy teaching, and co-operation with Turku

The question about the minimum required amount of teaching in astronomy should not be answered by just blindly looking at the minimum amount of credits required for a single kind of degree in astronomy. The minimum amount of variety required in teaching should be considered as well. For the astronomy program in Oulu to maintain its equivalent position among the other Finnish astronomical institutes, there needs to exist a similar amount of variety in offered courses.

The amount of credits included should remain comparable as well. The current amount of astronomy major credits in our degree is on the same level as in the University of Turku, and a bit less than in the University of Helsinki. It is also important to note, that in order for our astronomy unit to provide the students with a competitive degree, our degrees have to match the scope of teaching provided outside of Finland as well. Reducing the amount of required astronomy credits for B.Sc. and M.Sc. degrees at our university would mean that the degrees offered here are no longer applicable and comparable with other universities on an international scale. This would have serious consequences to the future of astronomy in Oulu. We would no longer be on the same level with some key European institutes, which would reduce mobility between universities, reduce success in having good post-doc positions, and make it impossible to integrate students to international collaborations. It would also shut down the well started practice of making double degrees in astronomy between Oulu and other European universities. Current examples of such double degrees are those with the universities of Heidelberg and Groningen.

Professor Heikki Salo and Professor Juri Poutanen (University of Turku) made a report "Tähtitiede Oulun ja Turun yliopistoissa: näkymiä tutkimus- ja opetusyhteistyön kehittämiseen" (Astronomy at the University of Oulu and Turku: prospects for development of research and educational cooperation) in December 2015. In the report they emphasize the existing national cooperation in the form of the NOT (Nordic Optical Telescope) observing course, held annually in Turku, with students and teachers also from Helsinki and Oulu (according to the Sisu portal (sisu.oulu.fi), 3 students have passed the course in 2015 (total 18 cp), 2 students in 2016 (12 cp) and 3 students in 2017 (18 cp)). According to the report, astronomy graduate students also participate regularly in international summer and winter schools during (the latest completed astronomy PhD degrees in Oulu - total of 6 in years 2013-2017 - included typically 3-4 such international courses).

The report found no problems with the already existing scope or quality of the teaching of astronomy in either Turku or Oulu, but noted that increased teaching co-operation could further diversify the teaching provided. Cooperation could be intensified by offering short intensive courses or even by video lectures including interactive training and feedback sessions, provided that extra financial support would be granted for the mobility of teachers/students. To facilitate such activities, the Finnish astronomy units made a joint Oulu-led proposal to develop digital teaching in astronomy (Digitaalinen opetus ja tutkimus tähtitieteessä (DOTT, 7.10.2016), as a response to Ministry of Education call "Erityisavustus korkeakouluille korkeakoulutuksen kehittämishankkeisiin"). However, the proposal did not advance, mainly because of the lack of support from the administration of the University of Oulu. Currently, all the astronomy studies in the University of Turku can be included to a degree in Oulu (and vice versa). With the exception of the NOT course (which has received Exactus support), only few students have used that possibility, one during the last three years – this is quite natural taking into account that there are no resources to support such activity.

From the beginning of 2017, all ESO Center seminars (every 1-2 weeks) are broadcasted online and in Oulu the seminars have been followed by the staff as well as 3-4 doctoral and 2-3 master students. A number of visitors to the ESO Center have given seminars in Oulu (4 in the academic years 2016-2017, travel expenses reimbursed by the Center).

4.7. Cost of education

At the moment, the degree program of physics pays 117 €/h for lectures and 37 €/h for other teaching to the research units. In 2017 the degree program compensated teaching to the research units as follows: 42 200 € to Space Climate[1], 8000 € to Ionospheric Physics and 43 500 € to Astronomy Research Unit. Teaching of mandatory courses in academic year 2017-2018, Space Climate Research unit had responsibility for “Fysiikan maailmankuva” and “Sähkö- ja magnetismioppi” courses, the latter one being replaced by “Sähkömagnetismi 1” course in the future. Ionospheric Physics unit had the responsibility of “Sähkömagnetismi” course and "Numeeriset menetelmät", and in the future for “Sähkömagnetismi 2” and “Mekaniikka 2” courses. Many physics and mathematics students also take the courses "Tähtitieteen Historia", "Tähtitieteen Maailmankuva", and "Tähtitieteen Perusteet" given by the Astronomy Unit.

The Astronomy Research Unit organizes a total amount of 50-65 cp of teaching per academic year, given by all the senior researchers of the unit. In the new degree program, the scope of each astronomy course is either 5 cp or 10 cp, and as a rough estimate based on the lecture and exercise hours of the courses "Fundamental astronomy I" and "Fundamental astronomy II", and the total amount of astronomy credits offered per year, the total cost of astronomy education to the degree program is around 37 200 € - 48 360 € per academic year. Altogether the degree program compensation for the organization of teaching forms about 6% of the unit's income. This indicates that astronomy teaching is funded essentially from the income earned by research output (publications, PhD degrees, external funding). This emphasizes the unit’s strong commitment to research-oriented teaching and training of future scientists.

4.8. Applicability of astronomy courses for students of space physics, and vice versa

The question of course suitability is complex. There are several courses available in the University's educational curriculum, which can reasonably be regarded as interesting, useful, and suitable for space physics and astronomy students. From the space physics student's point of view, for example, some astronomy courses like "Stellar structure and evolution" or "Stellar atmospheres" might, in principle, be interesting. However, these courses cannot compensate space physics courses since the orientation and emphasis in the two disciplines are quite different, space physics research focusing largely on plasma physics, astronomy on dynamics. In practice, the specialized research of the two fields clearly require dedicated course of their own. Even if the degree program would be common, in both disciplines it is necessary to keep the current teaching program almost entirely. If the selection of courses is reduced or courses combined with each other, internationally recognized high-quality research in both fields would suffer.

Space physics courses like “Plasma physics” or “Solar physics” could similarly be recommended as supplementary studies for astronomy students, although these courses focus on processes relevant for the solar-terrestrial environment, not on the stellar evolution of the Sun. It is currently possible

[1] When writing this report, S-MH. found a mistake – 42 h lectures too many, i.e. 4915 €, has been paid for to the Space Climate units. This will be correct in the next budget.

to include these studies in the astronomy major if the courses are found to be relevant for the student's specialization. From an outside perspective it may seem that there is a lot of overlap in courses like "Solar physics" given by the Space Climate research unit and "Stellar structure and evolution" given by the Astronomy research unit, but the specific objects of study and the focus and scope of these two courses are quite different.

As in many other fields of science, there is some overlap and commonly interesting topics for Astronomy and Space physics. In fact, Astronomy has some overlap with some other major subjects of physics as well. Most notably, there is a pool of theoretical physics courses that could reasonably be included as a part of major studies in astronomy. For an astronomer focusing in dynamics, “Analytical mechanics” is an essential course that has been included in the bachelor level studies in astronomy. Similarly, the course “General relativity” is crucial for astronomers specializing in cosmology. It is also important to note that some of the courses listed as free-choice space physics courses, like “Hydrodynamics” and “Electromagnetic waves”, can be relevant for both astronomers and space physicists, depending on their specialization, but the content of these courses is general and theoretical physics, not space physics.

5. Drawbacks and benefits of merging the units

5.1. Drawbacks and benefits for education

Although the scientific disciplines of Astronomy and Space Physics are partly related, their research goals, instrumentations and related methods are different. While Astronomy studies the dynamics and configuration of celestial bodies from the solar system scale to the largest structures in the universe, Space Physics investigates the structure and evolution of solar magnetic fields, solar electromagnetic and particle emissions, cosmic rays, and the physics of planetary magnetospheres, ionospheres and atmospheres. These differences impose different needs for the education and training of young researchers in these two disciplines.

For Astronomy, the existing courses are adapted and optimized to the needs of the structured curriculum for the Bachelor's and Master's degree (see Section 4). For Space Physics, the current Bachelor's degree requirements are not optimal. Space Physics students take now the same courses in the 25 cp "minor subject" package as those Physics students that orient to Molecular and Materials Physics, with the exception that the course Spectroscopic Methods is replaced with Basics of Space Physics (Table 6). A more optimal "minor subject" package for space physics would include, in addition to the Basics of Space Physics course, the following courses: Fundamentals of Astronomy, Data-analyysin perusmenetelmät (from Mathematics) and a Research project (Table 7).

In the Master's education, both Astronomy and Space Physics give their discipline-specific courses, which have practically little or no overlap (see Section 4). A few of these courses may be suitable for some students in either discipline, but both disciplines need to maintain their own curriculum of courses in order to be able to educate competitive researchers (both at Master's and PhD levels). The status of Astronomy as an independent study subject was discussed in spring 2016, when the University Board (http://www.oulu.fi/yliopisto/node/38743) decided to maintain the Master's degree in Astronomy. One should note that Space Physics of the University of Oulu has, since some 10-15 years now, the widest and the most versatile education in Finland in this discipline. This versatility has introduced several benefits to the University, by sustaining an influx of talented students and personnel to the two Space Physics units. The same is true for astronomy, with its success in participation to EU funded doctoral training networks. If the Master's degree education in Space Physics or Astronomy is reduced, the current, excellent situation will soon be lost and the national and international status of the University of Oulu in these disciplines will deteriorate. It is also important to note that the advanced courses for the Master's degree are also necessary for the PhD training. Therefore, no benefit would arise from merging of teaching in these disciplines, while the risk of a negative influence would be significant.

In summary, the number and contents of courses in the current curriculum of Astronomy and Space Physics is needed to maintain education for Bachelor's, Master's, and PhD students that is not only comparable and compatible with other universities, nationally and internationally (e.g. for double degrees), but even partly leading at the national level. In this vein, the reduction of the number or contents of courses, if it should arise, e.g., from the merging of the units, would be a serious drawback to the national status of the University of Oulu in comparison to other universities, making Oulu less attractive for students interested in these disciplines.

5.2. Drawbacks and benefits for research

All the three units have their own well-established and productive research programs and collaborations with researchers at a high international level (see Section 2). This is well demonstrated in the publication and citation records of the units. According to the NatureINDEX ranking (www.natureindex.com, which is an international equivalent to the national JUFO3 ranking), Space Climate and Astronomy have a great contribution to the publication record of the University of Oulu, being responsible for 20-40% of the weighted score (WFC of NatureINDEX) of all scientific publications of the University of Oulu during the last few years. In terms of research output normalized to financial resources, these units reach the level of top European universities.

This excellent situation in the publication record ultimately reflects a similar, good situation in the external funding of the three units, which has attracted outstanding researchers to the units. Forced merging of the units is unlikely to enhance the mutual collaborations or the scientific productivity of the units, nor the success rate of funding proposals. Collaboration between the units can be, and has occasionally been, carried out in specific research topics, even without merging the units.

5.3. Drawbacks and benefits for personnel policy and budget planning

At the moment the three units have their own leaders and other personnel. The personnel plans of the units aim to guarantee that the output of the units will remain at its current, highly successful level. It is not clear if these personnel plans would be kept intact after possible merging, when the three units would merely exist as research groups in a larger unit.

Merging of the three units would mean a reduction in the number of unit leaders and a re-distribution and concentration of administrative work. Moreover, internal administration efforts (group leader meetings, sharing of information among the large unit) would be complicated by adding an extra layer, making the system less dynamic. Benefits and drawbacks would partly neutralize, but one large unit would hardly reach the high level of functionality and agility of the current system of three smaller units.

In small units, the yearly fluctuations in funding would be *relatively* larger than in a large unit. Such fluctuations may occur if a large project ends. However, the *absolute* effect of the ending project remains exactly the same. The same amount of money is lost, and the same amount of personnel is in danger of dismissal. Therefore, the most important question, i.e., how the unit will balance its budget in order to adjust to the (at least temporarily) lower level of funding, remains the same for a large unit as for three smaller units. External funding has a considerably large fraction of the total budget of the three units, and most personnel is hired with this external funding. Realistic estimates into the future of several years ahead (see Section 2) show that all the three units are able to adjust their budgets to the end of ongoing large projects in such a way that the units can finance their key personnel, even with the smaller budget. Careful advance planning and a focused use of the unit's balance sheet are effective tools for the units to balance their budgets at times of changing external funding.

Accordingly, there are no administrational drawbacks from the existence of having three separate units, and the three units impose no financial threat to the budget of the University.

The current administrational structure of the University of Oulu is based on closely collaborating research units. It was introduced by the current rector, with the main aim to have more transparency and responsibility to financing. Research units are more effective and motivated to seek for external funding, which is beneficial for the whole University. The three units with their extensive external funding are in fact model samples of the success of this administrational structure. This structure has been in operation for a very short time only, less than three years. Therefore, this structure should be continued several more years into the future before changes based on the evaluation of its benefits and drawbacks can be made. In any case, such changes should not be made to successful units like the three research units in question.

6. Summary

Currently the three research units, Ionospheric Physics, Space Climate, and Astronomy carry out high-profile research that is internationally recognized and well connected. The units have nationally and internationally leading positions in certain research areas. They produce a significant, greatly over-proportional fraction of the science output of the University of Oulu. The educational curriculum of the units is well structured and healthy. Compared to the scientific output the cost of teaching is small (e.g. 6% for Astronomy). Possible merging of the units would neither release new resources, nor enhance the currently highly successful operation of the units. We find no recognizable added value that would arise from merging. Rather, there is a threat of losing agility from merging and adding an extra layer of internal administration.

16.1.2018

Työryhmän asettaminen /
Avaruusilmaston, Ionosfäärifysiikan ja Tähtitieteen tutkimusyksiköiden mahdollinen yhdistäminen

Asetan työryhmän, jonka tehtävänä on tarkastella Avaruusilmaston, Ionosfäärifysiikan ja Tähtitieteen tutkimusyksiköiden mahdolliseen yhdistämiseen liittyviä hyötyjä ja haittoja tutkimuksen, koulutuksen ja henkilöstöpolitiikan kannalta. Pyydän huomioimaan erityisesti seuraavat seikat:

- henkilöstösuunnitelmat (perusrahoituksella rahoitettava henkilöstö) sekä niiden kehittämistarpeet ja taloudelliset toteuttamisedellytykset, erityisesti keskeiset pidemmän ajan suunnitelmat (esimerkiksi Ionosfäärifysiikan tenure track -tehtävän rahoitus strategisen rahoituksen päättymisen jälkeen, huippuyksikkökauden päättymisen vaikutus Avaruusfysiikan tutkimusyksikköön)

- ESO-keskusmaksu

- laaja-alaisen LuK-tutkinnon suomenkielisen opetuksen ja maisteritutkinnon suuntautautumisvaihtoehtojen opetusresurssit (mahdolliset uudet rekrytoinnit)

Työryhmän jäsenet ovat:

Koulutusdekaani Saana-Maija Huttula

Professori Anita Aikio
Professori Kalevi Mursula
Professori Juergen Schmidt

Fysiikan maisteriohjelman vastuuhenkilö Seppo Alanko

Oulun yliopisto
Luonnontieteellinen tiedekunta

PL 3000
90014 Oulun yliopisto

Puh 029 448 1051
www.oulu.fi/lutk

Tutkijatohtori Ilkka Virtanen
Tutkijatohtori Ilpo Virtanen

Opiskelija Katja Matilainen
Opiskelija Juhani Pieskä

Puheenjohtajana ja koollekutsujana toimii koulutusdekaani Saana-Maija Huttula. Työryhmä voi tarvittaessa kuulla valitsemiaan asiantuntijoita.

Työryhmän tulee raportoida dekaanille 31.3.2018 mennessä.

Maarit Järvenpää
Dekaani

JAKELU:
Työryhmän jäsenet
Henkilöstöpäällikkö Tiina Pääkkönen