Evaluation of Estonian Research

- Particles and Fields, Mathematical Physics, Astronomy and Astrophysics -

Report to the Estonian Science Fund Council

by

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June 1992

The authors of this report were appointed for the purpose of this evaluation by the Swedish Natural Science Research Council.

NFR Naturvetenskapliga forskningsrådet
Swedish Natural Science Research Council

Foreword

Several Swedish organizations have been asked to take part in a general evaluation of all research performed at academic institutions in Estonia. NFR has agreed to organize the evaluation of Estonian research within the field of natural science. This report has been prepared according to an agreement between the Estonian Science Fund Council and the Swedish Natural Science Research Council (NFR).

During the spring of 1991 Estonian scientists completed reports on their research which were sent to NFR. These reports have subsequently been distributed among 14 Swedish evaluation groups. In total about 40 Swedish scientists are engaged in the evaluations. The groups are making site visits to the Estonian laboratories and institutes during 1991/92 to discuss the research performed, the plans for future activities and to get information about the working conditions, experimental facilities, financial resources etc. Each group has been instructed to produce a report assessing its particular research area.

This report concerns the sub-fields of particles and fields, mathematical physics, astronomy and astrophysics and will eventually be a part of an extensive report covering all Estonian research in natural science.

The organization of the site visits is done in close cooperation with the Estonian Science Fund Council. Although difficult times prevail in Estonia all the site visits have been successful. The NFR is grateful to the Estonian Science Fund Council for its efforts to handle all practical matters in connection with these visits.

The NFR is also grateful to the Swedish scientists who with enthusiasm and great skill have taken part in the demanding evaluation work.

Finally, the Council wishes to express its sincere hope that this evaluation report will contribute to a further positive development and strengthening of Estonian science.

Carl Nordling
Secretary General

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INTRODUCTION

The Estonian Science Fund Council has instructed Estonian scientists in the field of Particles and Fields, Mathematical Physics, Astronomy and Astrophysics to prepare reports concerning their research activities during the last 5 years. These reports were completed during the spring of 1991 and dealt with the following points:

- project leader(s)
- short description of the objectives
- summary of results
- summary of resources
- scientific staff and their qualifications
- list of publications
- dissertations
- scientific meetings organized
- prognosis of the future development of the project

In most cases the reports were accompanied by reprints of scientific publications written in English and Russian.

In July 1991 the reports were sent to NFR and during the autumn the Evaluation Committee received the reports. Site visits by the Committee to the research groups were done in the period April 27-29 1992. The Estonian Science Fund Council had appointed Dr Ain Kallis as organizer and contact person for this evaluation.

ACKNOWLEDGEMENTS

It was most interesting to get an in-depth view of the work of our colleagues in Estonia, at this time of major historical changes. Our work was made possible through the efforts of several persons from the Estonian Academy of Sciences. We would like to thank our hosts for their generous hospitality, and our special thanks go to Dr Ain Kallis for his efforts to facilitate all aspects of our visit. We hope that our deliberations will be useful for the further development of science and scientific collaboration alike.

GENERAL COMMENTS

The fields of knowledge of Estonian physics that this evaluation group has studied, comprise astronomy and astrophysics, field theory, mathematical physics (including general theory of relativity), and particle physics.

Particle physics and field theory aim at describing the nature of matter at the smallest scales and highest energies, whereas astronomy and astrophysics studies the Universe at large, properties of galaxies, stars and other celestial objects. The theory of general relativity is related to the space-time properties of objects that are dominated by gravitation.

Modern cosmology connects these different fields of study in the form of an evolutionary history of the Universe called the "Big Bang" scenario, where particle physics aspects are especially important in its early phases.

In Estonia, theory of particles and fields is represented at the Tallinn Technical University and at the Laboratory of Theoretical Physics at the Institute of Physics of the Estonian Academy of Sciences (Tartu), whereas Astrophysics is represented mainly at the Institute of Astrophysics and Atmospheric Physics of the Estonian Academy of Sciences (Toravere). We have made visits to the Tallinn Technical University, the Laboratory of Theoretical Physics, and the Institute of Astrophysics and Atmospheric Physics.

At the general level, the efforts of Estonian scientists in these fields should be seen both as research per se, and as a basis for education of younger physicists. Since the academic career in Estonia is not similar to the western European systems, we will comment upon this aspect below. Thirdly, its role is also to establish a contact of competence with the international scientific community, so that Estonian culture can become infused with the international scientific development.

The system of academy research institutes (where the main research activity is performed), separate from the universities, was built up in Estonia during its Soviet period. The relative isolation of the research in the academies has, in our opinion, several drawbacks. The young generation does not come into contact with the actively working scientists in their role as teachers, and the researchers do not get stimulus from the contact with the students. Also, a scientific career based on tenure track directly after recruitment to graduate study, does not create an optimal situation for academic competition, and the interaction of researchers with society becomes rather weak.

It appears that the situation on a general level being difficult in economic terms, has forced some good people to leave Estonia for longer periods. This is on a short-term basis a real threat to Estonian science, lest these people can be offered permanent positions to come back to as soon as the situation becomes economically more stable. Appropriate measures to minimize this "brain-drain" should be taken quickly.

An important influencing factor in the development of research areas in Estonia seems to have been the access (or rather lack of access) to western journals. The sparsity of such journals has sometimes tempted to place the emphasis on subjects that are not developed much in the world, or that are not "hot". This is understandable, but should now be quickly changed. Another related difficulty has been to get hold of western books. It seems nevertheless that some groups, e.g. the cosmology one, have been able to go into modern fields despite similar difficulties.

Graduate students and work in universities

The number of graduate students ("doctorands") as a whole appears remarkably low. One of the reasons appears to be the previous requirement that they be guaranteed a position in the same field following the completion of their degree, already at the time of being accepted for study. In our opinion, this policy should not be continued: for those persons who perhaps 20 years from now will be responsible for some enterprise in state, industry, university or academy, it is probably of minor importance what their current research topic is.

What is important, is that they get exposed to challenging problems, and learn methods for attacking difficult questions on an international level. Astronomy and physics have a great intellectual attraction, and this should be utilized to offer possibilities for graduate study to many more students than at present. For example, we believe that the astronomical institute in Toravere could accommodate perhaps twenty or even thirty graduate students. Certainly, only a small fraction of these would continue to work in astronomy in their later careers, but the migration of scientifically trained persons into all branches of society should be greatly beneficial, not least for the development of a national industry based on highly qualified science and technology.

Our impression is that the teaching staff at the universities have a much too high teaching load, while that at the academy institutes is much too low. The creation of a good scientific "atmosphere" at a university, requires the involvement in teaching also by the leading scientists. We noted, with satisfaction, that such changes are already in progress at the university and academy institutes in Tartu.

Age distribution of graduate students

We noted that the period of graduate study (as "doctorand") is preceded by extensive undergraduate studies (as we understand, normally 6 years). While this may, in some sense, mean a broad education for the future scientists, it also constitutes a problem since the new doctors become relatively old before graduating (most often above 30). As commented on above, it should be beneficial to science and society alike, to have a much increased flow of graduate students. However, since one intention with such a program, is to have more persons with a scientific education in different positions in society, these persons must have a chance to begin their career outside the academic world before they are too old. Then a more suitable age for the completion of a doctorate should be around 25-27 years. Thus a shortening of the undergraduate and graduate periods should be aimed for: it is better to have a larger number of graduate students complete their exams in a shorter time, than a smaller number continuing for a longer time.

Electronic computer networks

The (continued) development of electronic computer networks seems to us as being the most important improvement of infrastructure, which is possible in the short term. The computer links currently being established between the Nordic and the Baltic countries, promise to give capacity for remote login, file transfer, etc. to and from computers located almost anywhere in the world. Those scientists who have colleagues abroad, might obtain permission to use their computers, which then will become easily accessible for Estonian scientists without leaving their normal place of work. This is essential also to stimulate scientists not to leave their institutes for others abroad. The use of networking to run programs on computers located elsewhere, appears to be the by far most efficient method to improve computing capacity to world

standards, especially compared to the prospect of locally purchasing and maintaining the equivalent equipment. This applies in particular to smaller research groups outside the main institutes.

The possibility of remote login also opens exciting possibilities to join software developments together with groups elsewhere. (It also must have considerable commercial potential in the offering of software services by Estonian companies, although that falls outside our task to discuss.) The possibility of computer file transfer enables the easy acquisition of many computer programs from institutes around the world, and (at least in some branches of science) may also partly solve some problems with the deficit of hard currency for the purchase of scientific journals. In several disciplines, data bases are maintained at some institutes, where the text of most scientific articles recently published (or accepted for publication) in international journals is stored. At request by a computer user, copies of selected articles can be received via the computer network. Several of these data bases do not carry any charge for their use. In a similar vein, data bases containing the measurements from e.g. various international space experiments (IUE, Hubble Space Telescope, etc.) will also become available.

Analogous to the situation in western Europe, the costs for operating such computer networks should be substantially less than the use of traditional means of communication such as postal mail, telephone etc.

Scientific publishing

A topic discussed at all visited institutes concerned the possibilities and current patterns in scientific publishing.

A notable fraction of the scientific papers have in the past been published in media with very limited circulation (e.g. local institute series, conference proceedings). These publications are not only little known in the world, but they are generally also not accessible for computer database search. Thus, efforts should be made to publish the results in internationally well-known journals.

A notable fraction of papers cited in those published by Estonian scientists appear to be relatively old, not seldom published some ten or more years ago. While one should of course respect and use also older results, this appears to constitute a systematic difference to the citation patterns typical for the major journals in the west. There it is not uncommon that the work is based largely on preprints and articles published during the last few years. The reasons behind this pattern are not obvious, and there need be nothing negative in it (e.g. if the work is oriented toward long-lasting problems). However, the different working approaches may make it more difficult for Estonian scientists to find common interests with international groups, where there may be more interest in the latest problems discussed in e.g. recent preprints. This underscores the importance of rapid access to the international scientific community, e.g. via computer networks.

Organizing international conferences and summer schools

It is obviously important to develop contacts between (especially) the younger generation (both scientists and technicians) in Estonia and abroad. In order for collaborative projects with foreigners to be stable, it is further important that the activities be mutually beneficial. The current situation with regard to convertible currency severely limits the possibilities to support stays abroad for students from sources in Estonia.

However, there are very good opportunities to organize "summer schools" in

Estonia for participants from the Nordic and the Baltic countries, western Russia and other neighbors. In each course, one could accept perhaps some 30 graduate students or younger scientists, together with a number of lecturers, in order to discuss current topics during a couple of weeks. Estonia can offer attractive geographical locations (outside the main cities), which will normally be previously unknown to foreigners, and therefore interesting to visit. The cost (measured in convertible currency) will be (very) much lower than for organizing similar courses elsewhere (e.g. in Scandinavia). We note, with satisfaction, that such activities have already started: this summer there is organized a Nordic-Baltic School in High Energy Physics in Lohusalu village not far from Tallinn. Economic support here is obtained from the Nordic council of ministers, NORDITA (the Nordic institute for theoretical physics in Copenhagen), and a few other institutes.

Fellowships abroad for scientists from Estonia

Several organizations, e.g. in western Europe, offer fellowships for graduate students and scientists from e.g. Estonia to spend some time at institutes abroad. In our opinion, such fellowship programs would be most efficient at the present time, if the stays abroad were mainly of a rather limited duration, e.g. 1-2 months or so.

For the development of contacts with foreign organizations, it is most important that such opportunities be given to many workers at various Estonian institutes. Since only a rather limited part of these have yet had the opportunity to spend any significant time abroad, we believe the interests of Estonian science will be best served by having a larger number of persons spending shorter periods abroad. The opposite, i.e. a small number of persons spending long periods abroad, may in fact be counterproductive. Such programs remove what often is the best scientists from their home groups, during their long stay abroad their contacts with their home institute may be rather limited, and in the end (following perhaps a few years abroad) there is no guarantee that they actually will return home.

Changing patterns of scientific collaboration

The political changes in recent years have removed the previous artificial barriers against contacts with western countries. Such collaboration had been unnaturally limited by political causes since World War II, and at several contacts with Estonian scientists we noted an eagerness to (re)establish such contacts. While this is also happening on a grand scale, we nevertheless feel that we must caution against too great an optimism, as to how broadly such contacts can be developed in the near term. Institutes in the western countries have only a finite capacity to accept new collaborative partners.

Even though we advocate an orientation toward contacts with western science and change of academic system, we want to emphasize that, in our opinion, it is very important for Estonian physics and astronomy to keep their previous good contacts with leading scientists and institutes in e.g. Russia, Ukraine, and other parts of the previous Soviet Union. Several of these are among the world leaders in their fields. With its geographical location between east and west, Estonia has good prospects for collaboration in both directions, and it is most important that the links to institutes in the east remain active.

GENERAL COMMENTS ON PARTICLES AND FIELDS, AND MATHEMATICAL PHYSICS

In particles and fields, the main areas of interest of Estonian theoreticians are field theory of massless particles for higher spins, superstring theory, octonions and sedenions, and the general theory of relativity. Some other areas of mathematical physics are also represented.

In a small country like Estonia it is of course not possible to cover all fields of research in this area. It was nevertheless striking to us how very small an effort is going into studies of the internationally current main topics. Thus e.g. the effort on the "standard model", quantum chromodynamics, chiral symmetry-breaking, and weak interactions is small if at all existing. On the more mathematical side, little effort was going on in quantum field theory and gauge field theory. Other topics insufficiently developed were conformal field theory, the quark model and phenomenology of elementary particles.

Even if some reasons for this situation can be found in the lack of access to journals and books, it is our opinion that especially the standard model should keep some attention of the research workers, i.a. for educational purposes.

We also feel that a closer collaboration between, on one hand, the particle physics and field theory group and, on the other hand, the cosmology and astrophysics group should be something to strive for. This trend is clearly visible in western universities and is probably the best way to create a large enough environment for this branch of Estonian physics to thrive in.

GENERAL COMMENTS ON ASTRONOMY AND ASTROPHYSICS

Astronomy has a long and proud tradition in Estonia. Already in the early 19th century, the observatory of Tartu (then Dorpat) was of world renown. This tradition has extended into the present time, and the field continues to attract many gifted students.

The main research topics for astronomers in Estonia concern the large-scale structure of galaxies and the universe, and the properties of stars. Both theoretical and observational work is well represented.

Collaborative observational astronomy

To be able to work on a broad selection of scientific problems, Estonian astronomers require access to the most modern telescopes. Modern measuring apparatus, as used in European international observatories, normally allow measurements with a much higher quality than, for example, using traditional photographic techniques. To become familiar with such methods is important not only for the astronomers themselves, but also (or especially) for technicians and engineers, who might later utilize this knowledge elsewhere in society and industry, outside the field of scientific work.

All international observatories of Europe offer possibilities for scientists from other countries to utilize their instruments. This possibility should be actively exploited, much more than previously. Such projects carry importance not only for the acquisition of scientific data as such, but (and of at least equal value for Estonian science) form a natural basis for developing closer contacts with other groups working with similar measurements. We judge the competence of Estonian astronomers to be fully adequate to compete for observing time on these international telescopes.

ESO (European Southern Observatory)

Estonia has recently submitted a request to ESO, asking it to consider Estonia as a new member country. Although this will obviously be the subject of further discussions between Estonian and ESO officials, we still think we may express our opinion.

Although, in a longer time perspective, such an association could bring important benefits to Estonian astronomy and science in general, we are not convinced about its immediate feasibility within the next few years. Besides the obvious economic problems, there are other constraints on both the Estonian and ESO sides. Since the demand for use of the ESO telescopes considerably exceeds the time available, there will necessarily be a "preparatory" period of several years before Estonian astronomers gain the same experience in planning scientific programs with the ESO instrumentation, as scientists from the established member states. On the ESO side, there might be a certain reluctance to accept still more new member countries very soon, given that eastern Germany de facto recently joined the organization, while Portugal and Austria are expected to become full members in the near future. Potentially, there are several countries in "the former" eastern Europe, which might want to join ESO, and in this context it seems unlikely to us that Estonia could be given a preferential treatment. However, we strongly encourage Estonian astronomers to submit applications to ESO already now: for individual applications, the allocation of time at its telescopes does not depend on the formal membership of the applicant's home country.

NOT (Nordic Optical Telescope)

Another alternative lies in a possible association with the Nordic Optical Telescope which is part of the Spanish-international observatory on La Palma in the Canary Islands.

The current treaty for NOT, involving Denmark, Finland, Norway, Sweden and the host country of Spain, expires in May 1994, opening a possibility for other countries to join (for example, it is expected that Iceland will become a new member).

There have been informal discussions on a possible future Estonian share in the telescope on a level of perhaps 5%. These questions were recently discussed by the NOT organization, concluding that since the Nordic and Baltic countries do have a "special" relationship, that could be a basis for discussing suitable arrangements in associating the Baltic countries (taking into account their deficit of convertible currency). However, it was also concluded that an isolated Estonian membership is not favored, but rather a common association of all three Baltic countries, on a level not exceeding 10%.

It must be stressed that this should not be understood as an invitation, but rather the preliminary attitude toward plausible new applications in the NOT collaboration. Similar to the case at ESO, observing time at NOT is heavily oversubscribed, and there will necessarily be a preparatory period of optimally designing observing programs that are awarded time in the international competition. As for ESO, Estonian astronomers are encouraged to apply for observing time already now, irrespective of any formal association on the part of Estonia.

A few such observing proposals had been submitted already for the latest observing period, although no time was awarded. The reasons, we believe, are mainly those of adjusting to the competition with others with more experience in using the instrumentation. Renewed (and improved) project applications should eventually be awarded time, and as part of the preparatory process it should be arranged that Estonian astronomers become familiar with different programs carried out at the NOT.

The question of a possible Baltic association with the NOT observatory raises questions about economy, and how its share is to be covered. The investments have been about 50 million Swedish kronor, and the annual running costs amount to about 7 million kronor. For the foreseeable time, 10% of these amounts will be too expensive, if it must be paid in hard currency. Knowing the circumstances, it might however be possible to propose other arrangements. Perhaps it could be possible to place another (smaller) telescope on La Palma, to ease the pressure off NOT for those programs where the large telescope is not necessary? Such plans have already been discussed by Finland. If computer networks are further developed, it could become practical to employ a group of programmers in e.g. Estonia for the development of software. It should thus be possible to find some means of collaboration that would be mutually beneficial, and which could be the grounds for more formal negotiations of an association with the NOT (and through it with the entire international observatory on the Canary Islands).

Telescopes and instrumentation in Toravere

The observatory outside Tartu houses a collection of smaller and medium-size telescopes, although their use is limited by the astronomically poor weather conditions of northern Europe. This limitation is well recognized by Estonian astronomers, who have made efforts toward establishing a mountain observatory

with good climatic conditions in central Asia. To improve the recording of scientific data, electronic systems employing modern detectors of the CCD-type have been developed, including a 256 x 256 element infrared array.

The experience gained from such activities places Estonian astronomers as quite equal partners with colleagues from many other countries in discussing a future association with the European international observatories. In order for Estonia to fully benefit from such a possible association, it is necessary to maintain a certain level of instrumentation activity at the home institute, both to train students and engineers, and to demonstrate to local industrial companies (who might offer to construct some international instrumentation), what are the technical requirements. In order to fulfill such purposes, however, there is no need to use the telescopes every available night of the year.

The proposal to construct a new 2-meter class telescope in Toravere should be viewed in this context of potential collaboration with leading international observatories. We do not believe that foreseeable resources of Estonian astronomers alone will suffice to complete this project and turn it into an internationally competitive instrument. It might still be worth pursuing, but only on the condition that it becomes connected to the "entrance fee" for the Baltic countries in joining e.g. the observatory on La Palma.

Publishing in astronomy and astrophysics

Some general comments were given already above. Too often in the past, discoveries by Estonian astronomers did not receive the credit they deserved, because they were published in local publications with only a small readership in the world. However, efforts are being made to improve the situation.

We were shown proofs of the first issue of the journal Baltic Astronomy, intended to replace the several small institute series hitherto published in Estonia, Latvia and Lithuania. This joint effort is laudable: it is important to find methods to disseminate scientific results rapidly and widely. It remains to be hoped that Baltic Astronomy will reach a sufficient global circulation. The limit is not its modest subscription cost, but the circumstance that also several other journals (not the least from "the former" eastern Europe) are also being started, and scientific libraries in the world are quite selective in which journals they are ordering.

The most significant results, however, should continue to be published in the leading world journals, e.g. the European Astronomy and Astrophysics (A&A). Estonian astronomers are currently publishing several articles there, and we were informed that (for the time being), Estonian authors can publish there without paying the page charges, otherwise levied onto authors from countries that are not members of A&A.

This year, Czechoslovakia joined A&A, and Poland is joining as of 1993. The membership fee is computed according to the respective country's gross national product, and if the same formula is applied for Estonia, it would appear that the annual fee need be no more than some hundreds of German marks, a very modest amount which should be a good investment to permit the general publication of results in one of the world's leading astronomy journals, thus enhancing the visibility of Estonian astronomy.

EVALUATION OF RESEARCH GROUPS

Dr. Ilmar Ots
Laboratory of Theoretical Physics
Institute of Physics
Estonian Academy of Sciences
Tartu

Theory of Elementary Particles and Gravitation

Principal activities

The group comprises some ten researchers with rather disparate interests, ranging from phenomenology to pure mathematical physics. The activities of the group during the last five years have been in such diverse fields as general relativity, neutrino physics, higher-spin wave equations, supergravity, superstrings and membranes, symmetry groups for nonlinear wave equations, nonassociative and topological structures in field theory.

Evaluation

We met with the group, and heard short presentations by P Kuusk, J Lohmus, I Ots, L Palgi, R Tammelo, H Uibo and E Vesman. The average impression of the research is good. The group has organized a number of scientific meetings. Especially noteworthy are the international Tallinn symposia on neutrino physics, and the 1992 Nordic-Baltic summer school. The activities in "super" physics are commendable, although the isolation of the department has made it impossible to follow the front line development in this rapidly developing subject. The contributions therefore mostly have the character of marginal comments on the existing literature. The higher spin wave equation studies suffer from a lack of insight into the present understanding of interacting higher spins in gauge theories for higher spin (W) algebras. The approach taken in the group is most likely not viable for interacting theories. The group has a rather low international profile. Only ten percent of the listed papers are published in international journals. Of the recent ones, only the paper by K Palo in collaboration with A Niemi and others was known to us prior to the evaluation.

Recommendations

The group should continue to receive support. It is important to focus the activities and widen the international contacts. We recommend an emphasis on modern theoretical high energy physics and mathematical physics, such as gauge theories and string theory.

Dr. Väino Unt
Department of Astrophysics
Institute of Astrophysics and Atmospheric Physics
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Selected Topics in General Relativity and Gravitation

Principal activities

The group is involved in investigations of various aspects of general relativity. The early universe is studied in the inflationary scenario, in particular with regard to the quantum effects that should generate the necessary initial fluctuations. Isolated gravitating systems are also studied, in particular the asymptotic symmetry group, and approximation methods for describing radiating systems.

Evaluation

We met with V Unt and A Unt. The early-universe research involving L Kofman and his student D Pogosyan is good-very good, clearly integrated in the international research and with a record of publishing in international journals. The remaining part of the research is fair with offbeat research topics. Several Estonian researchers have received their training in the group, and the group has hosted a number of workshops with participation from the former Soviet Union. Two cand.sci. dissertations have been presented in the group.

Recommendations

We recommend no further support for this group (apart from salaries), unless Kofman returns to the group from abroad. If he returns, we believe that he should be funded and that this support should be given with a view toward expanding his activities. This could develop into a healthy research group in theoretical astrophysics.

Dr. Jaan Einasto
Dr. Mihkel Joeveer
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Structure and Evolution of Galaxies and Their Environments

Principal activities

About two decades ago, J Einasto made the important discovery of dark matter coronae around galaxies. This subject has remained the platform of the research in the group ever since. Today, available observational data along with dynamical models and algorithms are used to decompose galaxies into different mass components, including the dark matter corona. High-velocity clouds and companions around galaxies are found to be arranged in structures, whose dynamics may give information about the dark matter component. On larger scales, methods for determining membership and dynamical properties of galaxy groups have been devised. Analysis of star formation and stellar populations is carried out with the aid of photometric evolution models. In collaboration with countries of the former Soviet Union, the group is also participating in an observational survey of stars in certain parts of our galaxy. As part of this engagement, an automated data reduction system for spectral classification has been developed. Several scientific meetings have been arranged during the last years.

Evaluation

We met with the group, and heard short presentations by J Einasto, M Joeveer, J Vennik, P Tenjes, U Haud, V Malyuto, and others. This project is good to very good. Considering the limitations in computational facilities and observational data, the dynamical modeling of galaxies and their environments has produced some impressive results. In order to make a stronger impact on the international level, however, one has to be able to compete with several groups working on similar problems, using observational data obtained with modern telescopes equipped with state-of-the-art detectors. It is encouraging to see that several members now are involved in international cooperation. These projects are very promising and should be mutually beneficial, allowing Estonian astronomers to get access to modern instruments and computers.

Recommendations

On basis of a strong leadership and a vital research staff, support to maintain this group at least at its present level is strongly recommended. In particular, international cooperation should be facilitated and encouraged, e.g, permitting access to major international telescopes.

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Study of the Large-scale Structure of the Universe, its Formation and Evolution

Principal activities

The study of large scale structure is one of today's main directions in cosmology. This group pursues its work essentially along two different tracks. One is to use available galaxy redshift catalogs to analyze the topology of the luminous matter and derive information about the dark component. With the use of new and efficient methods, this has resulted in pioneering contributions to the understanding of the properties of voids and has revealed the existence of large scale filaments. The amount of biasing in galaxy formation and its dependence on morphological type have also been investigated. A substantial amount of work has been devoted to the analysis of superclusters. Recent efforts also include the multifractal interpretation of the large-scale structure.

The second approach aims at understanding the connection between the observed structure and the initial fluctuations, thus forming a link between cosmology and particle physics. The work is pursued either through a direct reconstruction of the primordial potential fields or through simulations of structure evolution under different initial conditions. Kofman's participation in the development of the adhesion model has greatly facilitated the non-linear stage of these computations. His theoretical work on the initial inflationary fluctuation spectrum has made a strong impact on the international scene.

Most of the results are now published in major international journals. The group is also very active in arranging scientific meetings.

Evaluation

We met with the group, and heard short presentations by J Einasto, E Saar, E Tago, I Suisalo, and others. This project is very good to excellent. Under the leadership of J Einasto and E Saar, the mainstream of the research should be maintained at a high level also in the future. An encouraging fact is that several group members, e.g. L Kofman, whose present work is widely appreciated, have been invited to spend extensive periods at institutes abroad. However, the level of interaction with the home institute often is very low, and the risk of considerable "brain drain" should be adequately tackled.

Recommendations

Support for this project is most strongly recommended. In particular, computer facilities and funds for facilitating international cooperation should be reinforced. It is important to create an attractive scientific atmosphere, such that visitors from abroad are attracted to spend some time with the group. One important question is the future of the International Centre for Cosmology, and the plans for construction of a specialized telescope. Our opinion on the latter project was discussed already in the general remarks. The intention of creating the Centre was also for it to serve as a meeting place for cosmologists from around the world. It is our opinion that a consensus in this direction on an international level will be needed for its further development.

Dr. Tonu Kipper
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Atmospheric Structure of Red Giants and Nonstable Stars and Their Chemical Abundances

Principal activities

During the later stages of stellar evolution, the outer atmospheres undergo great changes in giant stars. For example, the stars may become pulsationally unstable; the outer parts of their atmospheres may escape as a stellar wind; one may find radioactive isotopes brought up by gas motions from the stellar interior, etc. This group of about fifteen scientists and engineers is studying such problems, mainly using spectroscopic observations collected at Toravere and at other observatories abroad. There is also some theoretical work, and there are collaborations with several institutes in western Europe and in the former Soviet Union.

Evaluation

We met with the group, and heard short presentations by T Kipper, T Nugis, K Annuk, M Pehk, I Kolka, A Päsok, L Leedjärv, M Ruusalepp, and others. The group has a large number of publications, demonstrating a good to very good scientific level. Although there are several papers in e.g. the proceedings of international conferences, only a minor part of the results have appeared in major refereed journals.

Recommendations

A significant part of the previous work has been based on stellar spectra recorded on traditional photographic emulsions. Recognizing its limitations, the group has been developing detector systems with modern CCD arrays, but these appear not yet to have had a scientific impact. A major enhancement of data quality will be possible with spectra from any of the modern spectrometers at e.g. ESO or NOT, and the group is encouraged to submit applications to use these and other major telescopes abroad. Support is thus strongly recommended to permit such data to be collected abroad, and to be analyzed with adequate computer facilities at home. As to the publication patterns, although the new journal Baltic Astronomy might become important, the main results should be submitted to major journals such as Astronomy and Astrophysics.

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Physical Processes in Stellar Atmospheres and Envelopes

Principal activities

The work in this group of some ten scientists is mainly devoted to theoretical studies of the transfer of radiation, the character of gas motions, the propagation of waves, and other physical processes in the atmospheres of stars and planets. Theory of radiative transfer is applied to interpret observed spectra and light curves from single stars as well as more complex multiple star systems and nebulae. In particular, data in ultraviolet are used, as recorded from various space experiments.

Evaluation

We met with the group, and heard short presentations by A Sapar, T Viik, A Heinlo, I Pustylnik, J Pelt, U Uus, A Aret, T Feklistova, L Sapar, and others, as well as P Kalv from the Tallinn Observatory. The significant number of publications from the group demonstrate good and very good scientific levels. However, among the astronomy groups, this has the largest disparity between, on one hand, highly competent work and notable results and, on the other hand, much too limited publication in internationally visible refereed journals. (But with exceptions - Tonu Viik has a series of papers in well-known journals.)

Recommendations

Continued support for the group is strongly recommended. They have produced many notable results during past years, but these have not received their deserved attention in the world. Of high priority is therefore to prepare existing results for international publication. This applies in particular to the theoretical work on stellar convection by Undo Uus and that on photon correlations by Arved Sapar (which both should be published in e.g. Astronomy and Astrophysics), and the 25-year series of photometric observations of variable stars made at Tallinn Observatory by P Kalv and V Harvig (which should be published in e.g. Astronomy and Astrophysics Supplement Series).

Prof. Enc Ergma
Department of Theoretical Physics and Astrophysics
Tartu University

Evolution of Low-mass X-ray Binaries and Presupernovae

Principal activities

The project concerns theoretical studies of the physical evolution of compact binary stars, known for their strong and variable X-ray emission. Such problems are attracting a broad international attention, and will be the topics of further investigation with space experiments in the future.

Evaluation

We had a discussion with Prof. Ergma. The scientific results obtained during the past years (when Prof. Ergma worked within a high-energy astrophysics group in Moscow) are very good, and have been published in well-known journals. At present, Prof. Ergma is alone in working on these problems in Estonia, although she now has some students at Tartu. The work requires powerful computers, and we see it as very positive that collaborations have been developed with scientists in e.g. Helsinki, Moscow, and Rome.

Recommendations

It is most strongly recommended that Prof. Ergma is assured the possibility to continue her research as part of the duties at Tartu University, perhaps through some "sabbatical" stays at other institutes. This is one project where improved electronic networks will have an important and immediate impact, by establishing links to the powerful computers of her foreign collaborators.

Dr. Rein-Karl Loide
Dr. Romi Mankin
Department of Physics
Tallinn Technical University

Massless Wave Equations. Superfield Methods in the Theory of Gravitation and Elementary Particle Physics

Principal activities

This project is concerned with finding massive and massless relativistic wave equations for higher spin theories, both for ordinary fields, and for superfields. Another activity is to study the Huygens' principle in a background gravitational field.

Evaluation

We met with R-K Loide and R Mankin (Tallinn Teachers' Training Institute). The research is characterized as fair. The interesting question in the area of higher spin theories is that of interactions. It has been shown, within the context of the usual gauge theories, that interacting theories with spins higher than 2 are inconsistent. This has given rise to the present activities in gaugeing higher spin algebras, a very active field of research. The Tallinn group presents no other way of circumventing the interaction problems, and have made no attempt to connect to the higher spin algebra approach. The group has very limited international recognition and few publications in international scientific journals.

Recommendations

We were impressed to find that research is at all possible, given the heavy teaching duties of the scientists and the lack of financial support (apart from the university salaries). We recommend some support to lessen the teaching duties of Loide and Mankin, perhaps in the form of sabbaticals. This could also lead to an orientation of the research toward more modern topics.

APPENDIX

Background of evaluators

Nils Bergvall

Docent in Astronomy, presently at the Astronomical observatory, Uppsala University. His research concerns the early evolution of galaxies, interacting and starburst galaxies. He holds a position as a lecturer at the University, receiving half-time support from the Swedish Natural Science Research Council.

Dainis Dravins

Professor of Astronomy, presently at Lund Observatory of the University of Lund. His current research interests comprise observational and theoretical studies of atmospheric structure and activity in stars similar to the Sun; rapid astrophysical phenomena around compact objects; astronomical instrumentation, and observational methods. Observations are made at the European Southern Observatory, at the Spanish-international observatory in the Canary Islands, and using space experiments within the programs of the European Space Agency, the former USSR (Interkosmos) and USA (NASA).

Ulf G Lindström

Docent in Theoretical Physics at FYSIKUM, University of Stockholm. His area of research is theoretical high-energy physics, with an emphasis on quantum gravity and unification of the fundamental interactions. With a background in classical general relativity, he has worked in supersymmetric field theory, supergravity and superstring theory. Part of his research is in mathematical physics; the relation between supersymmetric theories and complex geometry.

Håkan Snellman

Docent in Theoretical Physics, presently at the Department of Theoretical Physics, Royal Institute of Technology, Stockholm. His research interests are quantum field theory, chiral symmetry breaking, quarkonium physics and astroparticle physics.