JOINT RESEARCH PROJECT PROPOSAL
by

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Title: **Taiwan-Baltic Open Cluster Study**

Duration: 01 August 2002 to 31 July 2005

Discipline: Astrophysics

1 Objective

The goals of this joint research project are (1) to provide useful clues to the understanding of stellar evolution and to the chemical history of the Galactic disk through comprehensive photometric and spectroscopic analyses of a selected set of open clusters, (2) to learn how the stellar spatial distribution evolves through internal dynamical interaction and by external perturbation, and (3) to expand the database for open clusters by adding new multicolor CCD photometry, radial velocity, and detailed abundance analysis.

The project will combine existing experience from different research teams of the participating countries to focus on a few specific key problems in stellar and galactic astrophysics. Our initiative will be the first step toward a long-lasting collaboration among the astronomy communities in the participating countries.

2 Abstract

We propose, through a trilateral collaboration, to study Galactic open star clusters to provide observational constraints on the chemical and dynamical evolution of the Galactic disk. Our study will also address important problems of stellar evolution, such as mixing processes, chromospheric activity and rotation. The

research will provide homogeneous photometric and spectroscopic measurements of a selected set of open clusters, mainly poorly-studied or not previously investigated at all, and spanning a wide range of ages. Our CCD photometric data will yield accurate determination of some basic cluster parameters, such as the reddening, distance, metallicity, and, from comparison with theoretical isochrones, the age. Radial-velocity measurements to an accuracy of 0.5 km/s will provide independent cluster membership diagnostics, identification of binary stars within a cluster, and determination of stellar rotation. With membership information, the evolution of stellar spatial distribution will be investigated to see how gravitational interaction and external Galactic perturbation affect the dynamics of a cluster. In addition, high-resolution spectra will be obtained for a number of cluster stars to derive chemical abundances so as to study their internal stellar processes.

3 Scientific Background

The study of stars in open clusters plays a key role in the development of our understanding of stellar and Galactic astronomy. Being originated from the same parental molecular cloud, stars of a wide range of masses in a cluster are at the same distance from the Sun, and have nearly the same chemical composition and ages. Due to these unique, fundamental properties, open clusters are ideal tools for comparison of the theories of stellar formation and evolution with observations, and for the investigation of the structure and evolution of the Galaxy.

In spite of the somewhat comprehensive studies of the dynamics of globular clusters — the old, populated, and compact stellar systems — there is however a general lack of equivalent understanding on open clusters. For example, astronomers do not know well how open clusters evolve dynamically, or even how spatially extended a particular star cluster goes. Why do young star clusters have their stars distributed as the King's model (King, 1962, Astron. J., 67, 471; Mathieu, 1984, Astrophys. J., 284, 643) as globular clusters do? Do massive stars tend to concentrate toward the center of a cluster more so than low-mass stars, as recent studies indicate (Pandey et al, 2001, Astron. & Astrophys., 374, 504)? Is this due to mass segregation from gravitational interaction among member stars, or inherited from molecular structure when the stars were formed? Do massive stars share a common center with the low-mass counterparts? If not, what might have caused this? Does this provide evidence for triggered sequential star formation?

To date, about 1200 open clusters are known; only half of them have been investigated at least once (Mermilliod 2000, ASP Conf, 198, 513). Of the latter, about 500 clusters have photometric observations, and roughly 200 clusters have some sort of radial-velocity measurements. About 100 clusters have at least one determination of proper motions, and less than 30 clusters have metallicity estimates from high-resolution spectroscopy. So far not a single cluster has had a complete census of all its cluster members. In fact only a handful of clusters have been investigated somewhat thoroughly for membership, e.g., the Hyades, the

Pleiades, NGC 752, and M 67.

During the last decade three key projects focusing on the open clusters have emerged: the astrometric *Hipparcos* satellite mission (1989–1993), the current WIYN (Wisconsin, Indiana, Yale, NOAO) Open Cluster Study, and the latest CFHT (Canada-France-Hawaii Telescope) Open Cluster Survey. The *Hipparcos* mission has made a significant impact on the study of nearby (closer than 300 pc from the Sun) open clusters. The CFHT Survey is a deep BVR CCD imaging project of 19 open clusters, with the primary aim to catalog and study the white dwarf stars in these clusters and, additionally, to determine the properties of the clusters, based on three-color photometry. The WIYN project is much comprehensive in that it combines deep photometric ($UBVRI$), astrometric (stellar positions and proper motions), and spectroscopic (stellar abundances, radial velocities, rotation velocities and activity) data for about 15 target clusters at distances up to roughly 5 kpc. The goal of the WIYN study is to provide a detailed description of each of these clusters to address a number of astrophysical problems. So far only a few clusters have been thoroughly observed by WIYN and CFHT. This illustrates the time consuming nature of a comprehensive star cluster study; any single project alone cannot remedy the existing deficiency of fundamental parameters for many of the open clusters. Additional projects are obviously called for, and the project we propose here will make a definite contribution to the field of Galactic open clusters.

4 Rationale for Collaboration

Our program calls for acquisition, analysis, and interpretation of large amounts of data from a variety of instruments. A wide range of expertise in astrophysics, physics, chemistry, computation, and instrumentation is therefore needed to make the program a success. Our collaboration will be able to integrate to fulfill the requirement.

There is a long history of previous collaboration between Latvian and Lithuanian astronomers. Since 1977 Latvian astronomers have been frequent guest observers on the Lithuanian telescopes at the Moletai Observatory of the Institute of Theoretical Physics and Astronomy (ITPA), Lithuania, and at the ITPA's Maidanak Observatory in Uzbekistan. As a precursor to the present project, a collaborative program of open clusters had been undertaken by Latvian and Lithuanian astronomers during the period 1986–1997. Using the Maidanak one-meter telescope, they obtained photoelectric seven-color data with the Vilnius system and from these derived the basic parameters for four open clusters: the Hyades (Dzervitis U., Paupers O. 1994, Balt. Astronomy, 3, 335), Alpha Persei (Dzervitis U., Paupers O., Vansevicius V. 1994, Balt. Astronomy, 3, 348), NGC 752 (Dzervitis U., Paupers O. 1993, Astrophys.& Space Sci., 199, 77), and NGC 7209 (Vansevicius V., Platais I., Paupers O., Abolins E. 1997, Mon. Not. Roy. Astr. Soc., 285, 871).

Furthermore, a CORAVEL-type spectrometer (Fig. 1) was built in 1998 by J. Sperauskas, from Lithuania, using the optical parts provided by I. Platais, from Latvia. A recent cooperation between J. Sperauskas and L. Začs in examination of binarity for carbon and s-process rich star BD+75 348 (Začs L., Schmidt M., Schuster W.J., Astron. & Astrophys., vol.358, 1022, 2000), and another cooperation between Platais and Sperauskas on cluster membership and binarity, both using the CORAVEL facility, also seem to be successful.

Figure 1: The CORAVEL-type spectrometer.

The Lithuanian group can share their experience in methods of rapid and accurate quantitative classification of stars of all types using the Vilnius and Stromvil photometric systems. The results of analyses of some stellar clusters are published by Straizys et al., 2001, Astron. & Astrophys., 374, 288, Boyle et al., 1998, Balt. Astronomy, 7, 369, Smiriglio et al., 1998, Balt. Astronomy., 7, 393, and Boyle et al., 1996, Balt. Astronomy, 5, 231. Theoretical stellar isochrones, which can be used for age determination of stars observed in the Vilnius photometric system, have been computed by Bressan and Tautvaisiene (1996, Balt. Astronomy, 5, 239). The Lithuanian members have 10-year experience of observing with the high-resolution spectrometer SOFIN on the Nordic Optical Telescope in La Palma, Spain. The work has started on the open clusters as well. One of the PIs, Tautvaisiene, gained much experience in high-resolution spectroscopy and investigation of mixing processes in stellar atmosphere while studying the open cluster M 67 (Tautvaisiene et al. 2001, Astron. & Astrophys., 360, 499).

The Taiwan group can share their experience in diagnosis of how stellar spatial distribution evolves as a cluster ages, under the influence of external perturbation, such as tidal forces, differential rotation, and collision with giant molecular clouds. Taiwan is presently involved in several major international projects in astronomy: (1) the Submillimeter Array (SMA) in Hawaii with the Harvard-Smithsonian Center for Astrophysics, (2) the Beijing-Arizona-Taipei-Connecticut (BATC) multicolor sky survey, and (3) the Taiwan-America Occultation Survey (TAOS), and Taiwan Oscillation Network (TON) to study helioseismology. The TON in particular has already set a good precedent of collaboration with Uzbekistan colleagues. Recently Taiwan has taken an initiative to build a millimeter array in Hawaii to measure the cosmic anisotropy microwave background radiation (AMiBA project) and its polarization. A deal has been signed with the CFHT to take part in building a wide-field infrared camera (the WIRCAM), in exchange of observing time on this 4-m telescope for clusters of galaxies to support the AMiBA project. As part of the development of the national infrastructure of Taiwan for excellent research in astronomy and astrophysics, the National Central University is currently building a one-meter telescope on the island. Such a small telescope can be scientifically competitive only by pilot or followup studies to supplement projects on large telescopes, particularly with a coordinated array of small telescopes on dedicated projects such as variability monitoring or survey programs. This is exactly what we propose to do, to synchronize a few small telescopes to focus on a few key astrophysical issues.

The Latvian group will share their experience in abundance analysis of stellar atmospheres using high-resolution spectra (especially for binaries and peculiar stars) and in isolation of cluster members from field stars. Imants Platais (at present on leave from Latvia) has considerable experience in the field of proper motions and will provide the necessary expertise and help to isolate the cluster members for further photometric and spectroscopic studies. The CORAVEL-type spectrometer will greatly enhance the whole open cluster program. The most precious feature of the radial-velocity study is the ability to detect spectroscopic binary stars. The Latvia group is very experienced in interpretation of atomic and molecular absorption spectra, formed at physical conditions typical for cool stellar atmosphere. Note that in the region of three Baltic states at moment there are only a few experienced researchers in this extremely active field of research. Previous international scientific cooperation has been fruitful (see Publications). We will be happy to distribute our experience through lectures and scholar exchanges, and are ready to collaborate in the framework of this project.

High-resolution spectroscopy (R > 45,000) is one of the most powerful tools in astrophysics. The technique makes use of stellar spectra, recorded with very high spectral resolution, permitting identifications of a multitude of spectral lines. The line profiles are then analyzed with respect to, for example, varying chemical composition among stars in different stages of evolution. Besides being useful for the scientific goal, the technique appears particularly promising in assuring front-line work by small research groups. A few nights of observing produce lots of data, whose analysis can be well pursued "at home" with modest laboratory facilities. The techniques we apply to our study, as well as the experience we gain, are much relevant in other disciplines, such as in atomic and molecular physics.

On the other hand, many space-mission satellites, for astronomy or for earth sciences, with instruments operating from ultraviolet to microwave wavelengths, have been or soon will be in orbit. Their main goals are observations of the Earth atmosphere or space. The analysis of their data requires extensive laboratory work because the number of species for which the spectra are known accurately enough (line positions, line intensities, and line profiles) is still quite small, especially over a wide spectral range. Furthermore, the needs of the observing community for laboratory data are continually evolving, particularly as technological developments open new possibilities (e.g. observations in submillimeter wavelengths).

In the present project we will take advantage of experience already built up in the fields of stellar photometry (Lithuania), radial velocities (Lithuania), proper motions (Latvia), and high-resolution spectroscopy (Latvia, Lithuania). The Taiwan group has recently initiated a project to study the evolution of stellar spatial distribution of young star clusters. The membership information derived from the photometric and spectroscopic observations by the Lithuania and Latvia groups will be readily available to the Taiwan group.

We envision an active academic exchange program among the three partners. Astronomers, especially students and postdocs, will visit each institute. Joint symposia will be held. Different levels of research experience from the members of the teams — from the youngest participant of some 20 years old to the oldest of 66 — will contribute to and benefit from the collaboration. Scientists in Taiwan has had few opportunities to work with Baltic colleagues. We expect our program, with astronomy having a tradition of international cooperation, and the fact that three partnership countries share a strong common interest in a specific subject of research, would give an impetus for future, long-lasting collaboration. We all look forward to the fruitful cultural and scientific return of this joint program.

In addition to scientific contents, the central thrust of our project would be the various instruments that would be used for the project. The current proposal combines efforts from different telescopes in Lithuania, in Uzbekistan, and in Taiwan – note the convenient longitudinal coverage – for a well focused project on star clusters. We describe these instruments in Sec. 5.

5 Technical Description

For our study, we have chosen some ten open clusters, most of which are either poorly-studied (NGC 1333, NGC 6996, IC 361, etc.) or previously not studied at all (e.g., King 6, Tombaugh 5). A few more clusters such as M 37, NGC 752, NGC 1750, NGC 7789 will be included in the project for more accurate determination of their basic properties and for the investigation of elemental abundances and mixing processes in atmospheres of the cluster stars. Two candidate open clusters, Collinder 428 and Barchatova 1, are included in our program to check if they are bona fide star clusters. We will also make use of sky survey databases, such as the Digitized Sky Survey (DSS) and the Two-Micron All-Sky Survey (2MASS), to identify loose star cluster candidates, based on density enhancement by star count or by two-point correlation technique that have been developed by the Taiwan group. The disintegration process of such clusters would lend much information on the dynamical interplay of the tidal force, and differential rotation, and thus the mass distribution of the Milky Way. The 2MASS database turns out very useful to study young open clusters. Our preliminary analysis shows a clear distinction between the radial density profiles for globular

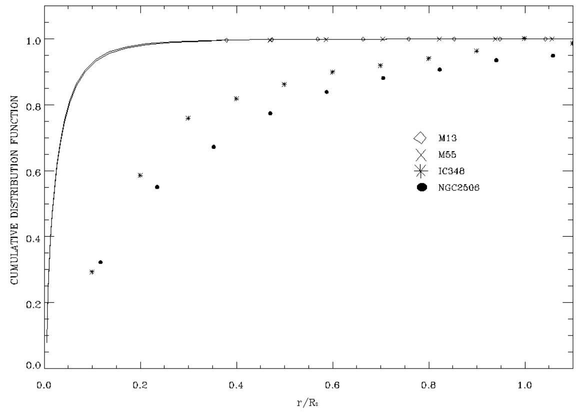

Figure 2: The stars are distributed progressly denser toward a cluster's center, more so for globular clusters (M 13, M 55) than for open clusters (IC 348, NGC 2506).

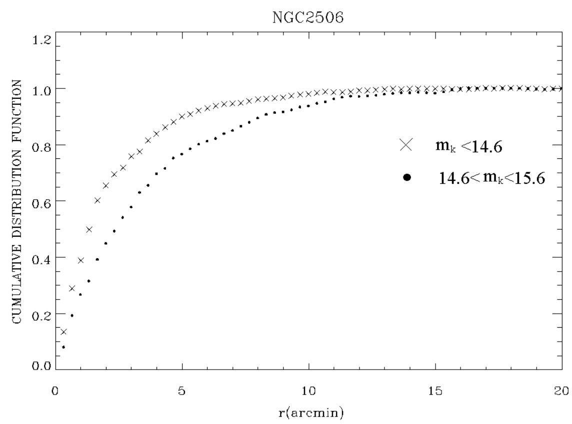

Figure 3: Stellar radial density distribution for NGC 2506.

clusters and open clusters (Fig. 2). In particular in the young cluster NGC 2506 (age 2 Gyr) massive stars are more concentrated toward the center of the cluster than low-mass stars (Fig. 3), a natural consequence of mass segregation.

As the main photometric tools, the seven-color Vilnius (UPXYZVS) and Stromvil (uPvbZyS) systems will be used, because of the ability of each of them to classify stars over the entire range of temperatures, luminosities, and metallicities even in the presence of interstellar reddening. The photometric results, coupled with the CORAVEL observations of radial velocities, are expected to clean the color-magnitude diagrams of a cluster, by weeding out field stars and by reducing the scatter of the main sequence caused by spectroscopic binary stars and by stellar rotation. For cluster binary stars thus discovered, orbital parameters will be determined with additional radial-velocity observations on longer terms. The comparison of observations with theoretical isochrones on these color-magnitude diagrams then will permit the determination of the ages of the open clusters and hence set constraints on stellar evolutionary models.

An average open cluster covers a considerable area of the sky, and typically contains only 1,000 members or less. A large fraction of field stars are photometrically indistinguishable from cluster stars, in particular toward faint magnitudes. In order to isolate the cluster members there are two basic methods which use kinematic properties of cluster stars: proper motions and radial velocities (Doppler shift of spectral lines) of stars. Information on stellar proper motions will help to isolate cluster members. Most clusters have been studied in terms of proper motions but sometimes this is not enough to derive clean samples of cluster stars. In this case, radial-velocity measurements can provide a decisive answer. Moreover, it is estimated that up to 50% of cluster members are binaries. As mentioned earlier, the CORAVEL-type spectrometer is capable of detecting spectroscopic binary stars. Our CORAVEL observations therefore will solve together the two major problems in star cluster study, the field star contamination and binarity.

We will obtain high-resolution spectra of stars in open clusters to identify the evolutionary state at which extra mixing processes start to take place and, furthermore, to learn how these processes depend on stellar mass, metallicity and age. We hope to reach stars of about 13 mag for this purpose. Modern data reduction codes developed at the Oulu University (Finland) will be used for reductions of observed spectra. A new generation of stellar model atmospheres together with modern packages of synthetic spectrum calculations, developed at the Uppsala Astronomical Observatory of Sweden, will be used for the theoretical analysis of more than 20 chemical elements for their abundances and isotope ratios.

A detailed analysis of very high resolution spectra of binary and peculiar stars in open clusters (selected using CORAVEL data) will be carried out to examine nucleosynthesis and to understand better physical mechanisms (mixing, accretion) in binary systems. The members of the Latvian group have considerable experience in this field. Chemical composition of stellar atmosphere will be analyzed using observations obtained on internationally accessible telescopes. Such approach guarantees observational data of the highest quality. We have previous experience in such observations; a number of observational programs have been granted in the past (see publications). We have previous experience in analysis of data from astronomy satellites (e.g., *Hipparcos*, *IRAS*, *ROSAT*, *Chandra*); such work will continue.

At the moment the Latvian group has a set of high-resolution spectra obtained at ESO and Special Astrophysical Observatory (Russia). The data reduction packages we use, IRAF (Image Reduction and Analyses Facility) for image processing and DECH for CCD+Echelle, allow scripted pipeline reduction of flat-fielding, bias/background subtraction, one-dimensional spectrum extraction, correction for diffuse light and cosmic rays, spectrum manipulation, etc. Significant experience of image (spectra) reduction has been obtained over the last decade. We are ready to share our experience in this field. Note, these reduction packages can also be used with success to measure individual line parameters, including positions, intensities, widths, etc. Atomic and molecular databases (VALD, JPL, SAO, etc.) are widely used both in astrophysics and Earth's sciences. The parameters (wavelengths, oscillator strengths, dissociation energies, etc.) from these databases together with computational methods and atmospheric models allow us to calculate the observed spectra. Standard computational methods (colors, ionization balance, excitation analysis, etc.) are used to determine the atmospheric parameters. The determination of elemental abundances (especially for cool stars) are far from trivial, however, so elaborate models have been developed over the last decades. We are using standard code WIDTH9 (ATLAS9) and the atmospheric models developed by Uppsala and Kurucz's groups for calculations of chemical composition. Using these models synthetic spectra are calculated. We look forward to seeing our partners from Taiwan and Lithuania in Riga to work on high-resolution spectra in the framework of this project and to brainstorm further cooperation.

5.1 Facilities and Equipments

Imaging and spectroscopic observations will be carried out with the following telescopes and instruments.

The Moletai Astronomical Observatory 1.65-meter Telescope

This facility (Fig. 4) belongs to the Institute of Theoretical Physics and Astronomy, and is equipped with the following instrumentation: (1) The CCD photometer, UV-enhanced and cryogenically cooled, with 1340×1300 pixels and standard $UBVRI$ filters. Vilnius and Stromvil photometric systems will become operational in 2002; (2) The three-channel general-purpose photometer with the $UBVRI$, Vilnius and Stromvil filters. It is possible to observe fast photometric variations of stars with this instrument; (3) The CORAVEL-type spectrometer for measurements of stellar radial velocities. This instrument has also been used in a number of other observatories; (4) The two-channel portable photometer with the filters of the Vilnius and Stromvil photometric systems..

The Maidanak Observatory 1-m Telescope

This facility is located in Uzbekistan at an altitude of 2500 m (Fig. 5). This site, located halfway between Baltic states and Taiwan, combines very good astroclimate — about 2000 hours of clear night time per year — and excellent seeing conditions (subarcsecond), and, due to its geographical latitude, can access to a large portion of both the northern and the southern skies.

Despite its remarkable site characteristics, the telescopes at Maidanak are obviously under-equipped. Through this project, by combining resources from participating partners, we will upgrade the telescope with a modern control system and state-of-the-art instruments. We envision the following instruments: (1) A

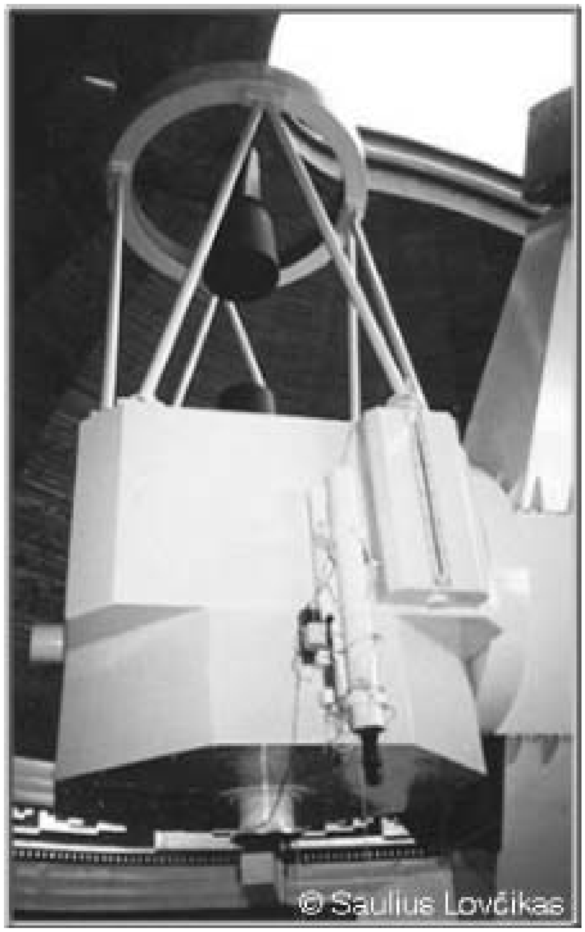

Figure 4: The Moletai 1.65-meter telescope

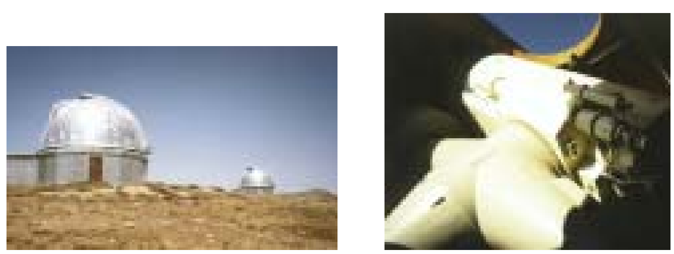

Figure 5: The Maidanak one-meter telescope

CCD camera, which will be acquired through this project; (2) The CORAVEL-type spectrometer, which will be used for radial-velocity measurements (as described for the Moletai telescope); (3) The two-channel portable photometer with filters of the Vilnius and Stromvil photometric systems (as described for the Moletai telescope).

The Lulin Observatory 1-meter telescope

This telescope (Fig. 6), to be commissioned in 2002, is located at an altitude of 2860 m. It will be equipped with a CCD camera for wide-field imaging with broad-band and narrow-band filters. The site is next to the Yusan (Jade Mountain) National Park in Taiwan, thus well protected against light pollution. It has an average of 200 observable nights per year, with a medium seeing of 1.3”. The site also hosts facilities for other scientific projects, including (1) an array of 4 small (0.5 m), wide-field (FOV∼3 sq. deg) telescopes for the Taiwan-America Occultation Survey, (2) a narrow-band imaging all-sky survey, (3) TEN (Taiwan Earthshine Network, similar to Taiwan Oscillation Network for helioseismology, which has one of the globally distributed stations in Tashkent), and (4) the Red Spirites experiment (atmospheric upward lightning).

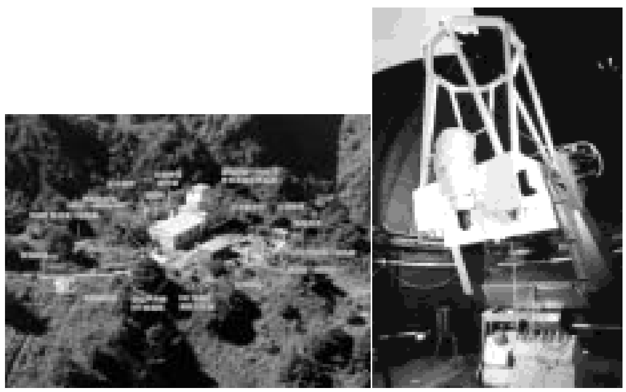

Figure 6: The Lulin Observatory and 1-m telescope.

In collaboration with Nagoya University in Japan and Purple Mountain Observatory in China, a near-infrared camera for imaging and low-resolution spectroscopy will be built soon thereafter, first tested on the 1-m and later used on large telescopes in Hawaii and in Arizona of the United States. Star clusters, particularly those at the earliest stages of their evolution, would be the natural first targets of these infrared instruments.

The Nordic Optical Telescope (La Palma) with SOFIN

In 2001, Lithuanian astronomers received 3 travel grants to the NOT telescope from the European Commission 5th Framework ”Human Potential” Programme activity Transnational Access to Major Research Infrastructures—European Northern Observatory REF:01-010, 01-012, 01-026 (PI: G. Tautvaisiene). We plan to use the European research programs for this project as well.

Special Astrophysical Observatory and Terskol Observatory

High-resolution echelle spectra in the large spectral range 3200-10100 Å will be obtained at the 6-m telescope (SAO; http://www.sao.ru) with echelle spectrometer LYNX and at the 2-m telescope (Terskol, 3100 m, Russia) with echelle spectrometer MAESTRO. MAESTRO (http://www.sao.ru/ gala/) has three observational modes R = 45,000, 80,000, and 190,000, respectively, and all the spectral region can be obtained simultaneously using 1242×1152 pixels front illuminated CCD (pixel size 22.5×22.5 μm). We have significant previous experience; a number of observing runs on the 6-m telescope have been granted since 1987 (collaborators Drs. V.E.Panchuk, V.G.Klochkova, I.F.Bikmaev, G.A.Galazutdinov, F.A.Musaev; see Publications of Latvian group). Recently we started observations at Terskol observatory in northern Caucasus (collaborator Dr. F.A.Musaev, Head of laboratory of coude-echelle spectroscopy).

European Southern Observatory

A part of high-resolution spectra will be obtained at ESO (http://www.eso.org). We have previous experience of observations here. Note that the PI of the Latvian group was the first astronomer from the Baltic countries to be awarded observing time as a principal investigator at ESO. Two projects prepared by L.Začs have been awarded in the frame of C&EE Programme of European Southern Observatory (B-01-012, E-06-002).

6 Project Management and Implementation

All of the operation of the proposed research activity, including instrument preparation, observation, data analysis, and administrative support, will be overseen by the 3 Principal Investigators, Grazina Tautvaisiene at ITPA, Laimons Začs at University of Latvia, and Wen-Ping Chen at NCU. They in turn form the Executive Committee that serves to communicate, and makes decision, on issues relevant to the joint project, in particular to the integration of different subprojects. Chen will be Coordinator of the Project.

Our joint program has strong support from the director of each participating institute (see attached agreement document from directors.) Each institute has made commitment to offer office spaces and access to its facilities (computing, observing) to visitors related to this project. Latvia will create training programs under this program (see the section on Training Opportunities.)

This project, though primarily a trilateral collaboration among Lithuania, Latvia and Taiwan, is endorsed by the Ulugh Beg Astronomical Institute (UBAI) of the Uzbek Academy of Sciences which is in charge of the operation of the Maidanak telescope now. The Letter of Support from its Director Dr Shuhrat Ehgamberdiev, is attached as Appendix, in which UBAI agrees to provide technical, clerical, and logistical support to observers at Maidanak Observatory. Some of the telescope upgrade would require involvement of UBAI scientists and engineers. To reduce traveling cost, UBAI staff may be subcontracted to offer service observing, with terms to be formulated once this proposal is approved. In conjunction with this program, we expect to have active scientific collaboration also with Uzbeks astronomers.

6.1 Training Opportunities

With a complementary suite of observing facilities to be used, this project will provide the researchers and students of each participating Institute/University which separately would have much limited accessibility to the variety of modern instrumentation. Our joint program accentuates on education by offering hands-on experience for students, from undergraduate to graduate levels, in instrumentation calibration, data acquisition, processing, analysis, and interpretation.

It is also foreseen within this project how some of the smaller telescopes each country owns might be exploited for education and training. The Moletai Observatory of ITPA, for instance, has recently become an international training center for post-graduate and doctorate students. The first international Nordic-Baltic research summer school was organized there in 1999, and the second one will take place in 2002 (see http://www.astro.lt/mao/norfa). This observatory can make an important contribution to the development of academic activities by offering training opportunities to PhD students.

A training site will be created at the Institute of Atomic Physics and Spectroscopy (University of Latvia) to stimulate interdisciplinary collaboration among astrophysicists (high-resolution spectroscopy) and scientists in the fields of atomic, molecular, and nuclear physics. Ventspils International Radio Astronomy Center (Latvia) could be a good training site in the future for researchers and students from the three countries.

As outlined before, our program is strongly geared toward young scientists. Through active academic exchanges, via workshops, symposia, observing trips, discussion over Internet and in person, our program provides an opportunity for international collaboration that will expose the young mind to stimulation, competition, and hence advancement. For this, we specifically include stipends in our budget so we can recruit the best students available to us.

6.2 Implementation Schedule

<u>First Year</u>

- Completion of CCD photometry in the Vilnius and Stromvil systems we already have obtained for some of the clusters at the United States Naval Observatory. The reduction and analysis of data will be undertaken for at least 3 open clusters. We expect to submit a paper for these results in the first year of the project.

- Photoelectric photometry of standard stars for at least 3 clusters in order to prepare for the CCD observations. The data reductions and analysis will start.
- Radial-velocity observations of binary stars in at least 5 open clusters.
- High-resolution spectroscopic analysis of the open cluster NGC 7789. The results too will be submitted for publication. New high-resolution spectral observations for at least two clusters will begin.
- Application of a numerical code developed by NCU to compute the luminosity function evolution of young star clusters. This will be used to infer the ages of a few youngest star clusters for which no main-sequence turn-off has occurred. At least one paper that outlines the methodology and some illustrative applications will be ready for submission in the first year.
- Upgrade of the Maidanak 1-meter telescope, including complete modernization of its electronics, control system, and an auto-guiding system. An Apogee AP-10 CCD camera will be on loan from the NCU to facilitate system upgrade shakedown and imaging observations. Evaluation of a new CCD camera starts.
- Upgrade of the Moletai 1.65-meter telescope control system.
- Observations of selected (using CORAVEL) binaries and peculiar stars using high-resolution spectrometers at ESO, SAO, or Terskol observatories. Fundamental parameters and photospheric abundances will be calculated in details using atmospheric models and spectral synthesis method.
- Two to three working places (computers, peripherals, high speed Internet connection, etc.) will be created for students and visitors at the Institute of Atomic Physics and Spectroscopy (IAPS, University of Latvia) to increase the research and teaching capacity and to initiate researchers/students exchange.
- Two to three new research positions will be created at the IAPS for young researchers in astrophysics (high-resolution spectroscopy) and related sciences (atomic, molecular, nuclear physics, etc.) to initiate multidisciplinary collaboration.
- Lectures on application of high-resolution spectroscopy in astrophysics will be prepared by L. Začs. G. Tautvaisiene will prepare lectures on galactic chemical evolution and W. P. Chen on spatial structure of star-forming molecular clouds and of star clusters. Related courses will be taught in each institute, and the teaching materials will be used for a symposium workshop to be held in the second year.

Second Year

- CCD observations, photoelectric photometry of standard stars and radial-velocity and spectral observations for at least 3 clusters.
- Completion of analysis tools for stellar spatial distribution, namely the two-point correlation function, nearest-neighbor method, radial density profile, etc. Star clusters for which membership information is available from photometric and spectroscopic diagnostics will be used now to infer their ages and structure. One paper on spatial structure of young star clusters will be ready for submission.
- The One-meter telescope at Lulin ready to take imaging observations of star clusters.
- Acquisition of a new CCD camera for the Maidanak 1-meter telescope. The camera should equip with a set of broad-band $UBVRIZ$ and narrow-band H_α, [S II], [O III], and perhaps also [N II] filters. Observing programs other than star clusters, namely on star formation and variability monitoring will be carried out.
- Upgrade of the auto-guiding system for the Moletai 1.65-meter telescope.
- Observations of selected binaries and peculiar stars using high-resolution spectrometers and abundance analysis using atmospheric models and spectral synthesis method.
- Researchers and students exchange on the base of training centers at IAPS and VIRAC.
- The first Taiwan-Baltic Symposium on star clusters will be held. At this stage we expect to have obtained some scientific results of our program, as judged by joint research publications. It should therefore be the right time for the complete collaboration team to meet, so we can check our progress, exchange new ideas, and present our work perhaps to a broader community. At this moment we have not fixed the format, venue or the dates for the symposium, but envision to make it an international meeting and open to other open-cluster communities as well. The planning and budgetary requests will be submitted separately.

Third Year

- Continuation of implementation of new hardware on telescopes. Completion of testing and calibration for the CCD camera for the Maidanak 1-m telescope.
- Coordinated observations by Maidanak and Lulin telescopes to start.

- Initiation of future collaboration with the newly furbished telescopes and instrumentation. Our joint project will set a good example of a trilateral collaboration, with scientific and instrumental (technical) exchanges. We believe other scientific collaborations will follow. For example, radio astronomy has recently rooted in Taiwan, first with Berkeley-Illinois-Maryland Array (BIMA, for which Taiwan bought observing time so as to train young astronomers and students, for the major projects to be taken later), then with the SubMillimeter Array (SMA), and Array for Microwave Background Anisotropy (AMiBA). Taiwan not only takes part in building the antennas, but also developed and fabricated world's leading amplifiers and receivers. Taiwan is also a partner to build a state-of-the-art large-format infrared camera for the CFHT (the WIRCAM), thereby gaining the capability for instrumentation development. The NCU group will also build its own infrared camera. The experience may be valuable to Baltic colleagues if they ever want to undertake similar projects. The success of the star cluster project we propose here no doubt will spur scientific and technical collaboration between Taiwan and the Baltic countries in more than stellar and optical astronomy. For instance, in order to study the structural evolution of young star clusters, we will compare with the hierarchical structure of molecular clouds. We therefore will propose to use the SMA for high-angular resolution mapping. This would be an excellent opportunity for Baltic astronomers to get access to the data taken by this unique instrument.

- Completion of observations of selected binaries and peculiar stars using high-resolution spectrometers, abundance analysis and interpretation (see second year). Two to three joint papers in refereed journals will be ready for submission.

- Preparation of review papers on open clusters and the Galaxy evolution.

- Summarizing evaluation of the program. Writing up reports to funding agents.

7 Benefits of Current Research

The necessary scientific and technical basis to be built up for the best use of the Maidanak 1-meter telescope (to upgrade, and to supply it with a CCD camera, etc.) will serve not only for this project but also for the future astronomical programs of Taiwan, the Baltic countries and Uzbekistan. In addition, the training site at the IAPS (University of Latvia) will pave the way for interdisciplinary collaboration in astrophysics, atomic, molecular and nuclear physics — with which the Latvian group has long association. We expect to learn much from our colleagues in these fields and, at the same time, the image and spectral analysis experience we gain can be readily applied to laboratory problems.

7.1 Toward Other Projects

One of the PIs, W. P. Chen, together with his graduate student, Mr. Hsu-Tai Lee, visited Maidanak Observatory in August 2001. With Dr Alisher Hojaev of the Ulugh Beg Astronomical Institute, they used the 1.5 meter and 0.6 meter of the Observatory for (1) narrow-band imaging of young stars and associated nebulosity, and (2) broad-band imaging survey of the star-forming region NGC 6820. For the time of their visit, the astroclimate and seeing conditions of the site were remarkable. Of the 10 nights they stayed on the mountain, 8 were perfectly clear and one was partially cloudy before a rainy day. The seeing was routinely subarcsecond, perhaps as good as an average of 0.6". As NCU is setting up a one-meter at Lulin Observatory in Taiwan, Maidanak Observatory would be a natural partner to join forces. Currently the Lulin 1-m, to be ready by the fall of 2002, has planned the following research projects what will gain immediate benefits of this project:

1. Monitoring X-ray Binaries (NCU)

   This will be a project with Yale University in the USA which utilizes their 1-m telescope in Chile to monitor X-ray binaries for outbursts. Taiwan is located half a globe away, therefore complementary to making a more complete time coverage, essential for a monitoring program. Maidanak is a suitable partner because it is well separated from either Taiwan or Chile. Furthermore, its excellent sky condition happens in the summer months, whereas in Taiwan, the best time is in the fall and the winter.

2. Variable Stars (NCU)

   This is a collaboration with the Sloan Digital Sky Survey (SDSS) team. With the existing 0.76 cm telescope in Lulin, the NCU group has already been following up to confirm RR Lyrae variables selected by the SDSS group based on color criteria. However we are limited to bright sources because of the size of the telescope. With the Lulin 1-m, with its much better optical and mechanical performance, we expect to go significantly deeper. This would allow us to use this kinds of variables — long used as standard candles for distance determination — to probe the Galactic structure out to large distances, notably the tidal interaction with the neighboring dwarf elliptical galaxy.

   RR Lyrae stars vary typically in less than a day. This time scale makes single-site observations difficult to have substantial phase coverage efficiently. We therefore would very much look for collaboration with observatories in other longitudes. In addition to Maidanak, we hope to involve 0.8 m telescope at Beijing Observatory in this project as well. A multi-site observing campaign not only offers a longer time coverage, a safer guard against unfriendly weather (especially for a time-honored event), but also enables simultaneous observations at different wavelengths or with different instruments (e.g., photometry versus spectroscopy).

3. Star Formation and Young Stellar Objects (NCU)

   The NCU near-infrared camera will be used to study young stars. The latest IR detectors are so sensitive that even a moderate telescope could easily go down to K$\sim$ 18 mag. The NCU group recently has used the 2MASS database to study the spatial structure of open clusters. However 2MASS only goes as faint as K$\sim$ 14.5 mag (10-σ), not deep enough for many open clusters to see much of the main sequence population. In order to know how the majority of faint stars are distributed, deep IR imaging is necessary. The infrared camera NCU group plans to build will finish in about 2 to 3 years, and the open clusters in our program, which will be already well studied with optical imaging and spectroscopy, shall be on the top-priority list of targets.

   Optical narrow-band imaging in H_α, [S II], and [O III], will be carried out at Lulin and at Maidanak. Such images in star-forming regions give diagnostics about radiation- and shock- excited nebulosity. We are particularly interested in compact H II regions and wind bubbles around Wolf-Rayet stars. These are excellent joint observing projects.

4. Future projects at Ventspils International Radio Astronomy Center (http://www.astr.lu.lv/VIRAC/) (Latvia)

   VIRAC and the 32-m radiotelescope as a future component of EVN, the European VLBI network, will be an excellent training site and instrument for research in the nearest future. Note that in 2001 the Nordic-Baltic Summer School has been organised here for graduated students (see http://www.astro.lu.se/radio2001).

5. Population II Spectroscopic Binaries (Lithuania)

   This is a long-term project to study binaries among Population II stars and RR Lyrae variables by radial-velocity observations with the CORAVEL spectrometer. To detect a reflex motion due to binarity, the observations must cover a considerable part of the orbital periods. Therefore, dedicated observing times such as with the Maidanak and Lulin telescopes — not readily available otherwise — would be effectively used for this project. In particular, light curves can be obtained with the Maidanak and Lulin imagers while Moletai Observatory is taking the spectra.

6. Vertical Structure of the Galactic Disk (Lithuania)

   This is a joint project with the Scientific and Technical Research Council of Turkey (TUBITAK) and Main Astronomical Observatory of Ukraine, based on multicolor CCD photometry and radial-velocity measurements in a number of proper-motion fields near the north and south Galactic poles. To obtain data on the southern fields, we will have to involve the telescopes located at geographical latitudes much more to the south. Along with the Maidanak and TUBITAK observing facilities, the Lulin telescope with its future CCD camera for wide-field imaging will be a perfect treasure.

The forementioned projects are not on star cluster research directly, but the telescope/instrumentation access this project aims to cultivate will be a fairly good asset to the small-telescope community in each country in general. In a global telescope network, any single site is just a node, but a multiple alliance of several telescopes widely distributed geographically will vastly increase the efficiency of a monitoring campaign. New collaborations may well be initiated.

In 2003, the European Commission will start the 6th Framework Programme which will give access to a larger number of European telescopes, and an international coordinated project will have a much better opportunity to compete for corresponding grants. We believe the project we are proposing here on star clusters is well planned in that we first enhance our own research work, before we delve into scientific collaboration. In the mean time, we work together to bring instrumentation into full operation, through which the joint activity shall start to phase in. We expect to have concrete results, as judged by paper publication, in the first year of operation. It is our hope that the initial success of this joint project will give us much credibility toward the application of the Framework Programme.

We expect the following core capabilities to be developed most of which will not duplicate any capability from the ground research and space missions, both present and previous:

- the ability to accurately determine the amount of interstellar extinction towards the cluster (and hence distance) and metallicity through the seven-color photometry which gives a distinct advantage over the three-color photometric tools (UBV, etc.) commonly used in other studies;
- the ability to determine the metallicity of the cluster in three independent ways, from (a) the seven-color photometry and (b) the depth of the cross-correlation function of the CORAVEL radial-velocity measurements and (c) high resolution spectroscopy which are not affected by interstellar reddening;
- the possibility of determination of stellar rotation through the CORAVEL measurements of radial velocities;
- capability to study such phenomena in stars as mixing processes, to relate them with variations of spectral and photometric parameters.

In summary, our joint project will (1) be the first to exchange experience among the astronomical communities of the three countries and to make the best use of existing astronomical instruments, without the need for excessive investment at the national level from each country; (2) help the recovery of astronomy in the Baltic states from its temporary dire state due to sudden political and economic change a decade ago; (3) create opportunities to stimulate and train students from undergraduate to graduate levels; and (4) provide a vehicle to render observing time access of telescopes at Maidanak Observatory and Lulin Observatory to a wider user community, thus of more scientific impact.

7.2 Scientific Advances and Breakthroughs

Our research will answer the following fundamental and currently pending questions in relation to the evolution of stars, open clusters and the Galaxy:

- evaluation of the chemical evolution of the Galaxy through the study of open clusters of different age and metallicity;
- good determination of distances and other fundamental parameters for a selected sample of open clusters, making contribution to the census of the Galactic cluster population;
- evaluation of the multiplicity in open clusters, making a significant impact on star formation history, dynamical evolution of the stellar systems, and constraints for stellar evolution theories;

7.3 Contribution to Quality of Life

Apart from its purely scientific merit, this project certain will have, through a mutually beneficial interplay between the scientific and socio-cultural climate, impacts on the development of human potential and political systems in the three countries. The Baltic countries have a long successful history in astronomy research. On the other hand, Taiwan is an ambitious rising star trying to jump-start its astronomy research. To demonstrate the lack of communications between these cultures, and the ignorance of our Taiwan colleagues, W. P. Chen was a coauthor of a paper published in Baltic Astronomy years ago. Yet before that Chen did not even heard of that journal! The unbalance of monopolization in Taiwan — scientifically, commercially, and culturally — toward the USA, Japan or West Europe will only improve if people start to make contact and to work together.

8 Intellectual Property Rights

The products of our collaborative project will be primarily scientific papers published in international journals. All relevant papers will be published together with the collaboration, with each institution and funding agent properly credited.

10 Researcher Resumes & Publication Lists

CURRICULUM VITA — Wen Ping Chen — Feb. 2002

Address:	Graduate Institute of Astronomy, National Central University Chung-Li, 32054 Taiwan Telephone: +886-3-422-3424; 426-2302 Facsimile: +886-3-426-2304 e-mail: wchen@astro.ncu.edu.tw url: www.astro.ncu.edu.tw
Personal:	Born Nov. 22, 1958, Taiwan; married; two children
Education:	Ph. D., 1990, Astronomy State University of New York at Stony Brook *Thesis*: Near-Infrared Milliarcsecond Observations by Lunar Occultation Technique *Adviser*: Dr. Michal Simon B. S., 1980, Physics Department, National Central University, Taiwan
Employment:	2000–now, Director, NCU/IA 1992–now, Associate Professor, NCU 1996.06–1996.12, Visiting Scientist, Harvard-Smithsonian Center for Astrophysics 1990–1992, Carnegie Fellow, Carnegie Institution of Washington 1983–1990, Graduate Assistant, SUNY-Stony Brook 1980–1982, Instructor, Motorvehicle Structure and Preventive Maintenance, ROTC Program, Taiwan
Memberships:	American Astronomical Society International Astronomical Union Chinese Astronomical Society (Taiwan) Chinese Physics Society (Taiwan)
Research:	Star Formation and Young Stars Kuiper-Belt Objects Star Clusters Variable Stars
Services:	Referee, Astrophysical Joural Grant Reviewer, NASA Execute Committee Member, Chinese Astronomical Society Editor Member, Physics Bimonthly (Taiwan) Editor, International Astronomical Union Colloquium 183 "Small-Telescope Astronomy on Global Scales"

Refereed Publications in the Last Three Years — W. P. Chen

1. On the ejection Velocity of Meteoroids from Comets, Ma, Y., Williams, I. P., & Chen, W. P., MNRAS in preparation (2002)

2. Strong Emission-Line Stars Identified toward the Rosette Nebula, Li, J. Z., Chen, W. P. et al, Astron. J., in press (2002)

3. Intermediate-band Surface Photometry of edge-on galaxy: NGC 4565, Wu, H., (BATC Team), Chen, W. P., Astron. J, in press (2002)

4. An Extraordinary Accretion Event Detected on DF Tauri, Li, J. Z, Ip, W. H., Chen, W. P., Hu, J. Y., & Wei, J. Y., Astrophy. J. Lett., 549, L89 (2001)

5. Spatially Resolved Spectro-photometry of M81: Age, Metallicity, and Reddening Maps, Kong, X. (BATC Team), Chen, W. P. et al, Astronomical Journal, 115, 2745 (2000)

6. Calibration of the BATC Survey: Methodology and Accuracy, Yan, H.-J., Burstein, D., (BATC Team) , Chen, W. P., et al., Pub. Ast. Soc. Pacific., 112, 691 (2000)

7. New Search for Star Formation in High-Galactic Latitude Molecular Clouds, Li, J. Z., Hu, J. Y., & Chen, W. P., Astronomy & Astrophysics, 356, 157 (2000)

8. First Discovery of Weak-Lined T Tauri Stars in High-Galactic Latitude Molecular Clouds, Li, J. Z., Hu, J. Y., and Chen, W. P., Chinese Science Bulletin, 44, 1396 (1999)

Other Group Members from Taiwan:

Chen, Wen-Ping, Principal Investigator, NCU

Hsu, Rei-Ron, Professor, Department of Physics,
National Cheng-Kung University

Chen, Alfred Bin-Chi, Research Fellow,
Dept. of Physics, National Cheng-Kung University

Fu, Hsiueh-Hai, Associate Professor,
Dept. of Earth Sciences, National Taiwan Normal University

Lee, Hsu-Tai, PhD Student, NCU

Chen, Jin-Wei, Master Student; to be in PhD program in fall of 2002, NCU

Chang, Yung-Hsin, Telescope Engineer, NCU

Chang, Ming-Hsin, Telescope Engineer, NCU

Researcher Resume (Lithuania):

Principal Investigator: Dr. Gražina Tautvaišienė

Institute: Institute of Theoretical Physics and Astronomy (ITPA)

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Phone: +370 2 621117

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Email: taut@itpa.lt

Present appointment: Deputy Director, ITPA, since 1998

Date of birth: 20/11/1958

Education: M.Sc.: Vilnius University, 1982

Ph.D.: Institute of Theoretical Physics and Astronomy, 1988

Employment records:
Assistant, ITPA, 1982
PhD student, ITPA, 1983–85
Scientific researcher, ITPA, 1988–91
Senior Scientific Researcher, ITPA, 1991–98
Deputy Director, ITPA, 1998–

Fields of research: Stellar spectroscopy and photometry; element abundances; chemical evolution of galaxies.

Awards and Grants:
American Astronomical Society Premium for scientists of the Former SU, 1994
NORDITA/Baltic–NW Russia Fellowship from the Nordic Council of Ministers, 1997
ESO Central and E. European grant A-01-069, 1994–95
European Commission grants of the "Human Potential" Programme for Access to Research Infrastructures – European Northern Observatory, REF:01-010, REF:01:026.

Membership of Professional Societies:
Member of the International Astronomical Union, 1994
Founding member of the European Astronomical Society, 1992
Member of the Lithuanian Astronomical Union, 1995

Publications: 64

Contributions to international conferences: more than 20

Outline of present research and corresponding publications:

Projects in which I am currently engaged include an observational campaign to determine element abundances in the atmospheres of red giants and horizontal-branch stars in the Galactic field and open clusters and to evaluate the extent of mixing processes in evolved stars [1-3]; developments of methods for the determination of stellar atmospheric parameters by means of ground and space photometry [4-5]; and modelling the chemical evolution of galaxies [6-10]. The work is going on in a close collaboration with astronomers in Sweden, Finland, Denmark, France, Italy, UK, USA and Canada.

1. Tautvaišienė, G., Edvardsson B., Tuominen I., Ilyin I. 2001, "Chemical composition of red horizontal branch stars in the thick disk of the Galaxy", Astronomy and Astrophysics, 380, 578-589.
2. Tautvaišienė, G., Edvardsson B., Tuominen I., Ilyin I. 2000, "Chemical composition of evolved stars in the open cluster M 67", Astronomy and Astrophysics, 360, 499-508.
3. Tautvaišienė, G. 1997, "Chemical abundances in 10 red horizontal branch stars located in the galactic field", Monthly Notices of the Royal Astronomical Society, 286, 948-956.
4. Tautvaišienė, G., Edvardsson B. 2002, α-process elements in the Galaxy: a possible GAIA contribution", Astrophysics and Space Science, (astro-ph/0201464)
5. Bressan, A., Tautvaišienė, G. 1996, "Theoretical isochrones in the observational plane of the Vilnius photometric system", Baltic Astronomy, 5, 239-246.
6. Pagel, B. E. J. and Tautvaišienė, G. 2000, "s/α/Fe abundance ratios in halo field stars: is there a globular cluster connection?", in "The Evolution of the Milky Way", eds. F. Matteucci and F. Giovannelli, Kluwer Academic Publishers, 27-33.
7. Pagel, B. E. J. and Tautvaišienė, G. 1998, "Chemical evolution of the Magellanic Clouds", 1999, Astrophysics and Space Science, 265, 461-468.
8. Pagel, B.E.J. & Tautvaišienė, G. 1998, 'Chemical evolution of the Magellanic Clouds: analytical models', Monthly Notices of the Royal Astronomical Society, 299, 535–544.
9. Pagel, B.E.J. & Tautvaišienė, G. 1997, 'Galactic chemical evolution of primary elements in the solar neighborhood II: elements affected by the s-process', Monthly Notices of the Royal Astronomical Society, 288, 108–116.
10. Pagel, B.E.J. & Tautvaišienė, G. 1995, 'Chemical evolution of primary elements in the Galactic disk: An analytical model', Monthly Notices of the Royal Astronomical Society, 276, 505–514.

Other Project Participants in Lithuania:

PhD/MSc students and Research assistants:

Mr. Viktoras Deveikis (Vilnius University)— Radial velocities

Mr. Vygandas Laugalys (ITPA)—Photometry

Mr. Eduardas Puzeras (ITPA)—Spectroscopy

Miss Rima Stonkutė (Vilnius University, ITPA)—Spectroscopy

Leading and senior researchers:

Dr. Stanislava Bartašiutė (Vilnius University; ITPA)
— Photometry, Radial velocities

Dr. Algirdas Kazlauskas (ITPA) — Photometry

Dr. Julius Sperauskas (Vilnius University; ITPA)
— Radial velocities

Prof. Vytautas Straižys (Head of Astron. Observatory, ITPA)
— Photometry

The group includes the best experts in photometry - Prof. V. Straižys (a founder of the Vilnius and Stromvil photometric systems); Dr. A. Kazlauskas (an expert in CCD photometry and data reductions); Dr. J. Sperauskas (a PI for the CORAVEL instrument); Dr. S. Bartašiūtė (an expert in stellar photometric classification and kinematics).

Included in the group are also four young and perspective PhD and MSc students and research assistants to be trained.

Researcher Resume (Latvia):

Principal Investigator: Dr. Laimons Začs

Institute: Institute of Atomic Physics and Spectroscopy

Home page: http://www.lza.lv/scientists/zacsl.htm

Present appointment: Leading Researcher; Head of Project

Date of birth: 25/02/1960

Education:
Dr.phys., 1992, University of Latvia
Special course in the field of observational astronomy, October 1987 - October 1988, Special Astrophysical Observatory (6-m optical telescope), North Caucasus, Russian Academy of Sciences
Phys.bachelor, 1984, University of Latvia (Faculty of Physics and Mathematics)

Employment records:
Institute of Atomic Physics and Spectroscopy, University of Latvia, leading researcher, since January 2001
Ventspils International Radio Astronomy Centre, leading researcher, 1997-2000
Radioastrophysical Observatory, Latvian Academy of Sciences, leading researcher, 1995-1997
Radioastrophysical Observatory, Latvian Academy of Sciences, researcher, 1992-1995
Special Astrophysical Observatory (SAO), Russian Academy of Sciences, researcher, January 1989 - December 1989
Radioastrophysical Observatory, Latvian Academy of Sciences, junior researcher, 1986-1987, 1990-1992
Military service, 1984-1986.

Fields of research:
Absorption spectra, High-resolution spectroscopy, Chemical composition of stellar atmospheres, Neutron-capture nucleosynthesis, Circumstellar matter

Languages:
Latvia, Russian, English, German

Honours,Awards, Fellowship and Professional Societies:
Referee for Astronomy & Astrophysics (A European Journal), EDP Sciences
Referee for The Astrophysical Journal, The University of Chicago Press
Membership, European Astronomical Society, since 1994
Membership, Latvian Physical Society, since 2000
Member of the Board, Ventspils International Radio Astronomy Centre, since 1999
Advisor of one master and two bachelor theses at the Physics Department of the University of Latvia

Number of papers in refereed journals: 29

Number of communications to scientific meetings: 20

Outline of present research:
The studies of high-resolution stellar absorption spectra were started in Latvia about 10 years ago by L. Začs. Since that more than 20 papers have been published in refereed journals, including Astronomy & Astrophysics (A European Journal) and Monthly Notices of the Royal Astronomical Society, the primary research journals in astronomy. More than ten observational programs have been granted on internationally accessible telescopes (European Southern Observatory, Special Astrophysical Observatory). The results on abundance analysis of heavy element rich (barium) stars have been reported (Invited review) at the prestigious symposium of the International Astronomical Union No.177. Later on pioneering effort was realized in abundance analysis of evolved stars (protoplanetary nebulae), cited now frequently in the journals with high ISI Impact factor. To increase capacity in this an extremely active field of research in 2001 at the Institute of Atomic Physics and Spectroscopy was founded the group of stellar spectroscopy.

Other Project Participants from Latvia:

Leading researchers and researchers:

Dr. Imants Platais, proper motion, associated member

Dr. Gita Revalde, atomic data

Dr. Juris Freimanis, radiative transfer

PhD/MSc students and Research assistants:

PhD student Janis Alnis, atomic and molecular data

Phys. bachelor Raivis Spelmanis, spectroscopy

Mg. phys. Oskars Alksnis, spectroscopy

List of recent/representative publications:

1. Platais I., Kozhurina-Platais V., Barnes S. Girard T., Demarque P., van Altena W. F.; Deliyannis C.P., Horch E., 2001. WIYN Open Cluster Study. VII. NGC 2451A and the Hipparcos Distance Scale, Astronomical Journal, vol.122, p. 1486

2. Začs L., Schmidt M.R., Schuster W.J., 2000. A carbon rich star BD+75 348: a binary? - Astronomy and Astrophysics, vol.358, pp.1022–1026

3. Začs L., Schmidt M.R., Szczerba R., 1999. A search for diffuse absorption bands in the spectra of two PPN candidate stars: HD179821 and SAO34504. - Monthly Notices of the Royal Astronomical Society, vol.306, pp.903–912

4. Začs L., Alksnis O., Musaev F.A., Bikmaev I.F., Galazutdinov G.A., 1999. An abundance analysis of the single-lined spectroscopic binaries with barium stars like orbital elements. II. The spectroscopic data. - Astronomy and Astrophysics Supplement Series, vol.136, pp.453–454

5. Revalde G., Skudra A., Mathematical modelling of the spectral line profiles in the high-frequency discharge, J. Quant. Spectr. Radiat. Transfer, V 61, No. 6, 1999, p. 717–728

6. Začs L., Nissen P.E., Schuster W.J., 1998. The chemical composition of HD196944: a carbon and s-process rich, very metal-poor star. - Astronomy and Astrophysics, vol.337, pp.216–222

7. Začs L, Klochkova V.G., Panchuk V.E., Spelmanis R., 1996. The chemical composition of the protoplanetary nebula candidate HD 179821. - Monthly Notices of the Royal Astronomical Society, vol.282, pp.1171–1180

8. Začs L., Klochkova V.G., Panchuk V.E., 1995. The chemical composition of post-AGB star, proto-planetary nebulae candidate IRAS 22272+5435 = SAO 34504. - Monthly Notices of the Royal Astronomical Society, vol.275, pp.764–772

9. Enders K., Becker O., Brand L.,Dembczynski J., Marx G.,Revalde G., Rao P.M., Stachowska E., Werthg., Hyperfine-structure measurements in the ground state of radioactive 150Eu+ ions, Phys.Rev.A, V 52, N6, 1995, p. 4434–4438