Slovak Academy of Sciences

Astronomical Institute

ANNUAL REPORT 2008

Astronomical Institute, Tatranská Lomnica, Slovakia

Contents

1 Foreword

The present form of the report of the activities of the Astronomical Institute of the Slovak Academy of Sciences (AI SAS) does not differ significantly from the last year report. Its structure and layout are, however, considerably different from those in the corresponding Slovak version (also available at our web page). The English version is focused almost uniquely on the scientific activities of the AI SAS and it omits a number of important 'non-scientific' issues, like, e.g., financial matters of the institute, teaching commitments at universities, etc.; these can only be found in the Slovak version. The report for 2008 is the sixth in the English language that I have the pleasure to present, and I hope you will find it of interest.

Our staff in High Tatras and Bratislava was changed considerably in 2008. After many years of intensive work, retired former director of AI SAS and scientist of the Department of Solar Physics Julius Sykora. Peter Zimmermann in mechanical workshop and Jana Pittichová in the Department of Interplanetary Matter also closed their positions at the Institute. Anna Bobulová started at the position of economy manager and Ján Klein in the position of mechanic. Marcela Bodnárová and Zuzana Krišandová started their PhD study in the Department of Solar Physics and Department of Interplanetary Matter.

It is useless to attempt to summarize content of the following many pages in a few rows here. Nevertheless, some important issues should be pointed out. The amount of scientific production is expressed by 74 papers in internationally distinguished refereed journals. A number of interesting results have been obtained, some of them being highlighted in what follows. AI SAS plays an important role in 19 well-established international projects and a number of informal collaborations.

AI SAS organized in 2008 two scientific meetings. Czech and Slovak Workshop on Interplanetary Matter held at Modra on May 12-16, 2008 - 30 participants from Czech republic, Poland and Slovak republic. International conference about successes of stellar astronomy held at Bošáca, May, 30 – June, 1 - 44 participants from 5 countries.

Astronomical Institute in 2008 participated in the preparation of materials for the Ministry of Education for the accession of the Slovak Republic to the European Space Agency.

The most important activity of AI SAS in 2008, outside of scientific activity, was applying for a grant from the EU Structural Funds. AI SAS together with the Institute of Experimental Physics and Pavol Jozef Šafárik University was successful and obtained the project entitled "Center of Space Research: Space weather effects"for a total of 39.96 million Sk. Funds are planned for a significant modernization of an infrastructure of all 3 institutions of the Centre.

The last volume of our journal Contributions of the Astronomical Observatory Skalnate Pleso (number 38) appeared in three regular issues. The journal is covered by the ISI and SCOPUS and is electronically available from our web page (http://www.ta3.sk) and the ADS database as well.

We have also succeeded to improve substantially our observational facilities and infrastructure. A connection of Skalnaté Pleso Observatory by a fiber optic was realised in the first phase (70%). The entire route from Tatranská Lomnica to Skalnaté Pleso will be completed in 2010. In 2008, the mirrors of 0.6-m telescope at the Skalnaté Pleso Observatory was coated by aluminum and silicon protective layers using a device given in operation in 2007. The second part of the exchange of 65-year old water supply connection to Skalnaté Pleso Observatory was realised in 2008.

Ján Svoreň
director of AI SAS

2 Research

2.1 Interplanetary matter

Observational facilities:
Skalnaté Pleso Observatory - a 61 cm reflector with a CCD camera, Lomnický štít Observatory and Stará Lesná Observatory – automatic bolide camera, Modra Observatory - a receiver of a forward scatter meteor radar.

Research activities:

- interrelations among the populations of small bodies in the Solar System and their evolution,
- a search for binary asteroids,
- creation of spatial models of asteroids,
- infra and visual photometry of asteroids and comets,
- investigation of the activity of selected cometary nuclei and its influence on the physical and dynamical evolution of these bodies,
- origin and evolution of Oort cloud comets,
- study of the structure of selected meteor showers,
- operation of bolide cameras within the framework of the European Fireball Network,
- investigation of physical characteristics of dust particles in the Solar System and Earth atmosphere,
- investigation of interrelation between meteor sporadic background activity and solar activity by a forward scatter radio system,
- search for hyperbolic and interstellar meteoroids using data from IAU Meteor Data Center Catalogue.

2.2 Solar physics

Observational facilities:
Stará Lesná Observatory - a horizontal solar telescope with spectrograph, Lomnický Peak Coronal Station - a double 20 cm coronagraph with a spectrograph.

Research activities:

- spectral analysis of the quiet and active solar photosphere and chromosphere using spectra from observations with large ground-based solar telescopes (Tenerife VTT, La Palma SST),
- study of the dynamics and energy transfer in the quiet and active upper solar atmosphere from SOHO (SUMER, CDS, EIT) and TRACE satellites data,
- study of rotational characteristics of sunspots and surrounding photospheric plasma based on own measurements,
- derivation of magnetic fields in specific coronal structures using own polarimetric solar eclipse observations,

- analysis of coronal holes and their relation to the background and local magnetic fields and a relationship between polarization and intensity of the green line in different coronal structures,
- study of a time-latitudinal distribution and large-scale development of solar prominences,
- observations of both the 530.3 nm and 637.4 nm emission coronal lines as well as the white-light corona to study solar cycles and long-term variations of the solar activity,
- preparation of the homogeneous coronal data set for the 530.3 nm coronal line and computation of the coronal index of solar activity.

2.3 Stellar astrophysics

Observational facilities:
Skalnaté Pleso Observatory and Stará Lesná Observatory - two 60 cm photometric reflectors, a 50 cm reflector with a CCD camera.

Research activities:

- investigation of interacting binary and multiple systems, symbiotic stars, novae and nova-like objects focused on physical processes during phases of their activity, studies of their origin, structure, evolution and physical conditions in the circumstellar environment,
- photometric detection of various manifestations of both regular and semi-regular stellar variability, models construction explaining the behaviour of the systems,
- use of the IUE, HST and X-MM-Newton spectroscopic data databases for the study of outbursts of symbiotic stars,
- analysis of photometric, spectroscopic and interferometric data for the determination of the basic parameters of the components of interacting binaries and multiple systems and study of their rotational velocities,
- study of spectroscopic orbits of contact binaries using the spectroscopy from David Dunlap observatory,
- discovery of new variables and binaries using the Canadian satellite MOST,
- photometric and spectroscopic investigation of chemically peculiar stars phenomena based on our own photometry, photometry from Hipparchos and spectroscopy from ESO, Mt. Stromlo, CFHT, Nauchnyj, Ondøejov, Rozhen and Zelenchuk observatories,
- study of the chemical composition and properties of the atmospheres of CP stars,
- study of rotational period changes of magnetic stars,
- study of atmospheres of extrasolar planets using the photometry and spectra taken by the satellite Spitzer.

3 Personnel

3.1 Executives

Director : J. Svoreň, deputy director : J. Žižňovský, scientific secretary : J. Rybák

3.2 Scientific Council

A. Bobák, E. Dzifčáková, K. Kudela, A. Kučera (chairman), L. Neslušan, E. Pittich, V. Porubčan, T. Pribulla (vice-chairman), V. Rušin, J. Rybák, A. Skopal, J. Žižňovský.

3.3 Department of Interplanetary Matter

Head: J. Svoreň
Staff in Bratislava: J. Farkašová, M. Hajduková, Jr., I. Kapišinský, M. Kocifaj, Z. Krišandová (postgraduate student), J. Pittichová (currently a post-doctoral scientist at the Institute for Astronomy, University of Hawaii, USA), E. Pittich, T. Paulech, V. Porubčan, N.A. Solovaya
Staff in the High Tatras: G. Červák (technician), M. Husárik (postgraduate student), M. Jakubík, Z. Kaňuchová, L. Neslušan, M. Pikler (technician), J. Svoreň, M. Tirpák (postgraduate student).

3.4 Department of Solar Physics

Head: A. Kučera
Staff: P. Bendík (technician), Marcela Bodnárová (postgraduate student), P. Gömöry, P. Havrilla (technician), Ľ. Klocok, J. Koza, R. Mačura (technician), K. Maník (technician), M. Minarovjech, V. Rušin, J. Rybák, M. Saniga, J. Sýkora.

3.5 Stellar Department

Head: D. Chochol
Staff: D. Božík (technician), J. Budaj, Ľubomír Hambálek (postgraduate student), L. Hric, V. Kollár, R. Komžík, E. Kundra (postgraduate student), K. Kuziel (technician), T. Pribulla, P. Schalling (technician), M. Sekeráš (postgraduate student), A. Skopal, J. Tremko, M. Vaňko, M. Zboril, J. Zverko, J. Žižňovský.

3.6 Administration and Maintenance

Head: A. Bobulová
Staff: M. Alman, J. Ambróz, R. Bekeš, F. Budzák, T. Drzewiecka, M. Dufalová, T. Griešová, Mária Guzyová, Ľ. Hanigovský, J. Klein, J. Krempaský, K. Krempaská, J. Krasula, V. Mačáková, D. Novocký, A. Sanigová, M. Šoltýsová, M. Zajíčková.

4 Guests

In 2008, the following guests visited our institute: G. Cevolani (ISAC (FISBAT) CNR, Bologna, Italy), H. Havlicek (Institut fur Diskrete Mathematik und Geometrie, TU Vienna, Austria), A. Hanslmeier (Institute of physics/IGAM, University of Graz, Graz, Austria), J. Janik (Institute of Theoretical Physics and Astrophysics, Masaryk University, Brno, Czech Republic), T. Krejčová (Institute of Theoretical Physics and Astrophysics, Masaryk University, Brno, Czech Republic), V. Krushevska (Main Astronomical Observatory, National Academy of Sciences of Ukraine, Kyiv, Ukraine), D.O. Kudryavtsev (SAO RAN, Russia), Y. Kuznetsova (Main Astronomical Observatory, National Academy of Sciences of Ukraine, Kyiv, Ukraine), P. Lévay (Institute of Physics, Budapest University of Technology and Economics, Budapest, Hungary), H. Meszaroszová (Astronomical Institute, Academy of Sciences of the Czech Republic, Ondrejov, Czech Republic), Z. Mikulášek (Institute of Theoretical Physics and Astrophysics, Masaryk University, Brno, Czech Republic), P. Pracna (Heyrovský Institute of Physical Chemistry, Prague, Czech Republic), K. Radziszewski (Astronomical Institute, University of Wroclaw, Poland),

P. Rudawy Astronomical Institute, University of Wroclaw, Poland), G. Rjabova (Research Institute of Applied Mathematics and Mechanics of Tomsk State University, Tomsk, Russian Federation), J.I. Romanjuk (SAO RAN, Russia), M.H. Semeida (National Research Institute of Astronomy and Geophysics (NRIAG), Helwan, Egypt).

5 Results

The main results acquired and published by the research personnel of the Astronomical Institute in the year 2008 are briefly described below. Information about the reference to the published paper in the list of publications is given in brackets.

1/ The most significant result of the year 2008 – result 1: Theoretical spectra and light curves of close-in extrasolar giant planets.

We present theoretical atmosphere, spectral, and light-curve models for extrasolar giant planets (EGPs) undergoing strong irradiation for which Spitzer planet/star contrast ratios or light curves have been published (circa 2007 June). By comparing models with data, we find that a number of EGP atmospheres experience thermal inversions and have stratospheres. Moreover, the presence of atmospheric water in abundance is fully consistent with all the Spitzer data for the measured planets. For planets with stratospheres, water absorption features invert into emission features and mid-infrared fluxes can be enhanced by a factor of 2. In addition, the character of near-infrared planetary spectra can be radically altered. We derive a correlation between the importance of such stratospheres and the stellar flux on the planet, suggesting that close-in EGPs bifurcate into two groups: those with and without stratospheres. (paper No. 19).

2/ The most significant result of the year 2008 – result 2: AG Draconis observed with XMM-Newton.

We revealed an anticorrelation between the supersoft X-ray fluxes and the optical fluxes, observed for the symbiotic star AG Draconis during its quiescent and active phases. This anticorrelation represents a general behaviour, which is independent from that how the outburst is strong and its type. During outbursts, the white dwarf luminosity increases, but the radiation is heavily absorbed by the circumstellar matter within the supersoft X-ray domain. In contrast, the brightness in the optical increases, as indicated by photometric observations and accurately calibrated low-resolution spectra. This is a consequence of the increased opacity at the vicinity of the white dwarf due to an increase of its stellar wind. (paper No. 20).

3/ The most significant result of the year 2008 – result 3: Uncertainty of the physical characteristics of AGB dust shells.

The properties of dusty and gaseous systems are usually obtained indirectly – by analyzing their spectra, extinction curves, scattering phase function or polarization. Optical thickness of the dense dust envelopes of AGB stars is traditionally calculated by Mie scattering theory under assumption that shape of sub-micrometer sized particles may affect the measured intensity of visible radiation only negligibly. We have shown that this assumption is not correct and that the uncertainty in the detected intensity due to uncertainty of the particle shapes can reach the value of 30%. This fact indicates that the real and model sizes of dust particles may differ significantly. As a consequence, this finding can change our view on dynamical evolution and lifetime of the dust population in AGB envelopes (paper No. 29).

4/ The most significant results for applications and public relations: Slovak astronomical seminar for teacher.

Staff of the AISAS in frame of the project APVV LPP-0146 "Meetings with the Universeöf the Slovak research and development agency prepared for days December 4-6, 2008 a seminar for teachers of the basic and grammar schools. The seminar was related to preparation of the coming International Year of Astronomy which was declated by UNESCO for the year 2009. Lectures were given on the solar corona and solar eclipses, on asteroids, Jovian planets of the Solar system, on galaxies, on evolution of the universe and on education of astronomy as an important motivating tool for understanding of different parts of physics. All participant have received a CD with text of the lectures as well as a paper copy of the almanac with the lectures. The main aim of the seminar was to provide teachers with news on the latest research results on the universe which could be used for teaching of astronomy and physics at schools. (Project APVV LPP-146, web page of the seminar: `www.astro.sk/ choc/open/08_casu/str`.

5/ The most significant results obtained within frame of international collaboration – result 1: The simulation of the Oort cloud formation

The understanding of the origin of cometary reservoirs is very important in developing the detailed unified theory of Solar system formation and evolution. Numerical simulation is the most effective and reliable approach in studying the dynamical evolution of the system, especially of the cometary cloud. In these works, we performed the numerical simulation of evolution of the proto-planetary disk represented by 10038 test particles, the largest number till now. The simulation covered the period of the dynamical evolution for the first two gigayears. Our computational tasks were run in GRID environment and lasted about 5 months on 240 CPUs. We established an international cooperation with other institutes (one from Poland and one from Italy), which was crucial for successful completion of our goal. Among the other interesting results we found the low efficiency in formation of the cometary cloud, the strongly dominant high galactic inclinations of cometary orbits and also the fact, that the comets came to cometary cloud not only from the Uranus-Neptune region, but also from the Jupiter-Saturn region and from the transneptunian region, as well (papers Nos. 19 and 33).

6/ The most significant results obtained within frame of international collaboration – result 2: The extremely rapid rotational braking of the magnetic star HD 37776.

Light and spectrum variability of chemically peculiar stars is commonly explained by a model of oblique rotator with a constant rotational period. Comparison of the historic and current observations revealed that in the case of the helium-strong star HD 37776 its rotational period is increasing. We analysed all the available observations since the year 1976, i.e. 1707 measurements in uvby, UBV, Tycho and Hipparcos photometric systems, as well as 550 our new UBV observations from 2006 and 2007, 53 spectrophotometric measurements of the He I 4026 A line, radial velocities in 23 Reticon spectra from CFH Telescope, 35 CCD Zeeman spectra from the 6-m telescop of SAO (Russia), 6 spectra from the Ondrejov and 8 spectra from the Rozhen 2-m telescopes. We found that the rotational period has risen by 18 seconds during 31 years and that it still continues. After ruling out the binarity, precession and evolutional changes we interpret this ongoing period increase as a braking of the star rotation, at least in its surface layers, due to the momentum loss through events or processes in the extended stellar magnetosphere (paper No. 35).

7/ The most significant results obtained within frame of international collaboration – result 3: Radiation pressure forces on micrometric particles – experiment vs. theory.

The primary intention of the project is to experimentally verify the theoretically derived effect of radiation pressure exerted on micrometer dust. In 2008, set of measurements was made in the laboratories of the German partner. It has been shown that photophoresis becomes a

dominant effect under moderate air pressure conditions, thus prohibiting the evaluation of radiation pressure effects. Therefore we reduced the air pressure significantly (in two orders of magnitude) and radiation pressure effects become dominant. After interaction with laser radiation the levitating particles jumped to different directions - just as predicted theoretically. This effect strongly depends on the shape, size and chemical composition of these particles. Using the results of relativistically covariant formulation we were able to derive the inequalities containing the extinction, absorption and scattering cross sections. These results will be compared with detailed numerical calculations based on Maxwell theory and then also verified experimentally (paper No. 25).

8/ Unikátne dáta, ktoré zachytávali moment vzniku ako aj dobu impulzívnej akcelerácie výronov koronálnej hmoty (CME), nám umožnili po prvý krát analyzovat' celkovú kinematiku týchto dynamických javov. Zistili sme, že fáza maximálnej akcelerácie CME a hlavné uvoľnenie energie z prislúchajúcej erupcie nastáva takmer simultánne v rámci časového intervalu kratšieho ako 5 minút. (APVV 0066-06, Rybák, Gömöry, práca č. 56) Unique data sets covering moment of initiation and acceleration of fast halo CME have allowed for the first time to analyze the whole kinematics of these dynamic events. We find a close synchronization between the CME acceleration profile and the flare energy release as well as peaks occur simultaneously within 5 minutes (Rybák, Gömöry, paper no. 56).

9/ We investigated the height dependence of the magnetic field parameters of a sunspot. We found that inside the spot the total magnetic field strength decreases with height. On the other hand, we showed that outside the spot the field strength increases with height. This result is interpreted in terms of magnetic canopies. We also found that the typical values of the current densities vary within the sunspot area in the range $\pm 40\,\mathrm{mA\ m^{-2}}$. Moreover, their values and values of magnetic helicities depend on the fine structure of the sunspots (paper No. 17)

10/ We analysed turbulent motions occurred on the solar surface. Variations of a continuum intensity and full width at half maximum of spectral lines were used as a tool. We found, that the turbulent motions are concentrated not only in the intergranular space but they appear also within central parts of bright granules. This findings support results of numerical simulations of the solar photosphere, where the supersonic horizontal motions of plasma inside granules can induce turbulence of plasma (Kučera, Rybák, paper no. 23).

11/ Sudden brightness in the white-light polar plume has been for the first time observed during the March 29, 2006 total solar eclipse. Apparent upward propagation speed as derived from ground based observations from Niger to Turkey with a time span over three hours, was 65 km $\mathrm{s^{-1}}$. Observed height for the brightness was located in the range from 50 to 200 hundred kilometers above the solar surface. Estimated lifetime of the polar plume, using also SoHO observations, was less than 24 hours. The upward speed of the brightness is in very good agreement with theoretical prediction for the propagation of magneto-acoustic waves in polar plumes (paper No. 39).

12/ It has been shown that characteristics of diffuse electromagnetic field depend on the particle topology, i.e. on the spatial distribution of individual materials in the particle. In case of carbon particles with ice coating, the rapid erosion can be observed as the particle approaches the Sun. The trajectory of such a core-mantle particle evolves in a complex manner due to changes of particle velocity as well as the speed of spiralling toward the Sun. Thanks to these two effects, the lifetimes of these particles differ from those for ideal homogeneous spheres (Kocifaj, paper No. 63).

13/ Excessive use of light (overillumination) unnecessarily wastes energy and almost prohibits professional astronomical observations. To reduce the light pollution levels a detail analysis is necessary before any changes of public lighting take place. To make such analyses possible, the theoretical model of spectral sky radiances has been developed and applied to set of ground-

based light sources. The model allows a numerical prediction of sky radiance distributions at any site (VEGA 3074 and APVV SK-CZ-0019-07, Kocifaj, paper No. 26).

14/ Dust particles captured in mean-motion resonances with planets (commensurability resonances) are driven not only by the electromagnetic radiation and the Lorentz forces and the Sun gravity, but also by the gravitational interaction with a planet. Survival of dust particles in such resonances essentially depends on how these particles interact with the electromagnetic radiation. In general, the capture efficiency is widely unknown quantity, since the real particles are neither spherical nor homogeneous – thus preventing a prediction of their dynamical evolution. The orbital evolution of such particles can be obtained only numerically, as shown in our computational experiment for planet of Neptune (VEGA 3074, Kocifaj, paper No. 28).

15/ The radiative forcing by carbonaceous particles distributed in the atmospheric environment is related to the particle absorption. Modelling the optical behaviour of such particles is generally important in estimations of the radiative balance of the atmosphere. It has been shown that backscattering quantities (like efficiency factor for backscattering, phase function and polarization at large scattering angles) are affected most significantly. Among others it means that remote sensing methods can provide very accurate information on the nature of the atmospheric particles (Kocifaj, paper No. 31).

16/ Optical and infrared observations of comet 21P/Giacobini-Zinner during its 2005 apparition were analysed. The onset of nucleus activity occurred at a pre-perihelion heliocentric distance 3.80 AU, and active out to heliocentric distance larger than 3.3 AU. A nucleus radius of 1.82±0.05 km was derived. The comet exhibited an extensive coma with a prominent dust tail. Molecules of CO and CO2 were recorded. No dust trail was detected, what means that the number density of trail particles had to be lower than $7\times10^{\check{}11}$ $\mathrm{m}^{\check{}3}$ (Pittichová, paper No. 40).

17/ We investigated the dynamical evolution of cometary orbits in the Oort Cloud when the Solar System passes through a spherically symmetric giant molecular cloud, which radial density distribution was approximated with normal (Gaussian) distribution. We did not find significant erosion of the Oort cloud, nor other significant change of its structure, on a scale of distances typical for the Oort Cloud (Jakubík and Neslušan, paper No. 61).

18/ Analyzing photographic orbits of the Lyrid meteoroid stream, the mean orbit, the form and size of the radiant area of the stream, were derived, and three distinctly different groups of orbits on short-periodic, long-periodic and extremal (hyperbolic) orbits in the stream were identified. Consistency of the filaments was verified by an investigation of the orbital evolution of their members. The long-periodic orbit is almost identical with that of the parent comet 1861 Thatcher. The hyperbolic orbits are most probaly result of erroneous measurements (Porubčan, paper No. 43).

19/ By an analysis of forward-scatter radio observations obtained by the meteor radar operating along the Bologna-Modra baseline for twelve years (1996-2007), a direct correlation between the variation of the sporadic meteor background activity and variation of solar activity over one solar cycle, was found (Porubčan, paper No. 92).

20/ In our analysis of meteors, with the aim of determining the occurence of interstellar meteors (ISM) in the vicinity of the Earth, we obtained a heliocentric velocity of vH = 46.6 km s^{-1} for an ISM arriving at Earth, taking into account the relative velocity of the Sun in the nearby stellar environment. According to this criterion, the proportion of ISM among the detected meteor orbits in the IAU Meteor Data Center for the population of meteors with masses greater than 10-3 kg was determined to be 2.5×10^{-4}, and their flux $7\times10^{-19}\mathrm{m}^{-2}\mathrm{s}^{-1}$ (Hajduková, papers Nos. 22, 98, 99).

The analysis of the 14 763 precise determined meteor orbits collected in the Japanese tv catalogue has called the occurence of interstellar meteoroids in the vicinity of the Earth into question, at least for meteoroids of masses corresponding to the video technique detections. The hyperbolic excesses of the heliocentric velocities are in all cases about one order lower than required from the velocity distribution of neighbouring stars. The upper limit of the proportion

of possible interstellar meteors to interplanetary ones among all investigated meteor orbits was determined to be 1.3×10^{-3}.

21/ By applying the method of indices on the set of precise photographic meteor orbits it was found that 249 out of 387 selected Geminids are grouped into 16 filaments. Geminid stream is compact and 4 branches of filaments can be identified only on the basis of space visualization and with the low numerous filaments included. According to our analysis, the two observed maxima of Geminids are product of the activity of two different groups of filaments. These parts of Geminids might appear to be as two different meteor streams, unless the similarity of their orbits was so high (Kaňuchová, Svoreň, paper no. 62).

22 / In the frame of the photometry of the objects of the interplanetary matter there were obtained photometric data on 19 asteroids at the Skalnate Pleso Observatory. Photometric program was focused on the potential binary asteroids, modeling the asteroid shapes and the objects transiting near the Earth vicinity. It was also collected 95 astrometric positions for 12 comets and 164 positions for 28 asteroids (VEGA 7009 and APVT-CZ-SK 0011-07, Husárik, Pikler, Tirpák, Červák, Kaňuchová, papers Nos. 74, 75, 76, 79, 80, 81, 82, 86, 87).

23 / In collaboration with the Astronomical Institute of the Czech Academy of Sciences there were analyzed CCD photometry results obtained at the Skalnate Pleso Observatory. We determined the synodic rotational periods and the amplitudes from the composite lightcurves of seven asteroids from the inner main belt: (1314) Paul, (2257) Kaarina, (3541) Graham, (4080) Galinskij, (4155) Watanabe, (12081) 1998 FH115, and (15415) Rikas (Husárik, paper No. 59).

24/ High-dispersion spectrograms of the interacting close binary TX UMa taken around the primary minima were used to compute the rotational velocity of the mass gaining component. Due to direct impact of the gas flow from the loser component onto the surface of the gainer, the gainer rotates twice as fast as expected in the case of a synchronous rotation (Komžík, Chochol, paper No. 64).

25/ An analysis of high-precision photometry of the old open cluster M67 obtained by the Canadian satellite MOST is presented. The observations include eclipsing binaries, delta Scuti variables and so-called blue stragglers. Two new eclipsing binaries in the field of M67 were detected. Photometric elements of two close binaries, AH Cnc and ES Cnc, have been determined (Pribulla, paper No. 47).

26/ Spectroscopic and photometric observations of the tightest known quadruple system VW LMi were analysed. Spectra disentangling of all four components and available times of minima enabled to determine of absolute parameters of all components, to detect apsidal motion and to find that the orbit of the non-eclipsing pair and the outer orbit of the system are coplanar. VW LMi is a unique example of a tight multiple system (Pribulla, paper No. 45).

27/ Photometric and spectroscopic observations performed at the David Dunlap Observatory lead to the detection of the contact binary with the shortest orbital period (outside galactic clusters). GSC 1387 475 with period of only 0.2178 days supports existence of the short-period and temperature limit of the contact binary stars. The analysis of the binary is complicated by a variable third component contributing by about 1/3 to the total light (Pribulla, paper No. 48).

28/ Precise radial velocities of 10 close binaries EG Cep, V1191 Cyg, V1003 Her, BD+$7^o o$3142, V357 Peg, V407 Peg, V1123 Tau, V1128 Tau, HH UMa and PY Vir enabled us to determine spectroscopic elements and to detect two multiple systems (PY Vir and BD+$7^o o$3142) (Pribulla, paper No. 49).

29/ Spectroscopy of the close binary AW UMa, which serves as an early-type contact binary prototype with small mass ratios showed significant departures from the Roche model. The shapes of the rotational profiles indicates presence of the differential rotation or abnormal limb darkening and existence of a mass stream encompassing both components. It is possible that the components of AW UMa are detached but engulfud in a thin envelope filling the outer Roche lobe close to the orbital plane (Pribulla, paper No. 46).

30/ Apparent orbital period changes of TW And, TT Her and W UMi showing cyclic variations were studied using the Cracow minima database. The most probable interpretation is the presence of a late-type third component around all three systems (Pribulla, Tremko, paper No. 32).

31/ Analysis of a newly-discovered contact binary star GSC 00008 901 with orbital period of 0.28948 days in the field of DV Psc shows intermittent presence of photospheric spots on the surface of the components. The components are found to be in a weak thermal contact (Pribulla, Vaňko, Hambálek, paper No. 38).

32/ Preliminary results of the search for third components to close binary stars were summed. The data show that as many as 2/3 of close binaries are members of the multiple systems. The final results were presented in paper Pribulla, T., Rucinski, S.M., 2006, AJ, 131, 2986 (Pribulla, paper No. 72).

33/ New high-resolution electronic spectra with high S/N ratio allowed us to dissolve the spectrum of 53 Aur, a CP star with dubious classification. We found that it is a binary star with two different CP stars, one of them of the B9-Mn peculiarity and the second one of an F0-m type (Zverko, Žižňovský, paper No. 70).

34/ In a theoretic study we analysed the influence of the uneven distribution of different chemical elements on the stellar surface. We showed that mainly due to boud-free transitions the radiative flux is redistributed from the high frequences to the visual spectral region. Thus, the rotating star (what is a common feature of all stars) exhibit periodic light variability, which can be detected by means of photoelectric photometry (Zverko, Žižňovský, papers Nos. 65 and 97).

35/ Based on the study of the shapes of light-curves of the magnetic CP stars in our database and analysing them by the PCA method, we identified 4 main types of their ligh-curves. Their main components acquired by the PCA characterize the physical origin of the light variability in bright or dark photometric spots on the surface of CP stars (Zverko, Žižňovský, paper No. 67).

36/ It was shown, that the light curves changes of the UX Ori type young stars CQ Tau and V1184 Tau are caused by large deviations from axial symmetry in the distribution of circumstellar dust, as well as by large variations in the mass accretion rate in circumstellar disks. A large amount of dust may also appear in the vicinity of a young star owing to collisions of planetesimals (Shugarov, paper No. 21).

37/ It has been found that the geometry of projective lines over modular rings fully describes the commutation algebra of the generalized Pauli matrices living in irreducible Hilbert spaces. A fundamental difference has been shown to exist between Hilbert spaces whose dimension is a product of primes and those whose dimension contains a square of a prime (Saniga, paper No. 24).

38/ An in-depth graph-theoretical and algebraic geometrical analysis of multi-qubit systems has been carried out. The geometry of two-qubit systems and its substructures is that of the generalized quadrangle of order two and its geometric hyperplanes. The geometry of three- and higher-order-qubit systems is that of symplectic polar spaces of the corresponding rank (Saniga, paper No. 42).

39/ We have made a very detailed study of the generalized Pauli matrices of a qubit-qutrit system, where a link to the geometry of projective lines was made possible only after passing to a dual Pauli graph and introducing the concept of a multiline (Saniga, paper No. 41).

40/ The first ever study of the projective plane over the ring of Galois double numbers has been made. A remarkable complementarity principle has been found when reducing modulo one of the two principal ideals of the ring. A few interesting astrophysical applications of this principle have also been discussed (Saniga, paper No. 52).

41/ We have also studied the projective line over the ring that is a direct product of three smallest Galois fields. We have revealed a very intricate structure due to the existence of two

different kinds of zero-divisors of the ring (Saniga, paper No. 51).

42/ We have discovered a subgeometry within the projective line over the full two-by-two matrix ring with entries from the Galois field of order two that fully describes the geometry of the generalized Pauli group of two-qubits. The subgeometry in question is isomorphic to both the projective line over a particular Jordan system of the ring and the generalized quadrangle of order two (Saniga, paper No. 53).

43/ We have discovered a new type of finite projective geometry, dubbed the "Fano-Snowflake." This geometry consists of non-unimodular free cyclic submodules over the smallest ring of ternions and may lend itself to interesting applications in may areas of physics. We have also briefly discussed a Jacobson radical decomposition of this geometry (Saniga, papers Nos. 88 and 89).

44/ We have found a unique relation between the quantum entanglement of three-qubit systems and the entropy of E_7 symmetric stringy black holes. This relation is embodied in the geometry of the so-called split Cayley hexagon of order two, in which a special role is played by a subgeometry isomorphic to the Coxeter graph (Saniga, paper No. 34).

6 Grants/Projects

6.1 International grants

- 2008, OPTICON – Trans-national access programme project (6FP EU): Dynamic fibrils in the upper photosphere, chromosphere and above - principal investigator: A. Kučera
- 2008, OPTICON – Trans-national access programme project (6FP EU): Spectroscopy of the quiet solar photosphere: properties of the shocks and the acoustic flux generation - principal investigator: J. Rybák
- 2008, OPTICON – Trans-national access programme project (6FP EU): Physical mechanisms driving solar microflares and network dynamics fibrils - relevance for coronal heating and mass supply - principal investigator: J. Rybák
- 2007-2008, Project FP6-2007-MERG-CT-2007-046475 (6FP EU) – Solar network dynamics - principal investigator: A. Kučera
- 2007-2010, Project FP7-2007-MIRG-CT-2007-200297 (7FP EU) – Brown dwarfs and extrasolar planets - principal investigator: J. Zverko
- 2008-2011, FP7- INFRASTRUCTURES-2007-1, SP4-Capacities, Collaborative project - 212482 (7FP EU) – European solar telescope planets - principal investigator: A. Kučera
- 2004-2008, USA-SK NSF project Space weather: numerical MHD study of CMEs: inicialization and propagation - principal investigator: J. Rybák
- 2006-2009, Project DFG 436 SLK 13/70-1 - temporal evolution of the photosphere and chromosphere in a quiet and active regions (project No. DFG 436 SLK113/7/0-1) - principal investigators: J. Rybák
- 2008-2009, Project DAAD D/07/01266 (SAV 350/OMS/Fun/07) - Radiation pressure on nonspherical particles - principal investigator: M. Kocifaj
- 2007-2008, Project Slovakia-France (CNRS) – Projective and related geometries for quantum information - principal investigator: M. Saniga
- 2007-2009, Project CNR-SAV - Meteoroids and space debrids: an important component of the near-Earth space environment - principal investigator: V. Porubčan

- 2007-2009, collaborative inter-institute (Slovakia - Croatia) - Time evolution of active processes in the solar atmosphere - principal investigator: A. Kučera
- 2007-2009 Project CNR-SAV - Meteoroids and space debris: an important component of the near-Earth space environment - principal investigator: V. Porubčan
- 2009-2009 project Zentrum fuer interdisciplinaere Forschung, University Bielefeld (Germany) - Finite Projective Ring Geometries: An Intriguing Emerging Link Between Quantum Information Theory, Black-Hole Physics and Chemistry of Coupling - principal investigator at AISAS: M. Saniga
- 2008-2009, collaborative inter-government project (Slovakia - Czech republic) - Characteristics of interplanetary objects in the vicinity of the Earth - principal investigator at AISAS: J. Svoren
- 2008-2009, collaborative inter-government project (Slovakia - Czech republic) - Spectral energy distribution in chemically peculiar stars and its variability - principal investigator at AISAS: J. Ziznovsky

6.2 Bilateral projects

- 2007-2009 Project Time evolution of active processes in the solar atmosphere - principal investigator: A. Kučera
- 2008-2010 Project NAS-SAV - Physical processes in active binaries and chromospheric activity of stars with planets - principal investigator: D. Chochol
- 2006-2008, collaborative inter-institute project (Slovakia - Bulgaria) - Abundance anomalies in single and binary stars - principal investigator at AISAS: J. Ziznovsky

6.3 Other projects financed by foreing sources

- 2008, Action Austria-Slovakia: Project No. 58s2 (SAIA) – Finite geometries behind Hilbert spaces - principal investigator: M. Saniga
- 2008, Project SLA/1039115 - Symbiotic stars: on the nature of the RS Oph outburst - - principal investigator: A. Skopal
- 2008/2010 Project EU GRUNDTVIG – 84100468/p-PO - Aurora polaris (Partnership Opportunity for Learning: Astronomy Resources for Inspiring Seniors) - principal investigator: D. Chochol

6.4 Grants of the Slovak Grant Agencies VEGA and APVT

- 2008-2009 Project APVV SK-CZ-0011-07 - Characteristics of interplanetary objects in the close proximity of the Earth - - principal investigator: J. Svoreň
- 2008-2009 Project APVV SK-CZ-0019-07 - Light pollution in Slovakia and Czech republic - principal investigator: M. Kocifaj
- 2008-2009 Project APVV SK-CZ-0090-07 - Energy distribution in the spectra of chemically peculiar stars and its variability - - principal investigator: J. Žižňovský
- 2007-2009 - APVT-0066-06 – Heating of the solar corona: observational verification of the physical mechanisms - principal investigator: J. Rybák

- 2007-2009 - APVV-LPP-0068 – Astronomy – science for teachers and pupils - principal investigator: A. Kučera
- 2007-2009 - APVV-LPP-0146 – Meetings with Universe - principal investigator: V. Rušin
- 2006-2010 - APVV-LPP-0172 – Olympiad for astronomy for scholars - principal investigator: L. Hric
- 2006-2009 - Complexes of small bodies of the Solar System - principal investigator: M. Hajduková
- 2006-2009 - Dynamics of small bodies in cosmic space, physico-chemical properties of the bodies - principal investigator: M. Kocifaj
- 2006-2008 - Investigation of properties of chemically peculiar (CP) stars - principal investigator: J. Zverko
- 2006-2008 - Quantum theory of information for multiparticle systems - principal investigator at AISAS: M. Saniga
- 2006-2008 - Multispectral analysis and modeling of development of active and quiet solar atmosphere atmosphere - principal investigator: A. Kučera
- 2007-2009 - The structure and characteristics of meteoroid streams and their parent bodies - principal investigator: J. Svoreň
- 2007-2009 - Structural studies of interacting binaries and multiple systems - principal investigator: A. Skopal
- 2007-2009 - Activity as a consequence of physical processes connected with mass transfer and accretion of matter in selected interacting binaries - principal investigator: L. Hric
- 2007-2009 - Research of magnetic fields in the solar corona and their reply in heliosphere - principal investigator: M. Minarovjech
- 2007-2009 - Role of non-gravitational forces in evolution of orbits of asteroids and comets - principal investigator: E. Pittich
- 2007-2009 - Influence of interstellar molecular clouds on dynamics of bodies in the Oort cloud and Kuiper belt - principal investigator: L. Neslušan

6.5 Institute projects

- Physics of the solar atmosphere - principal investigator: A. Kučera
- Solar eclipses - principal investigator: V. Rušin XXXX
- Structure of meteor streams - principal investigator: V. Porubčan
- Cosmic dust - principal investigator: I. Kapišinský
- Dynamics of comets and asteroids and investigation of cometary dust - principal investigator: E. Pittich
- The astrometry of asteroids and the mutual interaction of interplanetary matter - principal investigator: L. Neslušan
- Photometry of comets and asteroids and cometary astrometry - principal investigator: J. Svoreň

- Study of variable phenomena of early spectral type stars and automatization of their observations - principal investigator: J. Žižňovský
- Chemically peculiar stars - principal investigator: J. Zverko
- Close binaries - principal investigator: D. Chochol
- Cataclismic variable stars - principal investigator: L. Hric
- Symbiotic stars - principal investigator: A. Skopal
- Solar protuberances and automatization of solar observations - principal investigator: M. Minarovjech
- Solar cycle and Solar-terrestrial relations - principal investigator: J. Sýkora
- Outer layers of the solar atmosphere - principal investigator: J. Rybák

7 List of publications

7.1 Books and book chapters published in Slovakia

1. PITTICH, Eduard M.: Astronomická ročenka 2009, Slovenská ústredná hvezdáreň, Hurbanovo, 2009, ISBN 978-80-85221-58-9. p. 1-200 (in Slovak).

2. RYBÁK, Ján, SVOREŇ, Ján: Celoslovenský astronomický seminár pre učiteľov – 2008, Zborník prednášok. Tatranská Lomnica: Astronomický ústav SAV, 2008, ISBN 978-80-970059-0-0. p. 1-80 (in Slovak).

7.2 Book chapters published in Slovakia

3. GÖMÖRY, Peter: Vývoj vesmíru a jeho budúcnosť. In: Rybák, J., Svoreň, J., Celoslovenský astronomický seminár pre učiteľov – 2008 Tatranská Lomnica, Astronomický ústav SAV, Tatranská Lomnica, 2008, ISBN 978-80-970059-0-0. p. 7–16 (in Slovak).

4. HRIC, Ladislav:: Galaxie. In: Rybák, J., Svoreň, J., Celoslovenský astronomický seminár pre učiteľov – 2008 Tatranská Lomnica, Astronomický ústav SAV, Tatranská Lomnica, 2008, ISBN 978-80-970059-0-0. p. 57–66 (in Slovak).

5. HRIC, Ladislav: Premenné hviezdy. In: Astronomická ročenka 2009, ed. E. Pittich, Slovenská ústredná hvezdáreň, Hurbanovo, 2008, ISBN 978-80-85221-58-9. p. 158-171 (in Slovak).

6. HUSÁRIK, Marek: Asteroidy. In: Rybák, J., Svoreň, J., Celoslovenský astronomický seminár pre učiteľov – 2008 Tatranská Lomnica, Astronomický ústav SAV, Tatranská Lomnica, 2008, ISBN 978-80-970059-0-0. p. 17–28 (in Slovak).

7. CHOCHOL, Drahomír: Medzinárodný rok astronómie 2009 na Slovensku. In: Rybák, J., Svoreň, J., Celoslovenský astronomický seminár pre učiteľov – 2008 Tatranská Lomnica, Astronomický ústav SAV, Tatranská Lomnica, 2008, ISBN 978-80-970059-0-0. p. 52–56 (in Slovak).

8. PITTICH, Eduard: Čas, obloha od januára do decembra. In: Astronomická ročenka 2009, ed. E. Pittich, Slovenská ústredná hvezdáreň, Hurbanovo, 2008, ISBN 978-80-85221-58-9. p. 3-89 (in Slovak).

9. PITTICH, Eduard: Galileiho mesiace. In: Astronomická ročenka 2009, ed. E. Pittich, Slovenská ústredná hvezdáreň, Hurbanovo, 2008, ISBN 978-80-85221-58-9. p. 132-145 (in Slovak).

10. PITTICH, Eduard: Kométy. In: Astronomická ročenka 2009, ed. E. Pittich, Slovenská ústredná hvezdáreň, Hurbanovo, 2008, ISBN 978-80-85221-58-9. p. 106-113. (in Slovak).

11. PITTICH, Eduard: Pohyb planét po oblohe, elongácie a jasnosti, Mesiac krátko po nove. In: Astronomická ročenka 2009, ed. E. Pittich, Slovenská ústredná hvezdáreň, Hurbanovo, 2008, ISBN 978-80-85221-56-5. p. 90–103 (in Slovak).

12. PORUBČAN, Vladimír: Meteorické roje. In: Astronomická ročenka 2009, ed. E. Pittich, Slovenská ústredná hvezdáreň, Hurbanovo, 2008, ISBN 978-80-85221-58-9. p. 104-105. (in Slovak).

13. RUŠIN, Vojtech: Slnečná koróna a zatmenia Slnka. In: Rybák, J., Svoreň, J., Celoslovenský astronomický seminár pre učiteľov – 2008 Tatranská Lomnica, Astronomický ústav SAV, Tatranská Lomnica, 2008, ISBN 978-80-970059-0-0. p. 67-77. (in Slovak).

14. SVOREŇ, Ján: Joviálne planéty Slnečnej sústavy. In: Rybák, J., Svoreň, J., Celoslovenský astronomický seminár pre učiteľov – 2008 Tatranská Lomnica, Astronomický ústav SAV, Tatranská Lomnica, 2008, ISBN 978-80-970059-0-0. p. 29-42. (in Slovak).

15. SVOREŇ, Ján: Planétky – satelity asteroidov. In: Astronomická ročenka 2009, ed. E. Pittich, Slovenská ústredná hvezdáreň, Hurbanovo, 2008, ISBN 978-80-85221-58-9. p. 114-131. (in Slovak).

7.3 Papers in journals indexed in Current Contents

16. BADALYAN, O. G. - OBRIDKO, V. N. - SÝKORA, Július: Quasi-biennial oscillations in the North-South asymmetry of solar activity. In: Solar Physics, 2008, vol. 247, p. 379-397.

17. BALTHASAR, H. - GÖMÖRY, Peter: The three-dimensional structure of sunspots. I. The height dependence of the magnetic field. In: Astronomy and Astrophysics, 2008, vol. 488, p. 1085-1092.

18. BURROWS, A. - BUDAJ, Ján - HUBENY, I.: Theoretical spectra and light curves of close-in extrasolar giant planets and comparison with data. In: The Astrophysical Journal, 2008, vol. 678, p. 1436-1457.

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20. GONZÁLES-RIESTRA, R. - VIOTTI, R. F. - IIJIMA, T. - ROSSI, C. - MONTAGNI, F. - BERNABEI, S. - FRASCA, A. - SKOPAL, Augustin: AG Draconis observed with XMM-Newton. In: Astronomy and Astrophysics, 2008, vol. 481, p. 725-734.

21. GRININ, V. P. - BARSUNOVA, O. Yu. - SHUGAROV, S. Yu. - KROLL, P. - SERGEEV, S. G.: Large-scale photometric activity of UX Ori type stars. In: Astrophysics, 2008, vol. 51, p. 1-6.

22. HAJDUKOVÁ, Mária Jr.: Meteors in the IAU meteor data center on hyperbolic orbits. In: Earth, Moon and Planets, 2008, vol. 102, p. 67-71.

23. HANSLMEIER, A. - KUČERA, Aleš - RYBÁK, Ján - WÖHL, H.: Observation of turbulence in solar surface convection: I. Line parameter correlations. In: Solar Physics, 2008, vol. 249, p. 293-306.

24. HAVLICEK, H. - SANIGA, Metod.: Projective ring line of an arbitrary single qudit. In: Journal of Physics A: Mathematical and Theoretical, 2008, vol. 41, art. No. 015302, 12 pp.

25. KLAČKA, J. - KOCIFAJ, Miroslav.: Times of inspiralling for interplanetary dust grains. In: Monthly Notices of the Royal Astronomical Society 2008, vol. 390, p. 1491-1495.

26. KOCIFAJ, Miroslav: Light pollution simulations for planar ground-based light sources. In: Applied Optics, 2008, vol. 47, no. 6, p. 792-798.

27. KOCIFAJ, Miroslav - KLAČKA, J.: Dynamics of dust grains with a vaporable icy mantle. In: Monthly Notices of the Royal Astronomical Society, 2008, vol. 391, p. 1771-1777.

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32. KREINER, J. M. - PRIBULLA, Theodor - TREMKO, Jozef - STACHOWSKI, G. S. - ZAKRZEWSKI, B.: Period analysis of three close binary systems: TW And, TT Her and W UMi. In: Monthly Notices of the Royal Astronomical Society, 2008, vol. 383, p. 1506-1512.

33. LETO, G. - JAKUBÍK, Marián - PAULECH, Tomáš - NESLUŠAN, Luboš - DYBCZYŃSKI, P. A.: The structure of the inner Oort cloud from the simulation of its formation for 2 Gyr. In: Monthly Notices of the Royal Astronomical Society, 2008, vol. 391, p. 1350-1358.

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36. MINAROVJECH, Milan - RUŠIN, Vojtech - SANIGA, Metod.: 27-day variations of solar indices and cosmic ray neutron monitor intensities. In: Astronomische Nachrichten, 2008, vol. 329, p. 20-25.

37. MINAROVJECH, Milan - RUŠIN, Vojtech - SANIGA, Metod.: Coronal mass ejections, magnetic fields, and the green corona in cycle 23. In: Solar Physics, 2008, vol. 248, p. 167-176.

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39. PASACHOFF, J. M. - RUŠIN, Vojtech - DRUCKMÜLLER, M. - DRUCKMÜLLEROVÁ, H. - BĚLÍK, M. - SANIGA, M. - MINAROVJECH, Milan - MARKOVÁ, E. - BABCOCK, B. A. - SOUZA, S. P. - LEVITT, J. S. Polar plume brightening during the 2006 March 29 total eclipse. In: The Astrophysical Journal, 2008, vol. 682, p. 638-643.

40. PITTICHOVÁ, Jana - WOODWARD, C. E. - KELLEY, M/ S. - REACH, W. T.: Ground-based optical and Spitzer infrared imaging observations of comet 21P/Giacobini-Zinner. In: The Astronomical Journal, 2008, vol. 136, p. 1127-1136.

41. PLANAT, M. - BABOIN, A.-C. - SANIGA, Metod.: Multi-line geometry of qubit-qutrit and higher-order Pauli operators. In: International Journal of Theoretical Physics, 2008, vol. 47, p. 1127-1135.

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- DURKEE, R. - MASI, G. - KOFF, R. A. - GONCALVES, R.: Spin rate distribution of small asteroids. In: Icarus, 2008, vol. 197, p. 497-504.

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47. PRIBULLA, Theodor - RUCINSKI, S. - MATTHEWS, J. M. - KALLINGER, T. - KUSCHING, R. - ROWE, J. F. - GUENTHER, D. B. - MOFFAT, A. F. J. - SASSELOV, D. - WALKER, G. A. H. - WEISS, W. W.: MOST satellite photometry of stars in the M67 field: eclipsing binaries, blue stragglers and delta Scuti variables. In: Monthly Notices of the Royal Astronomical Society, 2008, vol. 391, p. 343-353.

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