Scientific report on the activities of the Associated European Laboratory « Astronomy Poland-France »

2004-2007

Introduction

The convention of the Associated European Laboratory "Astrophysics Poland-France" (LEA Astro-PF) was signed in May 2005, by the President of the Centre National de la Recherche Scientifique, the President of the Polish Academy of Sciences and the President of the Astronomical Astronomy of Paris. However, it started working and receiving funds since January 2004. This report presents the achievement of the LEA Astro-PF during the period January 2004 – September 2007.

The aim of the LEA Astro-PF is to develop the collaboration in Astrophysics between France and Poland. This collaboration in Astrophysics started more than 25 years ago, and developped considerably in the 1990'ties, thanks to the PICs Astronomie Pologne (1993-1995) then to the Jumelage Astronomie France-Pologne (1996-1999) and (2000-2003). The LEA Astro-PF is a follow-up of those structures. The working language of the LEA is English, and this is the reason why this report is written in English.

The LEA Astro-PF is composed of: the Laboratory Universe and Theories (LUTH) of the Paris Observatory, the Paris Institute of Astrophysics (IAP) and of the Nicolaus Copernicus Astronomical Centre (CAMK). Other teams may participate as well. The LEA Astro-PF is based in the LUTH (Paris Observatory). The internet site http://astropf.camk.edu.pl/ is maintained in Poland.

The scientific topics of the LEA include: galaxies and cosmology, high energy astrophysics, stellar structure, advanced stages of stellar evolution and interstellar medium, dense matter, compact stars and gravitational radiation, heliosphere and astrospheres, and extrasolar planets. Some of the collaborations are old, and still fruitful. Others, like those dealing with high energy astrophysics, are more recent and still expanding. Some are new, like the collaboration on exoplanets.

The essential activity of LEA Astro-PF is to support collaborations between French and Polish researchers, by funding short-term visits (typically 2-3 weeks). Participants of the French and Polish sides of the LEA meet twice per year (usually in France but occasionally in Poland) to examine the requests for visits.

As compared with the previous structures for collaboration between French and Polish astronomers, the LEA Astro-PF has developed additional activities aimed at reinforcing the exchange of scientific information and promoting the work done in collaboration.

Two or three short seminars are given by the participants during each of the bi-annual meetings.

Every year the LEA Astro-PF organizes a specialized workshop in Poland, on one of the hot topics of the collaboration. The participants to the workshop come from various institutions in France and in Poland and several collaborators from other countries are present as well.

The LEA Astro-PF also participates in the sponsorship of international conferences held in Poland and coorganized by both sides of the collaboration.

The scientific production of the LEA Astro-PF is quite large. Since 2004, over 134 joint publications have appeared, with about half of them in main international astronomical journals. Such an important overall scientific production, which leaves no doubt on the scientific achievements of the LEA, allows us to also support a few visits that will not necessarily lead to a

short term publication, but that are important in terms of common scientific reflection or of planning of future events.

Many PhD students have benefited from exchanges funded by the LEA Astro-PF. In some cases, it was possible to arrange longer stays for French or Polish post-docs and graduate students in the partner country. Several students issued from the collaboration have then managed to obtain a Marie-Curie Fellowship or a post-doc position in renowned foreign research centers.

The activities of the LEA Astro-PF foster new directions to be explored in common. For example, the workshop on gamma-ray bursts was the starting point of several new collaborations. The recent school "From the land of salt to the heavens of SALT" was motivated by the access of Poland to the largest southern hemisphere telescope SALT and proposed to Polish students a series of lectures on extragalactic astronomy by renowned scientists from over the world. A few days after the end of the school, several propositions of collaborations between Polish and French astronomers have already emerged.

The LEA also has an important social dimension, contributing to exchange of views and understanding between two different European cultures.

These aspects have been developed in a 23min movie by Krzysztof Kownas "Astrophysics without frontiers" devoted to the LEA Astro-PF. This movie, containing interviews of a dozen of participants of the LEA Astro-PF on both sides, was broadcasted on the Polish TV channel Polsat on the evening of 31 december 2006, and then in may 2007, on prime time.

The collaboration within the LEA Astro-PF has been made possible through the funding by both research agencies, the CNRS and the PAN, in the same proportions. It was our aim that the exchanges of reaserchers would occur in both directions in similar amount. We did not fully achieve this goal, but the situation has significantly improved, compared to what it was previously, thanks to the organization of Astro-PF workshops in Poland. Many French researchers have now made the trip to Poland, and have been very pleased by the way they have been welcomed and treated during their stay there. There is an increasing demand of French astronomers to visit their colleagues in Poland, sometimes even for long stays. On the reverse side, the situation is getting preoccupying. French institutions do not always have lodging facilities that make stays in a foreign country pleasant, efficient and cheap. Moreover, the new rules of the CNRS for the reimbursement of expenses of foreign visitors in France complicate enormously the management of the LEA and the life of the Polish astronomers. Above all, they completely ignore the fact that the economical conditions are not equivalent in both countries, and that the new rules imposed by the CNRS severely penalise the Polish reaserchers. As a matter of fact, if these rules are maintained, it is to be feared that this long-lived collaboration will come to an end.

The present report gives an overview of the main achievements within the LEA Astro-PF between 2004 and 2007, a short description of the workshops and conferences organized in common, a list of joint publications, and a financial report.

The scientific reports were sent by the various groups participating in the LEA Astro-PF, and are presented here without re-editing. In a few cases, the reports slightly overlap, but it was decided to leave them as they are, because each of them emphasizes a different aspect.

Grazyna Stasinska and Pawel Haensel
Coordinators of the LEA Astro-PF
September 2007

A Galaxies and Cosmology

* Title of collaboration:
Stationary axisymmetric solutions to the Einstein equations

* Polish participants:
Sebastian Szybka
Obserwatorium Astronomiczne Uniwersytetu Jagiellonskiego

* French participants:
Piotr Chrusciel
Laboratoire de Mathematiques et de Physique Theorique
Federation Denis Poisson
Faculte des Sciences
Parc de Grandmont
F37200 Tours, France

* Abstract of achievements and plans for the future:

A standard procedure for constructing stationary axisymmetric solutions of the Einstein equations proceeds by a reduction of to a 1+1 nonlinear equation for the Ernst potential. Solutions of the resulting equation can be obtained by solving a boundary value problem. Then, the space-time metric is obtained by solving ODEs for the metric functions. However, these ODEs are singular at the zero-level-set of the real part of the complex potential, which in vacuum corresponds to the ergosurfaces in space-time. It was shown by us some time ago that solutions of the Ernst equation lead to smooth ergosurfaces if and only if the Ernst potential does not have zeros of infinite order at the zero-level sets.

The first goal of our collaboration was to extend this analysis to the electro-vacuum spacetimes constructed out of solutions (E,phi) of the Ernst-Maxwell equations. We have been able to prove regularity results under restrictive conditions, and construct examples which indicate (but do not prove) that the regularity, which holds in vacuum, does not hold in electro-vacuum. More precisely, the analysis depends on which of the potentials, E or phi, contribute leading terms to the function f=-(Re(E) + |phi|^2) at the zero level set. We have proved smoothness of those zero-level-sets at which the real part of the Ernst potential Re(E) provides the dominant contribution to the function f=-(Re(E) + |phi|^2). In the remaining cases, we constructed examples of leading-order solutions with singular isolated ``ergocircles". However, it is not known which ``solutions at leading order", as constructed using Taylor series expansions, do arise from real solutions of the Ernst-Maxwell equations which are smooth across the zero-level set of f. This is the most important open question for further analysis.

The second goal of our collaboration was an attempt to address the question of existence, or lack thereof, of stationary double Kerr solutions with all singularities hidden under an event horizon. We have started investigating this problem in the double Kerr configurations with one extreme

object. In order to solve balance and regularity equations for such system heavy algebraic calculations are necessary. We have implemented numerical codes but this part of our collaboration is still in progress.

Our results on the electro-vacuum Ernst equation have been submitted for publication (see the arXiv reference below).

* Joint papers:

Chruściel P.~T., Szybka S.~J., 2007, arXiv, 708, arXiv:0708.1169, On the Ernst electro-vacuum equations and ergosurfaces

* Title of collaboration: **Black rings and black holes on branes**

* Polish participants: (first name, family name, institution of each member)
Marek Rogatko (Institute of Physics, Maria Curie-Sklodowska University)

* French participants: (first name, family name, institution of each member)
David Langlois (APC, UMR 7164 CNRS, Universite Paris 7, CEA, Observatoire de Paris)

* Abstract of achievements and plans for the future:

Contemporary unification theories such as superstrings or M-theory require 10 or 11 dimensional spacetime. The idea of multidimensional spacetime attracts our attention to n-dimensional geometry and multidimensional objects. Our Universe may be a brane or a defect emerged in some higher dimensional geometry. The first part of the project will be devoted to the behaviour of black holes on branes and the possibility of expulsion of the brane from their interior (the so-called Meissner effect). It will be interesting for what kind of the black holes this effect takes place and perhaps this effect will depend on the dimension of the spacetime. This effect can give us the answer about the dimension of the Universe. We plan also to study the late-time behaviour of the massive scalar and Dirac spinor fields in the spacetime of brane black holes and black rings. The studies of black holes topological defect system is also important from the point of view of uniqueness theorem for n-dimensional black holes. Namely, it is possible to treat n-dimensional topological defect as 'hair' on the black hole. The second part of the project will be connected with the topological structure of n-dimensional black holes, i.e., the possibility of existence of the black rings. We plan to study thermodynamics laws for these objects and to describe the dynamical evolution of them by means of the so-called 'dynamical horizons'. The results of investigations will help us to better understand the phenomenological features of n-dimensional black holes and the geometry of additional dimensions.

We started the collaboration on 6/11-15/11/07

* Title of collaboration: **Large-scale dynamics in the Universe**

* Polish participants:
Michal Chodorowski (Copernicus Astronomical Center)

* French participants:
Stephane Colombi (Institut d'Astrophysique de Paris)
Guilhem Lavaux (Institut d'Astrophysique de Paris)

* Abstract of achievements and plans for the future:

Analyses of the large-scale dynamics in the Universe can provide estimates of the fundamental cosmological parameters. In particular, comparing the large-scale distribution of galaxies to their peculiar velocities (deviations from the Hubble flow) enables one to constrain the parameter Omega, i.e. the mean density of the non-relativistic matter in the Universe. This is possible because the peculiar velocity field is induced gravitationally, so it is tightly coupled to the matter distribution. In the linear regime, the peculiar velocity of a galaxy is proportional to its gravitational acceleration, and the coefficient of proportionality is equal to Omega^{0.6}.

1) Cosmic velocity-gravity relation in redshift space:

One of major problems with such velocity-gravity comparisons is that in 3-D galaxy surveys, the third coordinate of a galaxy is not its distance but redshift. Since galaxies have peculiar velocities, redshift is a biased estimator of distance. All standard methods to deal with this problem have serious shortcomings.

In Paper 1. (cf. the list of publications) we invented a novel method, based on an analysis of the velocity-gravity relation directly in redshift space. Therefore, there is no need of (problematic) reconstruction of the density field in real space. We derived the relation in the linear regime and tested it successfully using controlled numerical experiments based on a cosmological N-body simulation (with N = 10^7 particles!).

We also discussed to some extent future applications of the method to galaxy catalogs, including a preliminary investigation on homogeneous `galaxy' samples (extracted from the simulation with simple prescriptions based on halo and sub-structure identification), to quantify the effects of the bias between the galaxy distribution and the total matter distribution.

While Paper 1. dealt only partly with observational effects, we aim now to conduct actual measurements in real galaxy catalogs, in collaboration with a graduate student, Guilhem Lavaux, and prof. Brent Tully from the University of Hawaii (USA).
During the past year, we have produced realistic mock catalogs with observational features (incompleteness, zone of avoidance, outer edge effects, cosmic variance, error in distance measurements, mass-to-light assignment) to check the robustness of the algorithm of comparison in extreme conditions. So far, the velocity-gravity relation is holding quite well provided the M/L relation for galaxies and/or clusters is known sufficiently well to prevent any bias. We have now begun testing the relation on real data, provided by prof. Brent Tully, with some positive preliminary results.

Our measurement of the cosmological parameter Omega, based on the velocity-gravity relation in redshift space, will provide an important alternative to estimates obtained from the anisotropy of the cosmic microwave background (CMB).

2) Motion of the Local Group:

Peculiar velocities of galaxies and groups of galaxies are generally determined by measuring their distances independently of redshifts. However, the motion of the Local Group of galaxies (LG) can be inferred alternatively: from the observed dipole anisotropy of the CMB. This anisotropy is interpreted as a direct measure, via the Doppler shift, of the motion of the LG relative to the CMB rest frame. The LG velocity inferred in such a way is much more accurate than estimates of peculiar velocities based on redshift-independent distances. Therefore, analysis of the LG motion remains an interesting alternative to current velocity-gravity comparisons, performed simultaneously for many galaxies, but with larger velocity errors.

To date, the best estimate of the gravitational acceleration acting on the LG can be obtained by measuring the flux dipole of the 2 Micron All Sky Survey (2MASS). For this estimate to be optimal, it is necessary to optimize the survey window through which the flux dipole is measured. In Paper 2, together with Jean-Baptiste Coiffard and Pawel Ciecielag, we explicitly constructed such a window for the 2MASS survey. The optimization in essence reduces to excluding from the calculation of the flux dipole galaxies brighter than the limiting magnitude K_min = 5 of the near-infrared K_s band. The misalignment angle between the LG velocity and gravity is a sensitive measure of their correlation: the higher the correlation, the smaller the expectation value of the angle. When our window is employed, the observed misalignment angle is expected to decrease with 90% confidence.

With a graduate student, Maciej Bilicki, we are going to estimate the LG gravity from the 2MASS survey, employing our optimal window. In the next step, we are planning to compare the LG gravity to its velocity and in such a way to constrain the cosmological parameter Omega. Again, our constraint will be an important alternative to estimates obtained from the anisotropy of the CMB.

* Joint papers: name of authors, journal reference, (or arxiv number if not yet published), year, title

1. Colombi S., Chodorowski M.~J., Teyssier R., 2007, MNRAS, 375, 348, Cosmic velocity-gravity relation in redshift space (23 MNRAS pages!)

2. Chodorowski M., Coiffard J.-B., Ciecielag P., Colombi S., 2007, arXiv, 706, arXiv:0706.0619, The optimal window for the 2MASS dipole

* Title of collaboration: **Kinematical modelling of spherical systems: dwarf spheroidal and elliptical galaxies and galaxy clusters**

* Polish participants: (first name, family name, institution of each member)
Ewa ŁOKAS, Radoslaw WOJTAK, Jaroslaw KLIMENTOWSKI (CAMK, Warsaw)

* French participants: (first name, family name, institution of each member)
Gary MAMON (IAP, Paris)

* Abstract of achievements and plans for the future:

Ewa Łokas and Gary Mamon have been pursuing a fruitful collaboration (begun in 2000) on the kinematical modelling of clusters of galaxies and of dwarf spheroidal galaxies as well as elliptical galaxies.

In 2003, they had developed a new method to estimate the mass, concentration and orbital anisotropy of these systems, based upon the first attempt to obtain joint constraints of the velocity dispersion and kurtosis profiles of a galaxy cluster (Łokas & Mamon 03). With doctoral student Teresa Sanchis (Barcelona), they tested their method on the halos of cosmological simulations and showed that the method had little bias and was efficient (Sanchis et al. 04). They later applied it to dwarf spheroidal galaxies, obtaining more realistic parameters than previously found (Lokas, Mamon & Prada 05), and to 6 clusters of galaxies (Lokas et al. 06).

Doctoral student Radoslaw Wojtak (supervised by E. Łokas) has been studying the halos in cosmological simulations. The velocity distributions were shown to be non-gaussian (Wojtak et al. 05). A full analysis of the distribution function is in preparation (Wojtak et al. 08). Using again cosmological simulations, and folding in the Hubble expansion, Wojtak also checked how the treatment of the removal of interlopers could be optimized (Wojtak et al. 07).

Doctoral student Jaroslaw Klimentowski (supervised by E. Łokas) analyzed a simulation of a dwarf galaxy repeatedly subjected to the tidal force of the Milky Way. In the end, the galaxy resembles a dwarf spheroidal galaxy, and he showed how the mass and other parameters found with the dispersion-kurtosis method (see above) are biased if the dwarf spheroidal is viewed with its tidal tails along the line of sight (Klimentowski et al. 07).

Mamon and Łokas also studied the dark matter contents of elliptical galaxies. They showed that ellipticals could not be dominated by dark matter in their inner regions (otherwise the velocity dispersion is much lower than observed) (Mamon & Łokas 2005a). They then showed that considering isotropic NFW models could lead to an underestimation of the mass within the virial radius by over a factor two (Mamon & Łokas 05b). Mamon & Łokas were able to express in the form of single integrals: the aperture velocity dispersion of an isotropic system (Mamon & Łokas 05a,06a) as well as the line of sight velocity dispersion of various anisotropic systems (Mamon & Łokas 05b,06b).

* Joint papers: name of authors, journal reference, (or arxiv number if not yet published), year, title

Sanchis T., Łokas E.~L., Mamon G.~A., 2004, MNRAS, 347, 1198, The reliability of the kinematical evidence for dark matter: the effects of non-sphericity, substructure and streaming motions

Wojtak R., Łokas E.~L., Gottlöber S., Mamon G.~A., 2005, MNRAS, 361, L1, Radial velocity moments of dark matter haloes

Mamon G.~A., Łokas E.~L., 2005, MNRAS, 362, 95, Dark matter in elliptical galaxies - I. Is the total mass density profile of the NFW form or even steeper?

Mamon G.~A., Łokas E.~L., 2005, MNRAS, 363, 705, Dark matter in elliptical galaxies - II. Estimating the mass within the virial radius

Łokas E.~L., Mamon G.~A., Prada F., 2005, MNRAS, 363, 918, Dark matter distribution in the Draco dwarf from velocity moments

Łokas E.~L., Wojtak R., Gottl{\"o}ber S., Mamon G.~A., Prada F., 2006, MNRAS, 367, 1463, Mass distribution in nearby Abell clusters

Mamon G.~A., Łokas E.~L., 2006, MNRAS, 370, 1581, Erratum: Dark matter in elliptical galaxies - I. Is the total mass density profile of the NFW form or even steeper?

Mamon G.~A., Łokas E.~L., 2006, MNRAS, 370, 1582, Addendum: Dark matter in elliptical galaxies - II. Estimating the mass within the virial radius

Wojtak R., Łokas E.~L., Mamon G.~A., Gottl{\"o}ber S., Prada F., Moles M., 2007, A&A, 466, 437, Interloper treatment in dynamical modelling of galaxy clusters

Klimentowski J., Łokas E.~L., Kazantzidis S., Prada F., Mayer L., Mamon G.~A., 2007, MNRAS, 378, 353, Mass modelling of dwarf spheroidal galaxies: the effect of unbound stars from tidal tails and the Milky Way

* Title of collaboration:
Investigation of the correlated timing and spectral variability of neutron star low mass X-ray binaries as observed with RXTE

* Polish participants: (first name, family name, institution of each member)
Marek Gierlinski, (Uniwersytet Jagielloński, Obserwatorium Astronomiczne, Kraków)

* French participants: (first name, family name, institution of each member)
Didier Barret (Centre d'Etude Spatiale des Rayonnements, CESR) & Olive Jean-François (CESR)

* Abstract of achievements and plans for the future:

We followed the timing properties of the neutron star low-mass X-ray binary system 4U 1705-44 in different spectral states, as monitored by the Rossi X-Ray Timing Explorer over about a month. We fitted the power density spectra using multiple Lorentzians. We showed that the characteristic frequencies of these Lorentzians, when properly identified, fit within the correlations previously reported. The time evolution of these frequencies and their relation with the parameters of the energy spectra reported in Barret & Olive are used to constrain the accretion geometry changes. The spectral data were fitted by the sum of a blackbody and a Comptonized component and were interpreted in the framework of a truncated accretion disk geometry, with a varying truncation radius. If one assumes that the characteristic frequencies of the Lorentzians are some measure of this truncation radius, as in most theoretical models, then the timing data presented here strengthen the above interpretation. The soft-to-hard and hard-to-soft transitions are clearly associated with the disk receding from and approaching the neutron star, respectively. During the transitions,

correlations were found between the Lorentzian frequencies and the flux and temperature of the blackbody, which is thus likely to be coming from the disk. On the other hand, in the hard state, the characteristic Lorentzians frequencies that are the lowest remained nearly constant despite significant evolution of the spectra parameters. The disk no longer contributes to the X-ray emission, and the blackbody is now likely to be emitted by the neutron star surface that is providing the seed photons for the Comptonization.

* Joint papers: name of authors, journal reference, (or arxiv number if not yet published), year, title

Olive, Jean-François; Barret, Didier; Gierliński, Marek, 2004, ApJ, Volume 583, Issue 1, pp. 416-423

* Title of collaboration: **Regular and chaotic motions in double bars**

* Polish participants: W. Maciejewski, OAUJ

* French participants: E. Athanassoula & A. Bosma, Observatoire de Marseille

* Abstract of achievements and plans for the future:
We used LEA Astro-PF funds to cover one 21-day visit of WM at Marseille in April/May 2004. During this stay we developed a method that estimates the fraction of phase-space occupied by regular motions in a potential of nested bars. It is a part of a larger project, now continued between the United Kingdom and France, after WM left Poland in September 2004. Within this project, we showed that the backbone of double bars is constituted by double-frequency orbits. These orbits represent oscillatory motion with two frequencies of driving by the two bars, and lack free oscillations. They are an equivalent of closed periodic orbits in a single bar, but they do not close in any reference frame. They map onto loops, first introduced by Maciejewski & Sparke. Trajectories trapped around the parent double-frequency orbit map onto a set of points confined within a ring surrounding the loop. Loops trap around themselves regular orbits to the same extent as stable closed periodic orbits in the single bar do. By analyzing maps of trajectories in double bars, we determined the fraction of the phase-space occupied by ordered motions in various potentials of double bars, and we select models of double bars that are most plausible dynamically. Currently we are working on the analysis of frequencies present in orbital motion in double bars, which will unveil the presence of resonances, and single out chaotic zones.

* Joint papers:

Maciejewski W., Athanassoula E., 2007, arXiv, 705, arXiv:0705.2005, Regular motions in double bars. I. Double-frequency orbits and loops % note: will be published in MNRAS Sept 2007 issue

Maciejewski W., Athanassoula E., 2007, MNRAS submitted, Regular motions in double bars. II. Phase-space survey

* Title of collaboration: **Nuclear kinematics of the doubly-barred spiral galaxy NGC 4303**

* Polish participants: W. Maciejewski, OAUJ

* French participants: Eric Emsellem, Observatoire de Lyon

* Abstract of achievements and plans for the future:
We used LEA Astro-PF funds to cover one 10-day visit of WM in Lyon in September 2004. During this stay we confronted the emission-line spectra (H-alpha and NII gas emission) of the central 1 kpc of a spiral galaxy NGC 4303, coming from the STIS long-slit spectrograph on the HST, and from the OASIS integral field unit. The combination of high resolution of STIS, and full spatial coverage of OASIS provided a leverage in the interpretation of gas kinematics in this nuclear region. This project was put on hold after WM resigned from his academic post in Poland.

* Joint papers:
the publication is still in a preparatory stage

* Title of collaboration:
Modelling of galaxy-galaxy and galaxy-ICM interactions in Virgo Cluster.

* Polish participants: (first name, family name, institution of each member)
Katarzyna, Otmianowska-Mazur, Astronomical Observatory of the Jagiellonian University
Marian, Soida, Astronomical Observatory of the Jagiellonian University

* French participants: (first name, family name, institution of each member)
Bernd, Vollmer, CDS, Observatoire Astronomique de Strasbourg

* Abstract of achievements and plans for the future:

We developed a set of tools for the modelling of galaxy-galaxy and galaxy-intracluster medium interactions in the Virgo Cluster. Based on kinematical data, taken from spectroscopic observations, we are able (i) to model the evolution of a particular cluster galaxy and (ii) to suggest its current stage in the evolution sequence. The dynamical model is taken as input for subsequent MHD simulations of the magnetic field evolution within the galactic disk. Assuming a cosmic-ray electron distribution, model maps of polarized radio continumm emission are calculated. These results are directly compared to our VLA polarized radio-continuum observations. This step represents an additional test for the reliability of our initial model based on spectroscopic observations only. Our models alow us to study the mechanisms responsible for the interactions in cluster environment, the history of the particular galaxy, and in consequence, its current tree-dimensional position and velocity within the cluster.

Using our tools we were able to model successfully the interaction of several galaxies in the Virgo Cluster, particularly NGC 4522, NGC 4654 (published already) and NGC 4501 (submitted to A&A). We performed a set of radio-continuum observations of eight Virgo Cluster members using the VLA. The main results of those observations are published. Using our modeling abilities we

plan to reconstruct the evolution of all Virgo spiral galaxies, which are large enough and bright enough in the radio continuum to be observed by existing radio telescopes. We are currently performing calculations for 3 more already observed Virgo spiral galaxies, and we are preparing a new VLA proposal to observe 20 more Virgo spiral galaxies in polarized radio continuum emission.

* Joint papers: name of authors, journal reference, (or arxiv number if not yet published), year, title

Vollmer B., Soida M., Beck R., Urbanik M., Chyży K.~T., Otmianowska-Mazur K., Kenney J.~D.~P., van Gorkom J.~H., 2007, A&A, 464, L37, The characteristic polarized radio continuum distribution of cluster spiral galaxies

Soida M., Otmianowska-Mazur K., Chyży K., Vollmer B., 2006, A&A, 458, 727, NGC 4654: polarized radio continuum emission as a diagnostic tool for a galaxy-cluster interaction. Models versus observations

Vollmer B., Soida M., Otmianowska-Mazur K., Kenney J.~D.~P., van Gorkom J.~H., Beck R., 2006, A&A, 453, 883, A dynamical model for the heavily ram pressure stripped Virgo spiral galaxy NGC 4522

Soida M., Otmianowska-Mazur K., Chyży K.~T., Vollmer B., 2006, AN, 327, 503, Magnetic field evolution in the perturbed Virgo spiral NGC 4654 - MHD 3D modeling

Vollmer B., Soida M., van Gorkom J.~H., Otmianowska-Mazur K., Beck, R., Urbanik, M., Kenney J.~D.~P., 2007, A&A (submitted), Pre-peak ram pressure stripping in the Virgo cluster spiral galaxy NGC4501

B High Energy Astrophysics

* Title of collaboration:
Systematic study of the coherence of kilo-Hz QPOs detected with RXTE

* Polish participants: (first name, family name, institution of each member)
Wlodek Kluzniak, (Copernicus Astronomical Centre, Warszawa, Poland & Zielona Góra University, Lubuska 2, 65-265 Zielona Góra, Poland)

* French participants: (first name, family name, institution of each member)
Didier Barret (Centre d'Etude Spatiale des Rayonnements, CESR) & Olive Jean-François (CESR)

* Abstract of achievements and plans for the future:
We have carried out a systematic study of the properties of the kHz quasi-periodic oscillations (QPOs) observed in the X-ray emission of the neutron star low-mass X-ray binary 4U 1608-52, using archival data obtained with the Rossi X-ray Timing Explorer. We have investigated the quality factor, Q, of the oscillations (defined as the ratio, $\nu/\Delta\nu$, of the frequency ν of the QPO peak to its full width at half-maximum $\Delta\nu$). In order to minimize the effect of long-term frequency drifts, power spectra were computed over the shortest times permitted by the data statistics. We show that the high Q of ~200 reported previously for the lower-frequency kHz QPO is by no means exceptional, as we observe a mean Q value in excess of 150 in 14 out of the 21 observations analysed and Q can remain above 200 for thousands of seconds. The frequency of the QPO varies over the wide range 560-890 Hz and we find a systematic trend for the coherence time of the QPO, estimated as $\tau=Q/(\pi\nu) = 1/(\pi\Delta\nu)$, to increase with ν, up to a maximum level at ~800 Hz, beyond which it appears to decrease, at frequencies where the QPO weakens. There is a more complex relationship between τ and the QPO rms amplitude, in which positive and negative correlations can be found. A higher-frequency QPO, revealed by correcting for the frequency drift of the 560-890 Hz one, has a much lower Q (~10) which does not follow the same pattern. We discuss these results in the framework of competing QPO models and we show that those involving clumps orbiting within or above the accretion disc are ruled out.

* Joint papers: name of authors, journal reference, (or arxiv number if not yet published), year, title
Barret, D.; Kluźniak, W.; Olive, J. F.; Paltani, S.; Skinner, G. K., 2005, MNRAS, Volume 357, Issue 4, pp. 1288-1294

* Title of collaboration:
The INTEGRAL observations of off-axis GRBs

* Polish participants: (first name, family name, institution of each member)
Miroslaw Denis (CBK)
Radoslaw Marcinkowski (IPJ, Swierk)
Tomasz Bulik (OA UW)

* French participants: (first name, family name, institution of each member)
Paolo Goldoni (APC)
Philippe Laurent (CEA, Saclay)

* Abstract of achievements and plans for the future:
Apart from afew gamma ray bursts in the field of view INTEGRAL detects many more GRBs with SPI ACS in the entire sky. Several of these bursts are also registered by the IBIS telescope (ISGRI, PISCIT and the Compton mode). We have developed a set of routines that allow to localize and analyze spectra of such bursts. These routines have been tested and applied to several bursts. We have written a succesful proposal for INTEGRAL observations of the off-axis GRBs. We are now preparing the first complete catalogue of the off axis GRBs with the inormation on localization, flux, duration and spectra.

* Joint papers: name of authors, journal reference, (or arxiv number
if not yet published), year, title

Bulik T., Denis M., Marcinkowski R., Goldoni P., Laurent P., Osuch Ł., 2007, AIPC, 921, 277, GRB spectra in the MeV range: hints from INTEGRAL

Marcinkowski R., Denis M., Bulik T., Goldoni P., Laurent P., Rau A., 2006, A&A, 452, 113, GRB 030406 - an extremely hard burst outside of the INTEGRAL field of view

Denis M., Marcinkowski R., Bulik T., Goldoni P., Laurent P., 2006, GCN, 5908, 1, GRB 061126: a GRB detected off-axis by INTEGRAL.

Marcinkowski R., Denis M., Bulik T., Laurent P., Goldoni P., Rau A., 2005, AIPC, 801, 133, Localization {\amp} spectra of the Integral Compton mode gamma-ray bursts

Marcinkowski R., Denis M., Bulik T., Laurent P., Goldoni P., Rau A., 2005, AIPC, 801, 131, First catalogue of the INTEGRAL off-axis gamma-ray bursts

Marcinkowski R., Laurent P., Denis M., Goldoni P., Bulik T., Rau A., 2005, NCimC, 28, 845, Gamma-ray burst detection and localization capabilities of the IBIS/INTEGRAL telescope Compton mode

Denis M., Marcinkowski R., Bulik R., Laurent P., Goldoni P., Santangelo A., 2004, ESASP, 552, 453, INTEGRAL Observations of the Accreting Pulsar OAO 1657- 415

Denis M., Grygorczuk J., Bulik R., Laurent P., Goldoni P., Santangelo A.,
2004, ESASP, 552, 295, INTEGRAL Observations of the Accreting Pulsar 4U 1626-67

* Title of collaboration:

High energy astrophysics: relativistic jets

* Polish participants:
Marek Sikora, N. Copernicus Astronomical Center, Warsaw, Poland

* French participants:
Jean-Pierre Lasota, IAP, Paris
Helene Sol, LUTH, Observatoire de Paris, Meudon

* Abstract of achievements:
X-ray and gamma-ray observations of blazars, combined with our best guesses regarding the central environments in quasars, allowed us to estimate the leptonic and total energy fluxes. The former is found to be too small to power the observed gamma-ray flares or to support the energetics of the radio lobes. Therefore, the energy flux in blazar jets must be dominated by protons or magnetic fields, but with the number of electron-positron pairs greatly exceeding the number of protons. We showed also that the lack of soft X-ray excesses in blazar spectra and kinematical data from all spatial scales indicate that jets are accelerated at least over three distance decades and that the acceleration process is completed prior to the blazar zone. We argued that this supports the scenario where the jet is initially dominated by the magnetic fields and and then, near the blazar zone, is converted to the matter dominated one.

We plan to conduct the research on astrophysical jets. In particular, we are going to investigate whether observed radio-dichotomy of active galactic nuclei is related to the black hole spin.

Joint papers:
Sikora, M., Begelman, M.C., Madejski, G.M., Lasota, J.-P., 2005, ApJ, 625, 72

* Title of collaboration:
Stationary axisymmetric solutions to the Einstein equations

* Polish participants:
A. A. Zdziarski, P. Lubinski (CAMK)
Sebastian Szybka

* French participants
P. O. Petrucci, J. Malzac, G. Dubus (Observatoire de Grenoble)

* Abstract of achievements and prospects:

Data analysis and theoretical interpretation of observations of Seyfert galaxies (with Petrucci)

Gamma-ray emission from binaries (with Dubus)

We presented the first INTEGRAL observations of the type 1.5 Seyfert galaxy NGC 4151. Combining several INTEGRAL observations performed during 2003, totaling about 400 ks of exposure time, allowed us to study the spectrum in the 2-300 keV range. The measurements presented here reveal an overall spectrum from X-rays up to soft gamma-rays that can be

described by an absorbed model based on a Compton continuum from a hot electron population from an optically thick corona, reflected on cold material, consistent with earlier claims. The time-resolved analysis shows little variation of the spectral parameters over the duration of the INTEGRAL observations. The comparison with CGRO OSSE data shows that the same spectral model can be applied over a time span of 15 yr, with flux variations of the order of a factor of 2 and changes in the underlying continuum reflected by the temperature of the electron population. When modeled with an exponential cutoff power law plus Compton reflection, this results in photon indices ranging from ?=1.5 to 1.9 and a cutoff energy in the range 100-500 keV.

We have studied data from The INTEGRAL satellite observations of the black hole binary Cygnus X-1 from 2002 November to 2004 November. These data provided evidence for significant spectral variations over the period. In the framework of the accreting black hole phenomenology, the source was most of the time in the Hard State and occasionally switched to the so-called "Intermediate State". Using the results of the analysis performed on these data, we presented and compared the spectral properties of the source over the whole energy range (5 keV-1 MeV) covered by the high-energy instruments on board INTEGRAL, in both observed spectral states. Fe line and reflection component evolution occurs with spectral changes in the hard and soft components. The observed behaviour of Cygnus X-1 is consistent with the general picture of galactic black holes. Our results give clues to the physical changes that took place in the system (disc and corona) at almost constant luminosity during the spectral transitions and provide new measures of the spectral model parameters. In particular, during the Intermediate State of 2003 June, we observe in the Cygnus X-1 data a high-energy tail at several hundred keV in excess of the thermal Comptonization model which suggests the presence of an additional non-thermal component.

We have observed the high-frequency peaked BL Lac PKS 2155-304 at redshift z=0.116, which is a well-known VHE gamma-ray emitter. Since 2002 its VHE flux has been monitored using the H.E.S.S. stereoscopic array of imaging atmospheric Cerenkov telescopes. During the 2006 July period, the average VHE flux was measured to be more than 10 times typical values observed from the object. We have discovered an extreme gamma-ray outburst in the early hours of 2006 July 28. The average flux observed during this outburst is very large, corresponding to about 7 times the flux from the Crab Nebula. Peak fluxes are measured with 1 minute timescale resolution at more than twice this average value. Variability is seen up to about 600 s in the Fourier power spectrum, and well-resolved bursts varying on timescales of about 200 s are observed. There are no strong indications for spectral variability within the data. Assuming the emission region has a size comparable to the Schwarzschild radius of a billion solar-mass black hole, Doppler factors greater than 100 are required to accommodate the observed variability timescales.

Talk of A. Zdziarski: Radiative processes and geometry of accreting black holes, Grenoble, 8.03.04

Future prospects.

We are now working on analyzing the spectrum of NGC 4151 from joint observations by INTEGRAL, XMM and RXTE. Given the high-resolution X-ray spectrum from XMM, we can construct a detailed model of the absorber of this source, as well derive the intrinsic broad-band X-ray spectrum (with P. O. Petrucci).

On 24-26 September 2006, Cyg X-1 was at its highest hard X-ray level since INTEGRAL's launch in October 2002. The two-day long light-curve of this observation shows a more or less constant flux at a level of about 1.5 Crab (20-40 keV) and 1.8 Crab (40-80 keV). On top of this high state, INTEGRAL observes an outburst lasting about 8 hours and reaching a maximum of about 2.0

Crab (20-40 keV) and 2.3 Crab (40-80 keV) in a pointing taken on 25 September 2006 between 20:58 and 21:57 UT. This is among the highest fluxes observed by CGRO/BATSE in the harder band and exceeds all previous observations in the 20-100 keV band. Furthermore, TeV emission was observed during that flare by the MAGIC telescope. We are now analyzing the detailed data set for this flare and constraining physical parameters of the source (with J. Malzac).

We are studying the nature of the TeV-emitting binaries, attempting to distinguish between two competing models, the pulsar one and the microquasar one. We are studying physical processes giving rise to the observed broad-band spectra, in particular Compton scattering and synchrotron emission. Additional processes shaping the spectra include Coulomb interactions and electron-positron pair production (with G. Dubus).

* Joint papers:

1. Analysis of the spectrum of the active galaxy NGC 4151 observed by INTEGRAL.

The High-Energy Spectrum of NGC 4151 Beckmann V., Shrader C.~R., Gehrels N., Soldi S., Lubiński P., Zdziarski A.~A., Petrucci P.-O., Malzac J., 2005, ApJ, 634, 939

2. (with J. Malzac)
Analysis of the spectrum of the X-ray binary Cyg X-1 observed by INTEGRAL.

The broad-band spectrum of Cygnus X-1 measured by INTEGRAL Cadolle Bel M., et al., 2006, A&A, 446, 591

3. (with P. O. Petrucci, G. Dubus) Analysis of the time variability and spectra from the blazar PKS 2155-304 as measured by HESS.

An Exceptional Very High Energy Gamma-Ray Flare of PKS 2155-304
Aharonian F., et al., 2007, ApJ, 664, L71

Discovery of VHE γ-rays from the distant BL Lacertae 1ES 0347-121
Aharonian et al.,
2007, A&A, 473, L125-L128.

* Title of collaboration: **Modelling of the TeV emission of blazars seen by HESS**

* Polish participants: (first name, family name, institution of each member)
Krzysztof Katarzynski, University of Torun

* French participants: (first name, family name, institution of each member)
Helene Sol, LUTH, Observatoire de Paris

* Abstract of achievements and plans for the future:

The jump in sensitivity performed by the new generation of Cherenkov telescopes as the HESS experiment in Namibia has provided astronomers with an increasing sample of currently about 20 blazars detected in the very high energy range around the Tera-electronVolt. A few years ago, we

developped theoretical models of synchrotron self-Compton (SSC) emission, both for stationary and for time-dependent cases. They now find direct application to the new data gathered by HESS. It is the right time to further develop them in view of the new constrains obtained from the observations. This especially concerns time dependent scenarios. Indeed in 2006, Cherenkov telescopes detected for the first time very short time scale variability from TeV blazars, down to the minute scale. HESS also had the possibility to monitore a source (PKS 2155-304) during a very active state for several nights in July/August 2006, and sending an alarm, to organize a multi-wavelength campaign with both ground and space detectors from radio to X-rays. It is a real challenge for theorists to be able to reproduce the multi-lambda light curves which have been obtained during that time. We worked on this problem during the recent stay of K. Katarzynski in Meudon last july and are now able to propose one SSC scenario for the evolution of the X-rays and gamma-rays fluxes observed during one of the night of very high activity of the source. We still have to analyse other possible scenarios, to study the long term evolution during the other nights of activity, and to explore the origin of the emission and variability at lower energies (in the radio and optical range).

* Joint papers: name of authors, journal reference, (or arxiv number if not yet published), year, title

Lichti G.~G., Paltani S., Mowlavi M., et al., 2006, ATel, 848, 1, INTEGRAL observation of flaring activity of Mrk 421
(includes Katarzynski and Sol)

Lichti G.~G., Neronov A., Mowlavi N., et al., 2006, ATel, 840, 1, High state of Mkn 421 in the hard X-rays
(includes Katarzynski and Sol)

Katarzyński K., Sol H., Kus A., 2003, A&A, 410, 101, The multifrequency variability of Mrk 421

Katarzyński K., Kus A., Sol H., 2003, ASPC, 290, 339, Modeling the multifrequency emission of blazars

Katarzynski K., Sol H., Kus A., 2002, sf2a.conf, 327, Modelling the multifrequency emission of blazars

Katarzyński K., Sol H., Kus A., 2001, A&A, 367, 809, The multifrequency emission of Mrk 501. From radio to TeV gamma-rays

(Our recent results are not yet published. Most probably, a part of them will be included as a discussion in the HESS paper by the consortium presenting the data, and a more detailed publication on the modelling will follow).

* Title of collaboration**: Gamma-ray emission from binaries**

* Polish participants: (first name, family name, institution of each member) Rafal Moderski (CAMK)

* French participants: (first name, family name, institution of each member) Guillaume Dubus(LLR, Palaiseau then LAOG, Grenoble)

* Abstract of achievements and plans for the future:

Our program is focused on very high energy (VHE) emission from galactic X-ray binaries. At the start of this program, VHE emission from these systems was largely speculative and based on (a) the presence of non-thermal emission at radio wavelengths (b) the analogy between 'microquasars' and active galactic nuclei. During our initial work, we searched the litterature to find candidate sources with good observations showing clear evidence for non-thermal processes that we could use as a basis for modelling. CI Cam appeared as an ideal candidate, with hard X-ray radiation during a flaring event which had all the characteristics of synchrotron radiation. We set out to model this source and found out that it was likely to be a binary composed of a white dwarf + giant. Extreme accretion resulted in detonation which subsequently shock-accelerated electrons. There are probably other sources with similar characteristics. We have modelled its emission including the VHE component. We have a paper in preparation.

Since then, MAGIC and HESS have detected emission from 3 binaries. These are problably powered by the interaction between a pulsar wind and a stellar wind, a different mechanism than originally envisioned. These binaries are not accretion-powered microquasars but rotation-powered very compact pulsar wind nebulae. One of us (GD) has developed extensive models of these sources. Nevertheless, there remains a distinct possibility that microquasars emit VHE radiation and the upcoming launch of GLAST (operating in the GeV domain) make theoretical studies all the more urgent. MAGIC has also recently reported a flare at >100 GeV energies from Cyg X-1, a genuine microquasar. The mechanism is totally unknown. Understanding this emission and planning HESS observations will be our next priorities.

* Title: **Modeling the X-ray spectra and variability due to magnetic flares in Active Galactic Nuclei**

* Polish Participants:
Bozena, Czerny, Nicolaus Copernicus Astronomical Center, Warsaw
Rozanska, Agata, Nicolaus Copernicus Astronomical Center, Warsaw

* French Participants:
Martine, Mouchet, Laboratoire Astroparticule et Cosmologie, Paris, France
Anne-Marie, Dumont, Observatoire de Paris, Meudon, France
Anabela C. Goncalves, Observatoire de Paris, Meudon, France
Rene Goosmann, Observatoire de Paris, Meudon, France

* Abstract Achievement/Plans:

It is commonly accepted that the X-rays from Active Galactic Nuclei (AGN) are produced by two radiatively coupled media with significantly different temperatures. An optically thick medium at T = (10^5--10^6) K, identified with inner parts of the accretion disk, is radiatively coupled to a very hot, optically thin corona at about T = 10^8 K. The heating of the corona can be explained by the "flare" model. This model assumes that the magnetic activity inside the differentially rotating disk creates magnetic loops that evolve on the disk surface and rise into space. At some distance from

the surface magnetic reconnection events release large amounts of energy within very compact regions. These sources emit the primary radiation, which is partly reflected by the disk and explains the observed Comptonized/reprocessed component.

We extended previous modeling of the X-ray reprocessing due to magnetic flares. The flare source creates an irradiated hot-spot on the disk by which the reprocessed component is re-emitted. To model the reprocessing we combine detailed radiative transfer computations of the local re-emission with relativistic modifications in the vicinity of the black hole. The results of this modeling of an individual co-orbiting flare are summarized in Goosmann et al. 2007a (in press) and Goosmann et al. (2006b). To connect this type of flare model to observed data it is useful to investigate X-ray variability. For an exceptionally strong flare event of the bright Seyfert galaxy MCG-6-30-15 spectral cross-correlations between different X-ray energy bands have been examined. We can reproduce the observed correlations using a simple analytical model based on the flare geometry described above. In this model the correlations are induced by time-delays due to the spatial distance between the flare source and the reprocessing spot (Goosmann et al. 2007b). We have also shown that the geometrical arrangement consisting of an individual flare source situated above the surface of the accretion disk is limited by the thermal expansion of the disk that follows the strong illumination by the flare. After a dynamical time-scale has passed the flare/spot geometry becomes more complicated - eventually the flare source is even embedded in the expanding material (Czerny & Goosmann 2004).

Assuming that the accretion disk is covered with many magnetic flares being triggered on a random basis we also investigate the resulting rms variability. The spectral evolution from spot distributions is examined using a Monte-Carlo method. The flares co-orbit with the accretion disk and have a limited lifetime. They randomly appear and disappear across the disk and their total number fluctuates around the average flare number defined. From such orbiting flare distributions we compute the time evolution of the spectra seen at large distances, thereby including corrections for the Doppler effects and for general relativistic effects in the vicinity of the black hole. Variability and time-averaged spectra are obtained and compared to XMM-Newton data of MCG-6-30-15. We can describe the observed variability data assuming a rapidly spinning black hole and increasing brightness of the flares toward the inner parts of the disk. Our modeling reproduces the relative lack of variability at the position of the iron Kalpha-line (Goosmann et al. 2006a, 2004).
So far, such Monte-Carlo simulations of many flares offer the best comparison with current observations. In the future we apply a more detailed prescription of the individual spot modeling (Goosmann et al., in preparation). In the context of solar flares one distinguishes between the so-called loop-top sources occurring in the elevated magnetic reconnection site and bright spots around the foot points of the magnetic loops. We want to generalize our modeling approach and also include several components of the emission for AGN flares.

Refereed articles (cited in the text):

Goosmann R.~W., Mouchet M., Czerny B., Dovciak M., Karas V., Rozanska A., Dumont A.-M., 2007a, arXiv, 709, arXiv:0709.1356, Iron lines from transient and persisting hot spots on AGN accretion disks

Goosmann R.~W., Czerny B., Karas V., Ponti G., 2007b, A&A, 466, 865, Modeling time delays in the X-ray spectrum of the Seyfert galaxy MCG-6-30-15

Goosmann R.~W., Czerny B., Mouchet M., Ponti G., Dov{\v c}iak M., Karas V., Różańska A., Dumont A.-M., 2006a, A&A, 454, 741, The structure and X-ray radiation spectra of illuminated accretion disks in AGN. III. Modeling fractional variability

Goosmann R.~W., Czerny B., Mouchet M., Karas V., Dov{\v c}iak M., Ponti G., Różańska A., 2006b, AN, 327, 977, Magnetic flares in Active Galactic Nuclei: modeling the iron K{α} line

Goosmann R.~W., Czerny B., Dumont A.~M., Mouchet M., Rozanska A., 2004, cosp, 35, 4351, X-ray variability of AGN and the flare model

Czerny B., Goosmann R., 2004, A&A, 428, 353, Flare-induced fountains and buried flares in AGN

Goosmann R.~W., Czerny B., Dov{\v c}iak M., Goncalves, A., Karas V., Mouchet, M., in preparation

Conference proceedings (not cited in the text)

Goosmann R.~W., Czerny B., Karas V., Ponti G., 2007, A&A, 466, 865, Modeling time delays in the X-ray spectrum of the Seyfert galaxy MCG-6-30-15

Goosmann R.~W., Czerny B., Karas V., Dov{\v c}iak M., Ponti G., Mouchet M., 2007, IAUS, 238, 99, Constraints on a strong X-ray flare in the Seyfert galaxy MCG-6-30-15

Goosmann R.~W., Mouchet M., Dovciak M., Karas V., Czerny B., Ponti G., 2007, astro, arXiv:astro-ph/0703240, Constraining global parameters of accreting black holes by modeling magnetic flares

Goosmann R.~W., Dovciak M., Karas V., Czerny B., Mouchet M., Ponti G., 2007, astro, arXiv:astro-ph/0701164, Modeling the X-ray fractional variability spectrum of Active Galactic Nuclei using multiple flares

Goosmann R.~W., Czerny B., Dumont A.-M., Mouchet M., Różańska A., 2006, ASPC, 360, 277, X-ray Variability of AGN and the Flare Model

Goosmann R.~W., Mouchet M., Dov{\v c}iak M., Karas V., Czerny B., Dumont A.-M., Różańska A., 2006, ESASP, 604, 625, X-ray Properties of Magnetic Flares Orbiting Above the Accretion Disk in Active Galactic Nuclei

Goosmann R.~W., Czerny B., Dumont A.-M., Mouchet M., Różańska A., Karas V., Dov{\v c}iak M., 2006, AdSpR, 38, 1398, X-ray variability of active galactic nuclei and the flare model

Goosmann R.~W., Mouchet M., Czerny B., Dumont A.-M., Różańska A., Karas V., Dov{\v c}iak M., 2005, sf2a.conf, 515, Modeling the X-ray spectra of magnetic flares in Active Galactic Nuclei

Czerny B., Collin S., Dovciak M., et al., 2005, AIPC, 801, 188, Comparison of the solar corona and the coronae above accretion disks surrounding black holes

Czerny B., Goosmann R., Karas V., Ponti G., 2005, astro, arXiv:astro-ph/0506080, Radio Quiet AGN

Goosmann R.~W., Czerny B., Dumont A.~-., Mouchet M., Rozanska A., 2004, astro, arXiv:astro-ph/0410079, X-ray Variability of AGN and the Flare Model

* Title of collaboration:
Thermal instabilities in constant pressure media and applications to model the soft X-ray excess and the variability in AGN.

* Polish participants: (first name, family name, institution of each member):
Bozena Czerny, Copernicus Astronomical Center, Warsaw, Poland.
Agata Rozanska, Copernicus Astronomical Center, Warsaw, Poland.

* French participants: (first name, family name, institution of each member):
Loic Chevallier, Observatoire de Paris-Meudon, LUTH, Meudon, France.
Suzy Collin, Observatoire de Paris-Meudon, LUTH, Meudon, France.
Anne-Marie Dumont, Observatoire de Paris-Meudon, LUTH, Meudon, France.
Anabela Goncalves, Observatoire de Paris-Meudon, LUTH, Meudon, France.
Rene Goosmann, Observatoire de Paris-Meudon, LUTH, Meudon, France.
Martine Mouchet, Observatoire de Paris-Meudon, LUTH, Meudon, France.

* Abstract of achievements and plans for the future:
It is well-known that thermal instability leads to the coexistence of two or more phases in the atmosphere of irradiated medium where the total pressure is constant or constrained (e.g., hydrostatic equilibrium). The Paris-Meudon group (Suzy Collin, Anne-Marie Dumont, Martine Mouchet, Rene Goosmann, Anabela Goncalves, Loic Chevallier) is involved in an active collaboration with Bozena Czerny and Agata Rozanska on studying the central regions of AGN, using the code TITAN for photoionized media. Prior to the present collaboration some work had already been done on thermal instabilities (Rozanska et al.2002). Under the constraint of radiative and pressure equilibrium, thermal instabilities are noticed using the TITAN code (Goncalves et al. 2007), and the goal of the present collaboration was to characterize further those thermal instabilities (Chevallier et al, in preparation; see below) and find some applications of these remarkable features in AGN: do they manifest themselves in the observed soft X-ray excess (Chevallier et al. 2006) and in the variation of the observed flux (Chevallier et al. 2007)?
The present collaboration started in 2004 and resulted in two papers in refereed journals (Chevallier et al. 2006; Chevallier et al. 2007), two papers from one french (Chevallier et al. 2005) and one international colloquia (Chevallier et al., ESASP 2006), one seminar given by Bozena Czerny at Meudon and two seminars given by Loic Chevallier at CAMK. Moreover, the group at CAMK got the last version of the TITAN code, thanks to many developments made by Anne-Marie Dumont. Loic Chevallier made a few developments of TITAN during his stay at CAMK, and provided some help to Agata Rozanska on this code.

About the first paper (Chevallier et al. 2006), the 2-10 keV continuum of AGN is well represented by a single power law, generally attributed to a hot Comptonizing medium, such as a corona above

the accretion disk. At lower energies the continuum displays an excess with respect to the extrapolation of this power law, called the "soft X-ray excess". A single power law correctly represents both the soft and the hard X-ray emission, and the soft X-ray excess may be an artefact due to the absorption of the primary power law by a relativistic wind. We argue that the - thick - absorbing medium should be in total pressure equilibrium, i.e. its density is far from constant, to constrain the spectral distribution which otherwise would be too strongly variable in time and from one object to the other, as compared to observations. This remarkable feature is due to thermal instabilities occuring in a zone which remains of the same size whatever the total size of the medium, its distance from the central source or its density on the illuminated face.

About the second paper (Chevallier et al. 2007), recent modeling of the warm absorber in active galactic nuclei has proved the usefulness of constant total (gas plus radiation) pressure models, which are highly stratified in temperature and density (Goncalves et al. 2006). We explore the consistency of those models when the typical variation of the flux from the central source is taken into account. We have performed a variability study of the warm absorber response, based on timescales and our photoionization code TITAN. We show that the ionization and recombination timescales are much shorter than the dynamical timescale. Clouds very close to the central black hole will maintain their equilibrium since the characteristic variability timescales of the nuclear source are longer than cloud timescales. For more distant clouds, the density structure has no time to vary in response to the variations in the temperature or ionization structure, and such clouds will show the departure from the constant pressure equilibrium. We explore the impact of this departure on the observed properties of the transmitted spectrum and soft X-ray variability: (i) non uniform velocities, on the order of sound speed, appear due to very high pressure gradients partly due to thermal instabilities, up to typical values of 100 km/s. These velocities lead to the broadening of lines. This broadening is usually observed and very difficult to explain otherwise. (ii) Energy-dependent fractional variability amplitude in soft X-ray range has a broader hump around ~ 1-2 keV, and (iv) the plot of the equivalent hydrogen column density vs. ionization parameter is steeper than for equilibrium clouds. The results have the character of a preliminary study and should be supplemented in the future with full time-dependent radiation transfer and dynamical computations.

For both papers, a considerable effort in the development of the code TITAN has been made by Anne-Marie Dumont, in order to characterize thermal instabilities and refine the numerical way of computing constant pressure models. Based on the new version of the code, another topic linked to thermal instabilities is planned for the future, i.e. characterizing the effect of electronic conduction. This study was started during the stay of Loic Chevallier at CAMK (Chevallier et al., in preparation).

* Joint papers: name of authors, journal reference, (or arxiv number if not yet published), year, title

Rozanska A., Dumont A.-M., Czerny B., Collin S., 2002, MNRAS, 332, 799, The structure and radiation spectra of illuminated accretion discs in active galactic nuclei - I. Moderate illumination.

Chevallier L., Collin S., Dumont A.-M., Czerny B., Mouchet M., Goncalves A. C., Goosmann R. W., 2005, SF2A conference, 519, The puzzle of the soft X-ray excess in AGN: absorption or reflection?

Chevallier L., Collin S., Dumont A.~M., Czerny B., Mouchet M., Goncalves A. C., Goosmann R., 2006, ESASP, 604, 605, The Role of Absorption and Reflection in the X-ray Spectrum of Active Galactic Nuclei.

Chevallier L., Collin S., Dumont A.-M., Czerny B., Mouchet M., Goncalves A. C., Goosmann R., 2006, A&A, 449, 493, The role of absorption and reflection in the soft X-ray excess of Active Galactic Nuclei. I. Preliminary results.

Goncalves A. C., Collin S., Dumont A.-M., Mouchet M., Rozanska A., Chevallier L., Goosmann R. W., 2006, A&A, 451, L23, A new model for the Warm Absorber in NGC 3783: a single medium in total pressure equilibrium.

Goncalves A. C., Collin S., Dumont A.-M., Chevallier L., 2007, A&A, 465, 9, Thermal instability in X-ray photoionized media in active galactic nuclei:. influence on the gas structure and spectral features.

Chevallier L., Czerny B., Rozanska A., Goncalves A. C., 2007, A&A, 467, 971, Response of the warm absorber cloud to a variable nuclear flux in active galactic nuclei.

Chevallier L., Czerny B., Rozanska A., Dumont A.-M., Thermal instabilities in thick stratified media in pressure equilibrium. Role of the thermal conduction by electrons, in preparation.

* Title of collaboration
X-ray modeling of the Warm Absorber in Active Galactic Nuclei

The work developed under this project name covered different studies, for instance, i) the modeling of the Warm Absorber in specific objects such as NGC 3783; ii) the investigation of some properties of pressure equilibrium plasma (e.g., thermal instability and variability issues); iii) the discussion of computational issues related to the transfer-photoionization code TITAN, and the development of a grid of models compatible with the current tools used to reduce and analyze X-ray data.

* Polish Participants:
Loic CHEVALLIER, Nicolaus Copernicus Astronomical Center, Warsaw (from October 2005 to September 2006)
Bozena CZERNY, Nicolaus Copernicus Astronomical Center, Warsaw
Agata ROZANSKA, Nicolaus Copernicus Astronomical Center, Warsaw (*)

* French Participants:
Loic CHEVALLIER, Observatoire de Paris, Meudon, France (before October 2005)
Suzy COLLIN, Observatoire de Paris, Meudon, France
Anne-Marie DUMONT, Observatoire de Paris, Meudon, France
Anabela C. GONÇALVES, Observatoire de Paris, Meudon, France (*)
Rene GOOSMANN, Observatoire de Paris, Meudon, France (before ???)
Martine MOUCHET, Laboratoire Astroparticule et Cosmologie, Paris, France

NB : The main contacts in France and Poland for this research project are identified with an asterisk.

* Abstract Achievement/Plans:

Active Galactic Nuclei (AGN) harbour super-massif black holes and many works are devoted to their accretion properties. However, AGN also display ionized winds (with velocities of a few thousands km/s); if such outflows leave the galaxy, they could play a key role in cosmological feedback and in the metal enrichment of the intergalactic medium. The main research interest of our collaboration concerns the physical properties and geometry of such ionized outflows. We are particularly interested in the study of the Warm Absorber (WA) ˆ a highly ionized gas observed in absorption in the X-ray spectra of many Seyfert 1 galaxies.

One way to address the physics of the WA consists in applying a radiative-transfer numerical approach to simulate the plasma properties, and then to confront those models to high-quality X-ray spectra. Our collaboration research activities thus combine observations and theory, in an effort to constrain the WA properties. In what concerns the modelling and simulation aspects, the transfer-photoionization code TITAN, developed and maintained at Paris-Meudon Observatory, represents an irreplaceable tool. TITAN uses an exact method (ALI) computing the full transfer for both the lines and the continuum. It is well suited for the study of hot, optically thick media, such as the accretion disk in AGN but also adequate for modeling optically thinner media, such as the Warm Absorber.

One of the goals of our French-Polish collaboration was to better understand the stratified nature of the WA and to provide a more physical approach to the observed properties of this astrophysical plasma. Spectra with a WA usually display lines covering a wide range in ionization potentials, implying the presence of an ionized medium with strong temperature stratification. Such stratification is usually accounted for through the presence of multiple regions of constant density displaying very different physical characteristics. We addressed the hypothesis that this stratification could be better described by a single medium in constant pressure equilibrium (Rozanska et al. 2006), applying it to the study of the highest-quality X-ray spectrum available for a WA ˆ that of NGC 3783, a 900 ks exposure obtained with the HETG aboard the Chandra X-ray satellite. The first article produced by our collaboration (Gonçalves et al. 2006) demonstrated that the WA in NGC 3783 can indeed be well described by a single medium (a clumpy, ionized gas with cosmic abundances) in constant total pressure. This is probably the case for all WA presently described by multiple zones of constant density.

However, maintaining those equilibrium conditions requires that the WA plasma should not be placed too far away from the ionizing source, located in the AGN center. Our first study provided a reasonable estimation for the location of the WA, at approximately 10^18 cm or less from the central engine (this value was obtained for a Hydrogen numerical density of 10^5 cm^-3). Further study on the general properties of the WA in AGN was conducted, demonstrating that this value is compatible with pressure equilibrium conditions (Chevallier et al. 2007, in a parallel LEA research project). It is now important to conduct a throughout study of the variability properties of NGC 3783, specifically. Such a project is foreseen in the framework of the LEA collaboration; it will help putting additional constraints on our preliminary estimates of the WA location, a subject of great debate. Indeed, the most uncertain WA quantities are the gas column density and its distance to the ionizing source (uncertainties of over 2 and 3 orders of magnitude, respectively!) and, as a consequence, the gas Hydrogen numerical density. Estimates of this parameter are usually obtained through the use of X-ray plasma diagnostics based on the He-like triplet lines, although some caution is needed when applying them to the WA gas in Seyfert 1s (Gonçalves & Godet 2007).

Is our constant pressure model description of the WA a truly general one, applicable to all WAs observed? Or is it just a particularity observed in NGC 3783? In order to answer this question, new studies must be conducted on different WA spectra of Seyfert 1 galaxies. We are also interested in

studying the physical characteristics of the X-ray emission gas observed in Seyfert 2s galaxies, and comparing the emitting gas properties to those of the absorbing plasma. A good starting point for future studies in the framework of the LEA collaboration is the HotGAS database ˆ the Chandra Grating Spectroscopy Database for Active Galactic Nuclei ˆ developed and maintained by T. Yaqoob. Several spectra in this database have already been selected by our collaboration for future study and would benefit from a more automated approach in what concerns the data fitting through constant pressure models. Therefore, before being able to massively test the hypothesis that other WA can also be modeled under pressure equilibrium, one should spend some time improving the computational methods involved in the process.

In that respect, the TITAN code has benefited from two major improvements in the course of this collaboration ˆ one concerns the identification and throughout computation of the thermal instability that develops in constant pressure media; the other consists in a major update of the atomic data used by our code, from 1000 lines to 4000 (the same lines used by Cloudy, a well-known photoionization code). A.-M. Dumont was the motor of both these developments.

The first modification to the code allowed us to further investigate the general properties of thick media in constant pressure equilibrium. It is general knowledge that a photoionized gas in thermal equilibrium can display a thermal instability, with three or more solutions in the multi-branch region of the S-shape curve giving the temperature versus the radiation-to-gas-pressure ratio. Many studies had been devoted to this curve and to its dependence on different parameters, but always in the optically thin case. The purpose of our work was to study the thermal instability in optically thick, stratified media, in total pressure equilibrium. We were also interested in comparing photoionization models issued from the hot and cold stable solutions, with those TITAN models computed with an approximate, intermediate solution (the most common option used by our collaboration).

In a first stage, we have developed a new algorithm to select the hot/cold stable solution, and thereof to compute a fully consistent photoionization model. We have then implemented it in the TITAN code and computed a set of models encompassing the range of conditions valid for the WA in AGN. Our study demonstrated that the thermal instability problem is quite different in thin or thick media. Models computed with the hot/cold stable solutions, or with an intermediate solution, differ all along the gas slab, with the spectral distribution changing as the radiation progresses inside the ionized gas. These effects depend on the thickness of the medium and on its ionization. This has observational implications in the emitted/absorbed spectra, ionization states, and variability. However it is impossible to know what solution the plasma will adopt when attaining the multi-solutions regime; we expect the emitted/absorbed spectrum to be intermediate between those resulting from pure cold and hot models. Such a phase-mixed medium can be well reproduced by intermediate solution models, like the ones we adopt in most of the computations conducted in the framework of this collaboration.

The interest of the French-Polish collaboration on the subject of thermal instability dates from early days (e.g. Rozanska et al. 2002) and will be pursued in a future investigation of the role of electronic conductivity on the onset of thermal instabilities (Chevallier et al., in preparation).

The second improvement of the TITAN code will provide a remarkable tool to better address the study of the WA in Seyfert 1 and 2 galaxies. Indeed, we can now investigate important features such as the Unresolved Transition Array, and also provide more realistic simulations of the observed (and expected) X-ray spectra of WA. A proper exploitation of this new and performing tool could use a certain degree of automation, namely through grids of models implemented in the XSPEC reduction and analysis software.

In the first stage of our collaboration, we have calculated a small grid of constant total pressure models with the 1000-lines version of the TITAN code. Such small grid was dedicated to fit the WA in NGC 3783 and has little other applications. Later on, a larger set of grids was computed; such grids were specially suited for the study of X-ray sources with a soft excess, such as NLS1s and some PG quasars. They were implemented into XSPEC and could be used in the future to put stronger limits to the origin of the soft X-ray excess in AGN (disk contribution vs. wind absorption?), thus completing the preliminary results of Chevallier et al. (2006). However, before applying a constant pressure model to the study of other galaxies from the HotGAS database, we should build a new set of grids with the most recent version of the TITAN code. Those grids should contain a large set of ionization models, covering a wide range of parameters (e.g. the gas column density and electronic density, the shape and strength of the ionizing continuum, the plasma abundances, etc.). Such a project is presently being conducted at Paris-Meudon observatory (PI: A.C. Gonçalves) and the resulting grids should provide substantial material for future research projects on the WA properties, in the framework of the Astro-LEA French-Polish collaboration.

Such large grids of photoionization models are also awaited by parallel LEA research projects to provide input to a global study of the variability in AGN. An attractive possibility to explain the X-ray spectrum of AGN, and its variability, is given by the magnetic flare model. This model assumes that localized magnetic reconnection events occur above the accretion disk and produce compact sources of hard X-ray radiation. Such a description requires detailed computations, including the modeling of the vertical structure of the accretion disk in hydrostatic equilibrium, multi-angle radiative transfer within the disk, and relativistic ray-tracing between the emitting accretion disk and a distant observer. A parallel project is investigating how these flares could play a role in the explanation of the variability properties of AGN. Future, common, goals are to simulate and to model the variability features (Power Density Spectrum, rms, time-averaged spectra, etc.) of a few Seyfert galaxies observed with XMM-Newton, Chandra and Suzaku. In the framework of this collaboration, A.C. Gonçalves is expected to spend a 2- to 4-month period at CAMK, in the near future.

In summary, our collaboration started in 2004 and so far resulted in two published papers in refereed journals (Gonçalves et al. 2006; Gonçalves et al. 2007), eight contributions to national and international colloquia, as well as two seminars given by A.C. Gonçalves at CAMK. This collaboration also participated in parallel LEA research projects that resulted in two published papers (Chevallier et al. 2006; Chevallier et al. 2007), and six contributions to national and international colloquia. Several new articles on the subjects described above are in preparation, e.g., on the subject of the WA variability and thermal instability in NGC 3783 (Gonçalves et al., in preparation) and on the subject of the flare model (Goosmann et al., in preparation).

* Joint papers:

1- Refereed articles

L. Chevallier, S. Collin, A.-M. Dumont, B. Czerny, M. Mouchet, A.C. Gonçalves, R. Goosmann, A&A, 449, 493, 2006, The role of absorption and reflection in the soft X-ray excess of active galactic nuclei. I. Preliminary results

L. Chevallier, B. Czerny, A. Rozanska, A.C. Gonçalves, A&A, 467, 971, 2007, Response of the warm absorber cloud to a variable nuclear flux in Active Galactic Nuclei

A.C. Gonçalves, S. Collin, A.-M. Dumont, M. Mouchet, A. Rozanska, L. Chevallier, R. Goosmann, A&A, 451, L23, 2006, A new model for the Warm Absorber in NGC 3783: a single medium in total pressure equilibrium

A.C. Gonçalves, S. Collin, A.-M. Dumont, L. Chevallier, A&A, 465, 9, 2007, Thermal instability in X-ray photoionized media in Active Galactic Nuclei: Influence on the gas structure and spectral features

A.C. Gonçalves et al., A&A (in preparation) Modelling the stratified Warm Absorber in NGC 3783: thermal instability and spectral variability aspects

Goosmann R.W., Czerny B., Dovciak M., Gonçalves, A.C., Karas V., Mouchet, M., in preparation

A. Rozanska, A.-M. Dumont, B. Czerny, S. Collin, MNRAS, 332, 799, 2002, The structure and radiation spectra of illuminated accretion discs in active galactic nuclei - I. Moderate illumination.

A. Rozanska, R. Goosmann, A.-M. Dumont, B. Czerny, A&A, 452, 1, 2006, Modeling the warm absorber in active galactic nuclei

2- Participation in conferences

L. Chevallier, S. Collin, A.-M. Dumont, O. Godet, A.C. Gonçalves, TAMP Workshop on X-ray Diagnostics for Astrophysical Plasmas: Theory, Experiment, and Observation, Cambridge, Massachusetts, USA, le 15-17 November, 2004. R.K. Smith (ed.), American Institute of Physics Conference Proceedings Vol. 774, New York, USA, 2005, pg. 57, X-ray Diagnostics with Full Radiative Transfer (ALI Method)

L. Chevallier, S. Collin, A.-M. Dumont, O. Godet, A.C. Gonçalves, R. Goosmann, M. Mouchet, GRETA meeting 2005 sur Radiative Transfer and Applications to Very Large Telescopes, Fréjus, France, 11-13 May, 2005. Ph. Stee (ed.), EAS Publication Series, Vol. 18, Les Ulis, Bonchamps-lès-Laval, France, 2006, pg. 203, AGN modelling with Full Radiative Transfer (ALI Method)

L. Chevallier, S. Collin, A.-M. Dumont, B. Czerny, M. Mouchet, A.C. Gonçalves, R.W. Goosmann, ESA symposium on The X-ray Universe 2005, El Escorial, Spain, 26-30 September 2005. A. Wilson (ed.), ESA Symposium Series 604 Vol. , Noordwijk, pg. 605, The role of absorption and reflection in the X-ray spectrum of Active Galactic Nuclei

L. Chevallier, S. Collin, A.-M. Dumont, B. Czerny, M. Mouchet, A.C. Gonçalves, R. Goosmann, workshop on The physics of the Warm Absorber in AGN, in Varsaw, Pologne, le 5-7 October 2005. A. Rozanska (org.), e-publication, The origin of the soft X-ray excess in AGN

L. Chevallier, S. Collin, A.-M. Dumont, B. Czerny, M. Mouchet, A.C. Gonçalves, R.W. Goosmann, conference dedicated to Leon Van Speybroeck on Six Years of Science with Chandra, Cambridge, Massachusetts, USA, 2-4 November 2005. A. Fruscione (ed.), e-publication, The role of absorption and reflection in the X-ray spectrum of Active Galactic Nuclei

L. Chevallier; S. Collin, A.-M. Dumont, B Czerny, M. Mouchet, A.C. Gonçalves, R.W. Goosmann, SF2A meeting 2005, le 27 June ˆ 1 July, 2005, Strasbourg, France. F. Casoli, T. Contini, J. M. Hameury, L. Pagani (eds.), EdP-Sciences Conference Series, 2005, pg. 519, The puzzle of the soft X-ray excess in AGN: absorption or reflection?

A.C. Gonçalves, S. Collin, A.-M. Dumont, A. Rózanska, M. Mouchet, L. Chevallier, R. Goosmann, ESA symposium on The X-ray Universe 2005, El Escorial, Spain, 26-30 September 2005. A. Wilson (ed.), ESA Symposium Series 604, Noordwijk, The Netherlands, pg. 545, A Constant Total Pressure model for the Warm Absorber in NGC 3783

A.C. Gonçalves, S. Collin, A.-M. Dumont, A. Rózanska, M. Mouchet, L. Chevallier, R. Goosmann, workshop on The physics of the Warm Absorber in AGN, in Varsaw, Poland, 5-7 October 2005. A. Rozanska (org.), e-publication, Modelling the Warm Absorber in NGC 3783 under pressure equilibrium conditions:

A.C. Gonçalves, S. Collin, A.-M. Dumont, A. Rózanska, M. Mouchet, L. Chevallier, R. Goosmann, conference dedicated to Leon Van Speybroeck on Six Years of Science with Chandra, Cambridge, Massachusetts, USA, 2-4 November 2005. A. Fruscione (ed.), e-publication, A Constant Total Pressure model for the Warm Absorber in NGC 3783

A.C. Gonçalves, S. Collin, A.-M. Dumont, A. Rózanska, M. Mouchet, L. Chevallier, R.W. Goosmann, workshop on invitation on AGN Winds in the Caribbean, St. John, US Virgin Islands, 28 novemberˆ2 december 2005, e-publication, A Constant Total Pressure model for the Warm Absorber in NGC 3783

A.C. Gonçalves, workshop on High Resolution X-ray Spectroscopy: towards XEUS and Con-X, Mullard Space Science Laboratory of University College London, Holmbury St Mary, Surrey, UK, 27-28 March 2006. G. Branduardi-Raymont (ed.). e-publication, pg. E10, A Single Medium Model for the Warm Absorber in NGC 3783

A.C. Gonçalves, S. Collin, A.-M. Dumont, The Multicoloured Landscape of Compact Objects and their Explosive Progenitors: Theory vs Observations, Cefalú, Italy, 11ˆ24 June 2006. L. Burderi et al. (eds.). American Institute of Physics Conference Proceedings Vol. 924, New York, USA, 2007, pg. , Thermal instabilities in Active Galactic Nuclei: the case of thin vs. thick ionized media

A.C. Gonçalves, S. Collin, A.-M. Dumont, A. Rózanska, M. Mouchet, L. Chevallier, R. Goosmann, XV ENAA meeting, Lisbon, Portugal, 28-30 July 2005, e-pub, Modelling the Warm Absorber in NGC 3783 with the TITAN code

A. Gonçalves, S. Collin, A.-M. Dumont, A. Rózanska, M. Mouchet, L. Chevallier, R.W. Goosmann, A. Szostek, SF2A meeting 2005, le 27 June ˆ 1 July, 2005, Strasbourg, France. F. Casoli, T. Contini, J. M. Hameury, L. Pagani (eds.), EdP-Sciences Conference Series, 2005, pg. 511, Modelling the Warm Absorber in NGC 3783 under pressure equilibrium conditions I. A test case for the TITAN code

A.C. Gonçalves, S. Collin, A.-M. Dumont, SF2A meeting 2006, 26ˆ30 June 2006, Paris, France. D. Barret, F. Casoli, T. Contini, G. Lagache, A. Lecavelier, et L. Pagani (eds), e-publication, TITAN: A transfer-photoionization code for hot, thick media

* Title of collaboration:
Using the code Titan to compute models of warm absorber in AGN

* Polish participants: (first name, family name, institution of each member)
Agata Rozanska, Copernicus Astronomical Center, Bartyca18, 00-716 Warsaw, Poland
Bozena Czerny, Copernicus Astronomical Center, Warsaw, Poland

* French participants: (first name, family name, institution of each member)
Anne-Marie Dumont, LUTH, Observatoire de Paris Meudon
Suzy Collin, Observatoire de Paris-Meudon, LUTH, Meudon, France.
Loic Chevallier, Observatoire de Paris-Meudon, LUTH, Meudon, France.
Anabela Goncalves, Observatoire de Paris-Meudon, LUTH, Meudon, France.
Rene Goosmann, Observatoire de Paris-Meudon, LUTH, Meudon, France. Martine Mouchet, Observatoire de Paris-Meudon, LUTH, Meudon, France.

* Abstract of achievements and plans for the future:
Agata Rozanska computed a large grid of models of warm absorber in AGN, with the help of the code Titan built by Anne-Marie Dumont, and the code DALI of Agata (and also the code Noar of A. Abrassart). We wished to obtain strengths of the predominant absorption lines versus column densities and illuminations to allow a comparison with the observations. Titan computes the temperature versus the depth in the medium, ionization structure, and spectra emitted or reflected by an illuminated medium. After the absorption coefficients computed by Titan, Dali computes intensities of the absorption lines.
We wanted to assume media in constant pressure, the most likely assumption. We were confronted with the thermal instabilities generated in these media. Thus, under the pressure of these requirements, we were obliged to develop the code Titan, introducing Ali computations in several directions, improvements of the z-grid with automatic cutting, changes in the interpolation of the source function to allow convergence of the Ali method around the temperature fall, computation of the two states (hot and cold) due to the thermal instabilities, updating the atomic data, and generally improving the code.

* Main Joint papers:

Rozanska A., Dumont A.-M., Czerny B., Collin S., 2002, MNRAS, 332, 799, The structure and radiation spectra of illuminated accretion discs in active galactic nuclei - I. Moderate illumination.

Rozanska A., Czerny B., Siemiginowska A., Dumont A.-M., 2004, ApJ, 600, 96 The origin of emission and absorption features in Ton S180 Chandra observations

Rozanska A., Goosmann R., Dumont A.-M., Czerny B., 2004, A&A, Modeling the Warm Absorber in AGN

C Stellar structure

* title**: Population study of variable stars in sample galaxies of the local system**

* Participants:
Drs Jean-Philippe Beaulieu IAP/Paris, Jean-Baptiste Marquette (IAP/Paris),
Alex Schwarzenberg-Czerny CC/Warsaw, Mr. Mariusz Wisniewski CC/Warsaw.

Our collaboration concentrated on investigation of populations of variable stars by means of large photometric surveys of objects in the local system of galaxies objects (LMC, SMC and M33) and on developing powerful tools for analysis of mass photometric surveys.

The shear amount of data collected within modern photometric surveys poses new challanges for efficient processing and analysis tools. One of the main gains of the collaboration facillitated by Astro-PF and its predecessor was enabling to combine our complementary expertise in that field. Before this collaboration modern statistical methods for analysis of light curves were developed an Copernicus Centre in Warsaw (A.Schwarzenberg-Cz.), and subsequently adopted by researches world wide in mass photometric surveys (OGLE, ASAS, Las Campanas Variable Star Survey, HAT, Direct,Debil). At the same time J-P Beaulieu and JB Marguette IAP/Paris were in position to start within large collaboration EROS PLANET surveys, belonging with OGLE and MACHO to world largest photometric surveys and obtained excellent data on pulsating and eclipsing variable stars in LMC and SMC. Thus at the start of our collaboration large efforts were undertaken to merge together powerful astrometric and photometric reduction packages developed mainly at IAP/Paris with the period-search and light curve analysis package TATRY, devejoped mainly in Copernicus Centre and with the data analysis and visualization system TOPCAT adapted at IAP. This system, profiting from our expertize both in stellar pulsations and relevant statistics forms powerful and elastic tool to extract top quality results from mass surveys. This was demonstrated by analysis of the whole M33 data within several month.

The M33 survey yielded most complete survey of variable stars in that galaxy, increasing their count 3-fold. The quality of our statistical analysis was demonstrated by finding among 2000 newly discovered cepheids, several revealing signatures of faint, second modes of pulsations. This enabled Beaulieu, Buchler and Marquette, by means of pulsation modelling, to perform detailed structure and composition analysis of these stars.

As part of his thesis (in preparation) M.Wisniewski performed cross-identification of EROS and 2MASS red variables, reviewed critically any photometric and astrometric deviations, resulting in our better understanding of instrumental effects in these surveys. Departing from this point he investigated pulsations in AGB stars and demonstrated new, efficient method for separation of carbon and oxygen rich stars.

Having in mind future investigation of extrasolar planets we (ASC & JPB) developed new method for detection of planetary transits, with good and definite statistical properties unavalible in the methods tried so far.

* Joint papers:

Hartman J.~D., Bersier D., Stanek K.~Z., Beaulieu J.-P., Kaluzny J., Marquette J.-B., Stetson P.~B., Schwarzenberg-Czerny A., 2007, yCat, 837, 11405, Variables in M33 (Hartman+, 2006)

Hartman J.~D., Bersier D., Stanek K.~Z., Beaulieu J.-P., Kaluzny J., Marquette J.-B., Stetson P.~B., Schwarzenberg-Czerny A., 2007, yCat, 737, 11405, Deep CFHT M33 survey variable catalogue (Hartman+, 2006)

Beaulieu J.-P., Buchler J.~R., Marquette J.-B., Hartman J.~D., Schwarzenberg-Czerny A., 2006, ApJ, 653, L101, Detection of Beat Cepheids in M33 and Their Use as a Probe of the M33 Metallicity Distribution

Hartman J.~D., Bersier D., Stanek K.~Z., Beaulieu J.-P., Kaluzny J., Marquette J.-B., Stetson P.~B., Schwarzenberg-Czerny A., 2006, MNRAS, 371, 1405, Deep Canada-France-Hawaii Telescope photometric survey of the entire M33 galaxy - I. Catalogue of 36000 variable point sources

Schwarzenberg-Czerny A., Beaulieu J.-P., 2006, MNRAS, 365, 165, Efficient analysis in planet transit surveys

Schwarzenberg-Czerny A., Beaulieu J.~-., 2005, astro, arXiv:astro-ph/0509833, Efficient analysis in planet transit surveys

Aerts, C., et al. 2004, Stellar Structure and Habitable Planet Finding, 538, 247

* Title of collaboration: **Evolutionary period change of RXJ2117+3412**

* Polish participants: Pawel Moskalik, Copernicus Astronomical Centre, Warsaw

* French participants: Gerard Vauclair, Observatoire Midi-Pyrenees, Toulouse

* Abstract of achievements and plans for the future: during the period of 2004-2007 I visited Toulouse once, on March 2007 for 14 days. We have worked on reducing photometric data on RXJ2117+3412. The star is a nucleus of an old planetary nebula and it is known to be a multimode pulsator. The goal of the project is to determine the rate of evolutionary period chanege in RXJ2117+3412. Analysis of data is still in progress. No results to report yet.

* Title of collaboration: **Fundamental parameters and stellar evolution**

* Polish participants:

Maria Kurpinska-Winiarska, Obserwatorium Astroomiczne UJ, Krakow, Poland

* French participants:
Edouard Oblak, Observatoire de Besancon, Besancon, France

* Abstract of achievements and plans for the future:
Our collaboration was supported for the first time by LEA in the second period of 2004. Detached eclipsing binaries are good candidates to test the stellar evolution models. However, in the 1.1-0.7 Msun mass range, some ambiguities persist between predictions of the stellar models and properties of binary stars obtained from the observations (Lastennet et al. 2003). Because of the strong selection effects, the sample of detached binary systems with main-sequence components of F-K spectral types is poor.Furthermore it is dominated by short-period, active systems. New, precise spectroscopic and photometric data i.e precise determination of the fundamental parameters for the new systems are necessary to solve these discrepancies. We have analyzed the radial velocity observations from our 12 missions at the OHP, with CORAVEL and Elodie instruments for 42 new detached eclipsing binaries (periods in general longer then 2.5 days) discovered during the Hipparcos mission. For 30 of them, for the first time, we obtained the radial velocity solutions. We found 2 triple systems (CN Lyn, CU Cam), never mentioned before, with a pronounced motion of the center-of-mass and radial velocity curve for the third body for each of these eclipsing binaries. Preliminary, long-period orbits are calculated. During same time, photometric observations at Cracow Observatory (16 systems), at Lvov Observatory (3 systems) and at Turkish Observatories AUG and TUG (3 systems) were carried out. At the end of 2006, the state of photometric data permitted to solve 6 systems ie. to determined absolute temperatures, masses and radii. Next systems are successfully investigated. Unfortunately, our idea to present only the spectroscopic orbits as a first article from a serie of papers were not accepted by A&A. The revision of this paper is prepared, this time, with added absolute stellar parameters for already solved 6 systems . The main purpose of our work is to verify a possible variation of the mixing-length convection parameter alpha(MTL) in function of component's mass for subsolar mass components. The discordant ages of the components (a very strong difference when alpha is assumed to be constant and equal to the solar value for all types of stars) disappear with new values of alpha(MLT). The system V2154 Cyg (one of already solved - masses 1.26 and 0.75) is a good system to verify the above relation. A grid of CESAM models (Morel 1997) for each of the components is calculated in collaboration with J. Fernandes and D. Valls-Gabaud.

References to the text:
Lastenet E., Fernandes J., Oblak E., Valls-Gabaud D., 2003, A&A 409, 611
Morel P., 1997, A&A Suppl. Ser. 124, 597

* Joint papers:
Carquillat J.-M., Prieur J.-L., Ginestet N., Oblak E., Kurpinska-Winiarska M., 2004, MNRAS, 352, 708, Contribution to the search for binaries among Am stars - VI. Orbital elements of ten new spectroscopic binaries, implications on tidal effects.

Oblak E., Lastennet E., Fernandes J., Kurpinska-Winiarska M., Valls-Gabaud D., 2004, Proceedings of "Spectroscopically and Spatially Resolving the Components of Close Binary Stars, ASP Conference Series, 318, 175, Fundamental parameters and stellar evolution.

Fernandes J., Oblak, E., Kurpinska-Winiarska, M., 2007, in Binary Stars as Critical Tools and Tests in Contemporary Astrophysics, International Astronomical Union. Symposium no. 240, S240, 388, The Eclipsing Binary System V2154 Cyg : Observations and Models.

Oblak E., Kurpinska-Winiarska, M., Carquillat, J.-M., 2007, in Binary Stars as Critical Tools and Tests in Contemporary Astrophysics, International Astronomical Union. Symposium no. 240, S240, 1250, Multiple Stellar Systems with Eclipsing Binaries.

D Advanced stages of stellar evolution, interstellar gas and dust

* Title of collaboration: **planetary nebulae: chemical composition and evolution**

* Polish participants
Sławomir Górny, CAMK Toruń

* French participants
Grażyna Stasińska, LUTH, Observatoire de Paris

* Abstract of achievements and plans for the future
We have performed a chemical composition study of a large sample of planetary nebulae located in the vicinity of the Galactic bulge, by adding observations performed by S. Gorny to observations published by other authors (Gorny et al 2004). It is the first time that a distinction between bulge population and inner disk population of Galactic planetary nebulae is made. The characteristics of these populations in terms of radial velocities and abundances patterns is very different. We have also looked for Wolf-Rayet signatures in the spectra of our samples of planetary nebulae, and found that the proportion of planetary nebulae with W-R nuclei is much larger in the bulge than in the entire galactic disk.
We are presently extending this study, using a much larger sample of bulge planetary nebulae observed with 4m class telescopes by Chiappini, and comparing the abundance distributions of planetary nebulae to those of stars.

In collaboration with M. Peña, from Mexico, we are revising the question of abundance gradients in the Milky Way, using planetary nebulae as test particles. So far, we have published only progress reports,

* Joint papers

Peña M., Stasinska G., Gorny S.~G., 2006, RMxAC, 26, 24, Using Planetary nebulae to determine the abundance gradient in the Galaxy

Szczerba R., Stasinska G., Gorny S.~K., 2005, AIPC, 804, International Conference on Planetary Nebulae as Astronomical Tools

Gorny S.~K., Stasińska G., 2005, AIPC, 804, 250, Chemical Composition of Planetary Nebulae in two Populations in the Direction of the Galactic Center

Peña M., Stasińska G., Gorny S.~K., 2005, AIPC, 804, 243, Using Planetary Nebulae to Analyze the Abundance Gradient in the Milky Way

Gorny S.~K., Stasińska G., Escudero A.~V., Costa R.~D.~D., 2004, A&A, 427, 231, The populations of planetary nebulae in the direction of the Galactic bulge. Chemical abundances and Wolf-Rayet central stars

* Title of collaboration**: post-AGB objects**

* Polish participants
Ryszard Szczerba, CAMK Toruń
Natasza Siódmiak, CAMK Toruń
Mirosław Schmidt, CAMK Toruń

* French participants
Grażyna Stasińska, LUTH, Observatoire de Paris

* Abstract of achievements and plans for the future

We have created an electronic catalogue of galactic post-AGB objects with aim to use the collected data for further investigation of this still not well understood phase of stellar evolution, between the AGB stage and the planetary nebula stage. This is the first data base constructed on this kind of objects, and required a thorough search in the literature.

We have used this database to show that post-AGB objects may be well used for investigation of nucleosynthesis on AGB, and constitute a sample – overlooked until now - that complements the information from planetary nebulae Further projects based on this catalogue are/will be related to investigation of the shaping process (imaging by SST, VLT and Akari) and to search for new post-AGB objects (using the whole sky survey by Akari).

* Joint papers

Szczerba R., Siódmiak N., Stasińska G., Borkowski J., 2007, A&A, 469, 799, An evolutionary catalogue of galactic post-AGB and related objects

Szczerba R., Siódmiak N., Stasińska G., Borkowski J., 2007, objects ASP conference series "Why Galaxies Care About AGB Stars ?"
Eds. Franz Kerschbaum, Corinne Charbonnel, and Bob Wing(in press) An evolutive catalogue of post-AGB and related objects

Stasińska G., Szczerba R., Schmidt M., Siódmiak N., 2006, A&A, 450, 701, Post-AGB stars as testbeds of nucleosynthesis in AGB stars

Siódmiak N., Szczerba R., Meixner M., Stasińska G., 2006, IAUS, 234, 511, Carbon and oxygen stars evolution in post-AGB phase

Szczerba R., Stasińska G., Górny S.K., 2005, AIPC, 804, International Conference on Planetary Nebulae as Astronomical Tools

* Title of collaboration**: Dust in planetary nebulae and HII regions**

* Polish participants
Ryszard Szczerba, CAMK Toruń

* French participants
Grażyna Stasińska, LUTH, Observatoire de Paris

* Abstract of achievements and plans for the future

Together with collaborators from Germany and Mexico, we have built a comprehensive model of the planetary nebula LMC-SMP61, starting from a detailed model on the central star which was used as an input to the photoionization code of G. Stasinska to model the nebula. Thanks to previous collaboration between G. Stasinska and R. Szczerba, the code includes the effects of dust, and allows one to use the diagnostics frovided by far infrared measurements provided by ISO. We demonstrated that the most up-to-date stellar atmosphere models were not able to account for the intensities of the emission lines produced by the nebula.

In a completely different context, but using our expertise of infrared emission from dust, we have studies the relation between the dust extinction as obtained by the Balmer decrement and the emission in the mid-and far- infrared of a sample of several thousands of galaxies from the Sloan Digital Sky Survey. We have shown that, unexpectedly, the IR emission of these galaxies is not correlated with the extinction.

* Joint papers

Sodre L., Mateus A., Stasińska G., Szczerba R., 2004, IAUS, 222, 215, The Balmer extinction sequence in spiral galaxies

Stasińska G., Mateus A., Jr., Sodre L., Jr., Szczerba R., 2004, A&A, 420, 475, What drives the Balmer extinction sequence in spiral galaxies?. Clues from the Sloan Digital Sky Survey

Stasińska G., Grafener G., Pena M., Hamann W.-R., Koesterke L., Szczerba R., 2004, A&A, 413, 329, Comprehensive modelling of the planetary nebula LMC-SMP 61 and its [WC-type central star.

* Title of collaboration: **Physical and chemical conditions in the translucent clouds.**

* Polish participants: (first name, family name, institution of each member)
Miroslaw Schmidt, N. Copernicus Astronomical Center, Torun

* French participants: (first name, family name, institution of each member)
Maryvonne Gerin, LERMA, Paris

* Abstract of achievements and plans for the future:

We started our collaboration this year with the two 7- and 5-days visits in Paris and in Torun. During visit in Paris one of us (MS) attended conference presenting poster entitled "Molecular line carrieris in the translucent clouds.". During visit in Torun we prepared proposal entitled "Shocks and PDRs in massive star forming regions". The aim of observations was to obtain maps of the massive star forming regions W51, DR21OH and W49 mainly in emission lines of CO and CI with the Caltech Submilimete Observatory. The observations were planned for good weather conditions. The proposal was accepted, but bad weather at the time of observations (4-8 September) disabled realization of the programme. Instead, bolometric observations at 1 mm were obtained. Independently, we started collaboration to develop the model of excitation of NH2 molecule with application to existing observations made earlier by MG. The collaboration is strictly connected with the guaranteed time project for the Herschel Space Observatory. We plan to continue our collaboration during next year.

* Title of collaboration:
Interpretation of UV spectra of symbiotic stars

* Polish participants:
Joanna Mikolajewska, N. Copernicus Astronomical Center, Warsaw

* French participants
Michael Friedjung, Institut d'Astrophysique, Paris (retired since october 2006)

* Abstract of achievements and plans for the future:

We have examined archival IUE, HST and FUSE spectra in order to better understand the physics of these binary objects. We were particularly interested in the radial velocity shift between the intercombination and zero velocity lines of highly ionized elements. In order to do this we examined line profiles and other aspects. We completed and published 2 papers on the interpretation of the emission line formation regions in CI Cygni. We used the emission line fluxes to determine electron densities and to calculate emission measures, suggesting line formation in regions rather smaller than the binary separation. Examination of the radial velocities led to us to find a systematic redshift of the high ionization resonance lines with respect to the intercombination, and He II lines. We discussed possible explanations of the redshift and the high resolution GHRS C IV profile. We favour that involving resonance line absorption by a circum-binary region most probably in an asymmetric wind interaction shell or in a wind from the accretion disk. Another paper on UV emission line regions of symbiotic binaries Z And, AG Dra, AX Per, RW HYa and SY Mus is in preparation.

* Joint papers: name of authors, journal reference, (or arxiv number if not yet published), year, title

Mikołajewska, J.; Friedjung, M.; Quiroga, C., A&A, 460, 191-197, 2006, Line formation regions of the UV spectrum of CI Cygni

Mikołajewska, J.; Friedjung, M., Ap&SS.296, 441-444, 2005, Towards an Understanding of Radial Velocity Shift in UV Spectra of Symbiotic Stars

Friedjung, M.; Mikolajewska, J.; Zajczyk, A.; Eriksson, M.; to be submitted to A&A, 2007, UV Emission line shifts of symbiotic binaries

* Title of collaboration:
Small scale structure in IS clouds

* Polish participants: (first name, family name, institution of each member)
Jacek Krelowski, Center for Astronomy, Nicholas Copernicus University

* French participants: (first name, family name, institution of each member)
Patrick Boissé, Institut d'Astrophysique de Paris

* Abstract of achievements and plans for the future:
During the two stays in Paris of J. Krelowski, the analysis of the spectral data obtained for this program was discussed. In particular, we compared spectra obtained at OHP (PB) and Terskol or BOAO (JK). This pushed us to continue coordinated observations of our target (HD34078) to get a better time sampling and some redundancy. The set of spectra obtained allowed us to clearly establish the reality of strong variations for CH and CH+ absorptions towards HD34078; the analysis of these data (complemented by spectra obtained through a collaboration with S. Federman, USA) and their implications in terms of small scale IS structure will be published soon in a common paper (Boissé et al. 2007, in preparation).

* Joint papers: name of authors, journal reference, (or arxiv number
if not yet published), year, title

Boissé, P., Le Petit, F., Rollinde, E., et al., 2005, A&A, 429, 509,
A far UV study of interstellar gas towards HD 34078: High excitation H2
and small scale structure

Galazutdinov, G. A., Manicò, G., Krelowski, J., 2006, MNRAS, 366, 1075, Blueshifted diffuse interstellar bands in the spectrum of HD 34078

E Dense matter, compact stars and gravitational radiation

* Title of collaboration**: Dense matter and compact stars**

* Polish participants:
Michal Bejger, Pawel Haensel, Julian Leszek Zdunik (CAMK Warsaw)

* French participants
Eric Gourgoulhon, Brandon Carter, Francois Limousin, Silvano Bonazzola (LUTH Meudon), Nicolas Chamel (LUTH Meudon, now at Universite Libre de Bruxelles, Belgium)

* Abstract of achievements and plans for the future:
We studied the effect of phase transitions in neutron stars on their rotational properties. In particular, we found criteria for the dynamical instability during the pulsar spin down, and criteria for the occurrence of the stable back-bending phenomenon. We formulated conjectures on the relation between the instabilities in static and rotating neutron stars, and we have shown them to be valid in various 2-D numerical simulations.

In a series of papers we studied the phenomenon of entrainment of superfluid neutrons by the crystal lattice in neutron star crust. We derived formulae needed for the calculation of neutron effective masses, relevant for the phenomenon of pulsar glitches. We also calculated the entrainment matrix for the liquid neutron star core. We calculated the effect of superfluidity on the non-equilibrium beta processes in neutron star cores.

Using the 3-D code we calculated the impact of the dense matter equation of state on the inspiral phase of the neutron-star – neutron-star coalescing binary, and we found characteristic of gravitational waves emitted by the coalescing binary system.

We plan to continue and expand our studies of coalescing neutron stars by including more physical effects (dissipation, heating, neutron star crust). We plan to undertake studies differential rotation of neutron stars. We also plan to continue our studies of the transport phenomena in dense matter and their application to neutron star dynamics and evolution. We plan to study dynamics of neutron stars including magneto-hydrodynamical effects, and apply them for modelling still mysterious gamma-ray bursts. Our studies of the impact of the phase transitions of dense matter on neutron star rotation will be extended to dynamics of collapse following their instability.

* Joint papers: name of authors, journal reference, (or arxiv number if not yet published), year, title

Gondek-Rosinska, T. Bulik, D., Gourgoulhon,E., M. Bejger, P. Haensel, J.L. Zdunik, 2004, "Gravitational waves from binary neutron stars" in Soci\'et\'e Fran\c caise d'Astronomie et d'Astrophysique:Scientific Highlights 2004, Proc. Semaine de l'Astrophysique Fran\c caise

(Paris, France, juin 2004), Eds. F. Combes, D. Barret, T. Contini, F. Meynadier, L. Pagani, EDP Sciences, p351-354

Zdunik, J.L., P. Haensel, E. Gourgoulhon, M. Bejger, "Hyperon softening of the EOS of dense matter and the spin evolution of isolated neutron stars", 2004, Astronomy and Astrophysics, 416, 1013

M. Bejger, D. Gondek-Rosinska, E. Gourgoulhon, P. Haensel, K. Taniguchi, J. L. Zdunik, 2005, "Impact of the nuclear equation of state on the last orbits of binary neutron stars" Astronomy and Astrophysics, 431, 297

Carter B., Chamel N., Haensel P., 2005, Nucl. Phys. A 748, 745 "Entraiment coefficient and effective mass for conduction neutrons in neutron star crust: simple microscopic models "

Carter B., Chamel N., Haensel P., 2005, Nucl. Phys. A 759, 441 , "Effect of BCS pairing on entrainment in neutron superfluid current in neutron star crust "

Villain L., Haensel P., "Non-equilibrium processes in superfluid neutron-star cores ", 2005, Astron. Astrophys., 444, 539

Villain L., Haensel P., , 2005, Phys. Rev. D 71,083001,« Inertial modes in stratified rotating neutron stars: an evolutionary description »

Zdunik J. L., P. Haensel, M. Bejger,"Spin-up of the hyperon-softened accreting neutron stars", Astron.Astrophys. 441 (2005) 207-211

Carter, B., Chamel, N., Haensel, P. Entrainment Coefficient and Effective Mass for Conduction Neutrons in Neutron Star Crust:. Macroscopic Treatment, 2006 International Journal of Modern Physics D 15, 777

Chamel, N., Haensel, P., Entrainment parameters in a cold superfluid neutron star core, 2006, Physica Review C 73, d5802

Gondek-Rosinska, D, M. Bejger, T. Bulik, D., Gourgoulhon,E., P. Haensel, F. Limousin, J.L.Zdunik, Taniguchi, K., 2006 "The final phase of inspiral of neutron stars: realistic equations of state", Advances in Space Research, in press (doi:10.1016/j.asr.2006.09.021)

Zdunik J.L, M. Bejger, P. Haensel, E. Gourgoulhon, 2007, "Energy release associated with a first-order phase transition in a rotating neutron star core", stronomy and Astrophysics 465, 533

Zdunik, J.L., P. Haensel, M. Bejger E., Gourgoulhon, 2006, "Phase transitions in rotating neutron stars cores: back bending, stability, corequakes, and pulsar timing", Astronomy and Astrophysics 450, 747

* Title of collaboration: **Structure and evolution of neutron stars**

* Polish participants: (first name, family name, institution of each member)
Dorota Rosinska (Gondek), Leszek Zdunik, Pawel Haensel, Tomasz Bulik

* French participants: (first name, family name, institution of each member)
Eric Gourgoulhon, Francois Limousin, Michal Bejger

* Abstract of achievements and plans for the future:

We have modeled the structure and evolution of neutron stars and strange quark stars with particular emphasis on the stages in which gravitational radiation and high energy radiation (X-ray and gamma ray) is emitted. We matched the computed properties to future or existing observations in order to constrain the equation of state (EOS) at supranuclear densities.

In particular we have investigated the properties of: 1)neutron star (or strange quark star) binaries Coalescing compact star binaries are expected to be among the strongest sources of gravitational radiation to be seen by laser interferometers. They are also candidates for short-duration gamma-ray burst sources.

We have performed numerical relativistic calculations of the final phase of inspiral of neutron star binaries and strange quark star binaries. We have used several modern EOS taking into account the existence of hyperons or strange quark matter in the core of a neutron star. The main results is that it would be possible to impose constraints on the nuclear matter EOS from gravitational wave observations of last orbits of inspiral of neutron star binaries (the frequency of gravitational waves at the marginally stable orbit strongly depends on the EOS). We plan to study the influence of phase transition(s) inside neutron star on last orbits of inspiral of neutron star binaries.

In order to choose the initial parameters for the calculation of double neutron star systems we have used the population synthesis method, i.e we synthesized the population of binary neutron stars using the knowledge of the evolution of their progenitors. We have shown that a significant fraction of the observed binary neutron star systems in gravitational waves will have equal masses or will contain stars with low mass ratios < 0.7. The second case has so far been overlooked in relativistic calculations of hydrodynamical inspiral or the merger phase.

2) differentially rotating neutron stars The neutron star binary merger will lead to the formation of a massive, rapidly and differentially rotating neutron star (strange star) or to the prompt collapse to a black hole. The maximum mass of differentially rotating remnant is crucial for distinguishing between these two final objects. Gravitational wave observations of coalescing binary neutron stars may be able to distinguish these outcomes.

We have developed a code to calculate relativistic equilibrium models of differentially rotating neutron stars and found the maximum available mass depending on a degree of differential rotation. We model the stars by adopting a polytropic EOS.

We plan to study the effect of stiffness of EOS on the maximum allowed mass.

3) rapidly rotating neutron stars in Low Mass X-ray Binaries

We have calculated the maximum orbital frequencies of stable circular motion around uniformly rotating relativistic stars using a multi-domain spectral method. We have shown that the properties of orbital motion around strange stars differ from those around neutron stars - it allows a discrimination between different models of dense matter in some theories of kHz QPOs.

* Joint papers:

Gondek-Rosińska D., Bulik T., Belczyński K., 2007, AdSpR, 39, 285, Masses of merging compact object binaries

Gondek-Rosińska D., Bejger M., Bulik T., Gourgoulhon E., Haensel P., Limousin F., Taniguchi K., Zdunik L., 2007, AdSpR, 39, 271, The final phase of inspiral of neutron stars: Realistic equations of state

Gondek-Rosińska D., Bulik T., 2005, AIPC, 801, 227, Maximum orbital frequencies for rotating neutron stars and strange stars and kHz QPOs in low-mass X-ray binaries

Limousin F., Gondek-Rosińska D., Gourgoulhon E., 2005, PhRvD, 71, 064012, Last orbits of binary strange quark stars

Bejger M., Gondek-Rosińska D., Gourgoulhon E., Haensel P., Taniguchi K., Zdunik J.~L., 2005, A&A, 431, 297, Impact of the nuclear equation of state on the last orbits of binary neutron stars

Gondek-Rosińska D., Bulik T., Belczyński K., 2005, MmSAI, 76, 632, Selection effects in detecting gravitational waves from binary inspiral .

Gondek-Rosińska D., Bulik T., Belczyński K., 2005, MmSAI, 76, 513, What can we learn about neutron star binaries from gravity wave observations?.

Limousin F., Gondek-Rosińska D., Gourgoulhon E., 2004, sf2a.conf, 363, Quasi-equilibrium sequences of binary strange quark stars in general relativity

Gondek-Rosińska D., Bulik T., Gourgoulhon E., Bejger M., Haensel P., Zdunik L., 2004, sf2a.conf, 351, Binary neutron stars as sources of gravitational waves

F Heliosphere and astrospheres

The solar wind - interstellar medium interaction

* Polish participants: (first name, family name, institution of each member)
Romana Ratkiewicz-Landowska, Space Research Centre
Jolanta Grygorczuk, Space Research Centre

* French participants: (first name, family name, institution of each member)
Lotfi Ben-Jaffel, Institut d'Astrophysique de Paris

* Abstract of achievements and plans for the future:
Our goal for the research during 2004-2007 was the investigation of the interaction between the solar wind (SW) and the local interstellar medium (LISM). Between many aspects of this interaction we are interested in deriving the unknown strength and orientation of the interstellar magnetic field.

For that purpose we have been using and developing our 3D MHD numerical code. In order to investigate the interaction of the magnetized SW plasma with the magnetized LISM plasma we have introduced the interplanetary (inner) magnetic field (IMF) into our numerical calculations. Up to that moment the analysis of the MHD SW-LISM interaction has been done with the outer magnetic field only. In order to include the IMF we have had to improve the grid of our 3D MHD code. Implementation of the IMF into the code required the modelling of the heliospheric current sheet (HCS). Although the HCS was modelled in the simplest possible way, we have obtained very interesting results in the problem of modelling the heliosphere. As we could expect, the so called numerical reconnection appeared, indicating new, in comparison with previous results, asymmetries of the heliospheric boundary. We realized however that the numerical reconnection may dominate the physical reconnection which requires much more sofisticated model. So in order to reduce the influence of the numerical reconnection we have made many numerical simmulations with different boundary conditions. Our results we presented at the IGPP-UCR Annual International Astrophysics Conferences in 2004, 2005 and 2006. All of them were published in the Conference Proceedings AIP: 719, 781 and 858 (see the list of publications). Recently we attended the Astronum 2007 conference in Paris in June. We presented the poster entitled "What do we know about the local interstellar magnetic field". This paper (submitted for publication) refers to the work done by Ben-Jaffel, Puyoo, Ratkiewicz (ApJ,533:924-930,2000), in which the orientation of the local interstellar magneticfield was for the first time predicted on the basis of theoretical models combined with Voyagers and HST data. The topic is very timely and also discussed by other authors in Science during the last several years.

Since besides the magnetic fields the third very important factor influencing the SW-LISM interaction is the neutral component of the local interstellar medium, parallely we have been working on the fluid and kinetic models describing the distribution of the neutral hydrogen. We would like to stress that up to now the neutral hydrogen has been included into our model as a constant flux , i.e. in a non self-consistent way, providing some information about the influence of the neutral component on the heliosphere.

In our future work we would like to complete the implementation of the fluid and kinetic models for the neutral hydrogen. The models will work with our 3D MHD code iteratively. We also would like to continue the comparison of the observational data with the results from our models. For that purpose we need the further development and improvement of 3D MHD code using the newest techniques, and we need the access to data from the present and future space missions.

* Joint papers: name of authors, journal reference, (or arxiv number
if not yet published), year, title

Ratkiewicz R., Ben-Jaffel L.,Grygorczuk J., 2007, Astronum 2007, submitted

Ratkiewicz R., 2006, ASTRA, 2, 11, MHD modeling of the Heliosphere: a critical evaluation of different models

Ratkiewicz R., Grygorczuk J., Ben-Jaffel L., 2006, AIPC, 858, 27, The interaction between the heliospheric and interstellar magnetic fields at the heliopause

Ratkiewicz R., Grygorczuk J., Ben-Jaffel L., 2005, AIPC, 781, 294, The Termination Shock and Beyond: MHD Modeling

Ratkiewicz R., Grygorczuk J., Ben-Jaffel L., 2004, AIPC, 719, 93, Questions about effects of interplanetary and interstellar magnetic fields on the heliospheric interface

Ratkiewicz R., Grygorczuk J., Ben-Jaffel L., 2004, cosp, 35, 2347, What space missions instruments may see at the heliospheric interface?

G Extrasolar planets

* Title of collaboration**: Modeling radial velocity and photometric observations of stars hosting planets**

* Polish participants:
Krzysztof Gozdziewski, Torun Centre For Astronomy

* French participants:
Jean Schneider, LUTH (Paris Observatory)
Juan Cabrerra, LUTH (Paris Observatory)

* Abstract of achievements and plans for the future:

I. Fitting radial velocity curves with muliplanet models.

During visit of K. Gozdziewski in Meudon (2006) we re-implemented the "kfit" code based on the genetic algorithm for the analysis of radial velocity data sets for different multi-object configurations. Usually, the multi-planet models lead to many equally good orbital solutions. A first step to obtain a quasi-global map of the best fit solution in parameter space is to use Keplerian orbits to model the RV data. The next step of developing the code that we started is of particular importance for evaluating the relevance of bets fits of radial velocity data sets with one or several planets. The best fit solutions in the sense of the best chi2 may be physically unlikely if they correspond to unstable systems. The new fitting procedure includes the dynamical stability as a supplementary constraint. The basic application of the codes is the reanalysis of published solutions. It has already led to the prediction of a few Neptune-like planet candidates; observers are currently planning new observations to verify the existence of these predicted candidates. The methods we applied has been proved to be robust and efficient. The most spectacular result obtained with the "kfit" code is independent detection of a new, 4-th planet in the mu-Arae system with the archive data (Butler, ApJ, 2006).

II. Preparation of some aspects of the analysis of future light curves from the CoRoT satellite

During the visit of K. Gozdziewski in Meudon (2006) we started to work on exploitation of a Lomb-Scargle periodogram for analyzing light-curves. During the next visit (2007) we worked on the dynamical model for the analysis of transit timing in case of 3 body systems: planet+ satellite multi-planet systems, planets in binary star systems. That model include mutual gravitational interactions of the bodies in the system as well tidal forces, relativistic interactions with the parent star and quadrupole distortion of the central body. The model can be used to detect small planets through precise timing of transits. We also discussed the RV follow-up strategy (with cooperation of Maciej Konacki of CAMK, Warsaw).

* Joint papers: name of authors, journal reference, (or arxiv number

if not yet published), year, title

Gozdziewski, K., Maciejewski, A.J., Migaszewski, C.: On the Extrasolar Multiplanet System around HD 160691, 2007, ApJ, 657, 546-558

Gozdziewski, K., Migaszewski, C.: About putative Neptune-like extrasolar planetary candidates, A&A, 449 (3), 2006, 1219-1232.

Gozdziewski K.: Dynamical modeling of multi-planet systems from stellar velocity curves (poster presented at 10-th CoRoT week, Nice, 2006).

LEA Astro-PF workshops

1rst LEA Astro-PF workshop
* title: **Compact Stars:Structure,Dynamics, and Gravitational Waves**

* date and place
October 13-15, 2004, CAMK Warsaw

* main organizer(s)
P. Haensel and J.L. Zdunik

* number of polish participants: 8
* number of french participants: 5
* number of participants from other countries: 3

* topics, highlights and any relevant information

This was a gathering of theorists working on neutron stars and gravitational waves. A group of topics included modelling of pulsations and matter flows in superfluid neutron stars, relevant for neutron stars as sources of gravitational waves and for theories of pulsar glitches. Talks on instabilities of rotating neutron stars and on dissipative damping processes withing them were also presented. Three talks were devoted to modeling of neutron-star quakes due to phase transitions in their cores, which are also potential sources of gravitational waves. Three talks described analyses and modeling of the galactic population of close neutron star binaries (with neutron stars and black holes), whose coalescence might be the most promising sources of gravitational wave bursts.

The presence of a world leading expert on pulsations in rotating neutron stars and their damping by gravitational radiation, Niels Andersson (Southampton University, Great Britain) was crucial for the lively and stimulating atmosphere of the workshop.

2nd LEA Astro-PF workshop
Title: **"Physics of Warm Absorber in AGN"**
Date and place: 5-7.10.2005, CAMK, Warsaw, Poland
Main organizer: Agata Rozanska
Number of polish participants: 8
Number of french participants: 6
Number of participants from other countries: 13
Topics, highlights and any relevant information:
Main subject of the meeting was devoted to the physics of warm absorber in active galactic nuclei (AGN). The warm absorber became a hot topic since the new generations of X-ray satellites (Chandra XMM-Newton) came into use. We see great amount of absorption and emission lines in 90% of AGN. The resolution of satellites allows us to determine line profiles and put constrains on

velocities of absorbing matter, which is most probably outflowing. We have discussed physical conditions and origin of the warm absorber in different types of AGN. We have compared the results of various approaches to modelling the warm absorber, and have discussed the most effective approach to data analysis which would help to constrain the models.

3rd LEA Astro-PF workshop

* Title: **Astro-PF Gamma-Ray Bursts workshop**

Date and place: Copernicus center in Warsaw from the 4 to 6 Oct. 2006.

Main organizers: T. Bulik and M. Denis on the polish side and R. Mochkovitch and P. Goldoni on the french side.

* Polish participants:

K. Belczynski New Mexico State University
W. Brodzinski Copernicus Center, Torun
T. Bulik Copernicus Center, Warsaw
B. Czerny Copernicus Center, Warsaw
M. Denis Space Research Center, Warsaw
J. Dyks Copernicus Center, Torun
A. Galkowska Copernicus Center, Torun
W. Kluzniak Copernicus Center, Warsaw
L. Mankiewicz Copernicus Center, Warsaw
R. Marcinkowski Space Research Center, Warsaw
S. Oslowski Astronomical Observatory of the Warsaw University
G. Pojmanski Astronomical Observatory of the Warsaw University
A. Raiter Copernicus Center, Torun
A. Sadowski Astronomical Observatory of the Warsaw University
G. Wrochna Soltan Institute for Nuclear Studies, Swierk/Otwock

* French participants:

J.L. Atteia Observatoire de Toulouse
M. Boer Observatoire de Haute-Provence
F. Daigne Institut d'Astrophysique de Paris
P. Goldoni Service d'Astrophysique, Saclay
A. Klotz Centre d'Etude Spatiale des Rayonnements, Toulouse
R. Mochkovitch Institut d'Astrophysique de Paris
A. Pelangeon Observatoire de Toulouse
S. Schanne Service d'Astrophysique, Saclay

* Other countries

T. Donaghy University of Chicago
S. Mereghetti IASF, Milano
J. Nousek Penn State, USA

* Topics and highlights

This 3 day meeting was focused on the recent developments in the study of Gamma-Ray Bursts (GRBs) both on the observational and theoretical sides (the full programme and many of the

presentations are available at http://astropf.camk.edu.pl/index.php?sid=7). The first day was devoted to the description of the observational results obtained in space by the three satellites HETE2, Integral and Swift and from the ground by robotic telescopes (Pi of the sky, TAROT). The ECLAIRs satellite project and the future VLT instrument X-shooter for the spectroscopic observation of GRB afterglows were also presented. The ability of Swift to slew in a few minutes to the exact location of a detected GRB has allowed for the first time a detailed follow-up of the early afterglow in the X-ray and visible bands. These observations have led to puzzling results that are not easily explained in the context of standard afterglow models. During the second day two talks have addressed these difficulties and proposed different ways which may help to solve them.

The sensitivity of Swift and the capacity to rapidly localize the detected GRBs has also increased the number of bursts with known redshifts. The redshift distribution has been shifted to larger z values, with a maximum going from 4.5 (pre-Swift) to 6.3 in the Swift era. This has motivated many works on the possible use of GRBs as cosmological tools and several talks discussed the GRB redshift distribution and its consequence for cosmology.

During the third day different possible families of GRB progenitors were presented such as binary neutron stars (for short GRBs) or population III stars (for high-z GRBs). The meeting was a big success. In addition to the registered participants it was also followed by a group of students. The discussions have been very fruitful and possible collaborations have emerged for example on the progenitors of short GRBs (K. Belczynski and R. Mochkovitch), on robotic telescopes (L. Mankiewicz and A. Klotz) or on distance indicators (T. Bulik and A. Pelangeon).

4th LEA Astro-PF workshop
Title**: Non-standard Approach to HESS Data Processing and Interpretation**

The workshop will take place in Nicolaus Copernicus Astronomical Center in Warsaw between 19 and 21 November, 2007 and is mainly sponsored by LEA Astro-PF (Polish-French) collaboration program.

HESS has been proved to be a very successful experiment bringing the very high energy astrophysics to the new era. Recently a group of Polish astronomers has joined the collaboration. The main objective of the workshop is to introduce the new members to the process of data reduction and analysis and to spark discussion on the problems associated with this task. We also aims to discuss the theoretical aspects of the gamma-ray emission mechanism including possible, non-standard interpretation of the data.

The Workshop will consist of two parts:
(i) software development and data analysis tools, and
(ii) theoretical models of high energy emission and its observational implications.

Sponsors: The workshop is mainly sponsored by LEA Astro-PF (Polish-French) collaboration program. The program covers the participation of the French researchers in the workshop, and we will have limited funds to support other participants

Participants (Polish only): Tomasz Bulik (OAUW, Warsaw), Rafal Moderski (CAMK, Warsaw), Bronisław Rudak (CAMK, Torun), Jacek Niemiec (IFJ,

Krakow), Michal Ostrowski (OAUJ, Krakow), Lukasz Stawarz (OAUJ, Krakow), Wlodek Bednarek (IFUL, Lodz), Anna Zajczyk (CAMK, Torun), Agnieszka Sierpowska-Bartosik (IFUL, Lodz), Jaroslaw Dyks (CAMK, Krakow)

Location: The workshop will take place at the Nicolaus Copernicus Astronomical Center in Warsaw, Poland

International conferences sponsored by the LEA Astro-PF

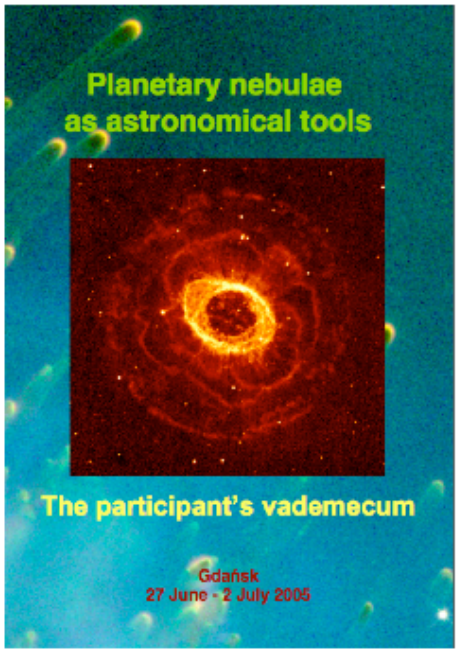
* title of conference: **Planetary Nebulae as Astronomical Tools**

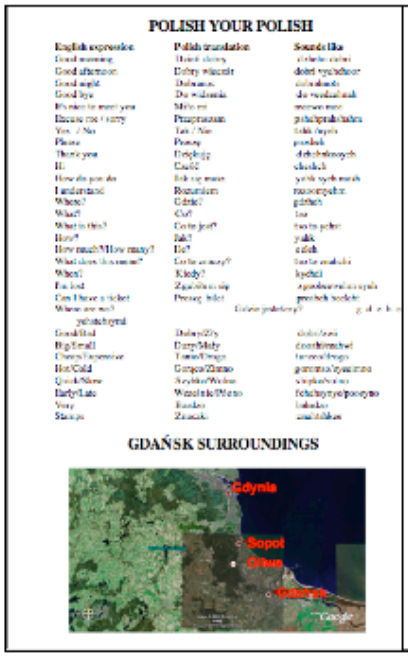
* date and place: 28 June – 2 July 2005, Gdańsk, Poland

* main organizer(s)
Grażyna Stasińska, Ryszard Szczerba

* participants:
12 Polish participants
5 French participants
85 participants from other countries

Extraits du vademecum distribué aux participants de la conférence « Planetary Nebulae as Astronomical Tools »





(conception et réalisation G. Stasinska)

* topics, highlights and any relevant information:
Planetary Nebulae as tests of stellar evolution theories
Planetary Nebulae as tests of stellar nucleosynthesis theories
Planetary Nebulae as tests of stellar atmosphere models
Planetary Nebulae as test of photoionization models
Planetary Nebulae as tests of radiation hydrodynamics
Planetary Nebulae and the interstellar medium
Planetary Nebulae and progenitors as sites of cosmic dust formation
Planetary Nebulae as observational constraints for models
of galaxies chemical evolution
Planetary Nebulae to determine the total masses of galaxies
Planetary Nebulae to detect stellar populations in the intergalactic space
Planetary Nebulae to test dynamical evolution/build up of galaxies
Planetary Nebulae as cosmological candles
Planetary Nebulae as a subject for public outreach

About 15 invited reviews, 3 topical discussions. All posters were advertized by a one-minute oral presentation.

Proceedings of the conference have been published in "International Conference on Planetary Nebulae as Astronomical Tools", AIP Conference Proceedings, Vol. 804. Edited by R. Szczerba, G. Stasinska, and S. K. Gorny.

The conference was accompanied with an intense outreach programme:
- a booklet written by G. Stasinska & M. Kozuchowska "planetary nebulae, flowers of the cosmic fields", distributed to schools in the Gdansk region
- an art contest for school children on planetary nebulae

- an open public lecture on “planetary nebulae, flowers of the cosmic fields”

* title of conference
Evolution and chemistry of symbiotic stars, binary post-AGB and related objects

* date and place
August 28-30, 2006, Wierzba, Poland

* main organizer(s)
Joanna Mikolajewska, Ryszard Szczerba
The conference was dedicated to Michael Friedjung, a participant to the LEA, retiring in the fall of 2006.

* total number of participants
42 (Poland -12, France -1)

* topics, highlights and any relevant information: The main aims of the meeting was to discuss topics related to evolution of symbiotic stars and binary systems with a post-AGB companion. In particular, it was discussed how evolution in binary system influences the physics and chemistry of these systems, how modern techniques allow to search for new members of symbiotic and binary post-AGB objects, as well as how detailed structures of some spectacular systems can be investigated. The scientific program included 9 comprehensive reviews and 35 oral and poster presentations

The conference proceedings was published in Baltic Astronomy, 2007, Vol. 16, No.1, Proceedings of the meeting “Evolution and Chemistry of Symbiotic Stars, Binary Post-AGB and Related Objects”, eds. J. Mikołajewska and R. Szczerba

* title of conference: **From the land of salt to the heavens of SALT**
* date and place: 23-27 september 2007, Krakow
* main organizer(s): Grazyna. Stasinska (France), Dorota Koziel, Staszek Zola (Poland)
* number of polish participants: 35
* number of french participants: 3 (lecturers)
* number of participants frm other countries: 3 (lecturers)
* topics, highlights and any relevant information:

The participation of Poland to the construction of SALT, the Southern African Large telescope, one of the largest single optical telescope in the World, opens new perspectives for Polish Astronomy. In particular, it should allow to develop directions in extragalactic astronomy that were so far little explored by Polish astronomers. We proposed a series of lectures on Extragalactic Astronomy by outsanding lecturers from over the World, to provide an up-to-date introduction to some of the most important aspects of extragalactic astronomy. The school was directed to researchers at all levels (master or PhD students, post-docs as well as confirmed researchers) working or studying in Polish institutions. The "conference" dinner was held insite the salt mine of Wieliczka. The entire school was a success and established new contacts among Polish astronomers and astronomers from France, Switzerland, Brazil and the US.

* title of conference: **Extrasolar planets in multi-body systems: theory and observations**
* date and place: June 2008 (planned), Torun, Poland
* main organizer(s): K. Gozdziewski, M. Konacki, Jean Schneider,
* number of polish participants 20
* number of french participants 5

* number of participants from other countries 30
* topics, highlights and any relevant information

The topics of the workshop will be related to the observations, analysis of data and the dynamics of extrasolar planet in multi-body environments, in particular:

- planets in binary star systems
- multiplanet systems
- satellites of planets in multi-planet systems

Some comments on the LEA Astro-PF by the participants

Je souhaiterais souligner ici combien l'aide de ce programme a été efficace en ce qui concerne nos activités. Deux fois l'an, dans les observatoires respectifs, le travail en commun a permis de lever des ambiguïtés difficiles à traiter par internet, de nous mettre au courant de visu de méthodes nouvelles de traitement des données et de favoriser le développement de nouvelles collaborations avec des scientifiques d'autres pays.
Je tenais à vous remercier au nom de tous pour l'aide efficace apportée à nos études.

Edouard Oblak

LEA Astro-PF has proved to be a very fruitful binational scientific collaboration. Let's hope it will not be spoiled by ad-hoc unwise administrative decisions.

Michal Chodorowski

This collaboration would not have been possible with the support of the LEA

Gary Mamon

The participants valued very much the flexibility of the scheme, i.e. the good amount of freedom in arranging the collaboration, without having to fill in extensive paperwork.

Witold Maciejewski

In the past we found the LEA program easy. It represented an efficient source of financing our collaboration. However, the increasing 'paper work' with time connected to LEA prompts us not to think very optimistic about the future.

Bernd Vollmer

The LEA is particularly good for the flexibility it offers to the community. One of the most important aspects of the LEA in our case has been to strengthen ties between French and Polish teams that are now working within the HESS collaboration. Poland was not in the HESS collaboration when this work was started. The exchanges made possible by the LEA have certainly helped create right away and very easily collaborations within HESS with Polish colleagues. Visits to CAMK have been extremely positive in this respect.

Rafal Moderski

The Astro-LEA French-Polish exchange program has greatly supported the work described above. Regular mutual visits by Bozena Czerny and Agata Rozanska to the Observatoire de Meudon and by Martine Mouchet, Anne-Marie Dumont, Anabela C. Goncalves, and Rene Goosmann to the Copernicus Center in Warsaw enabled close and efficient collaboration. The LEA program further enables a long (2 to 4 months) stay of Anabela C. Goncaalves as a visiting scientist at the

Copernicus Center in Warsaw. This visit is soon to begin and will be very beneficial for our current and future work on X-ray flares in AGN.

René Goosman

During the October 2005 visit, A.C. Gonçalves also participated to the Warm Absorber Workshop organized by A. Rozanska. It was the opportunity to meet with many X-ray Astronomy experts and get involved in numerous exciting debates taking place in a friendly and professional environment. CAMK facilities are excellent, matched only by the warm welcome provided by our Polish collaborators.
This successful story of a close and efficient collaboration was commented in a short television film by Krzysztof Kownas, diffused by the Polish television. A.C. Gonçalves participated in that movie, sharing her experience in the framework of the Astro-LEA French-Polish collaboration.

Anabela Gonçalves

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