Russian Conference on

Physics of Neutron Stars

ABSTRACTS

June 24–27, 2008

Ioffe Physical-Technical Institute

Saint-Petersburg

Russian Conference on
PHYSICS OF NEUTRON STARS

ABSTRACTS

June 24–27, 2008

Ioffe Physical-Technical Institute
Saint-Petersburg

Editors: D. A. Varshalovich, A. I. Chugunov, A. Y. Potekhin, and D. G. Yakovlev

Saint-Petersburg

Saint-Petersburg State Polytechnical University Publishing
2008

Preface

The conference on Physics of Neutron Stars at the Ioffe Physical-Technical Institute on June 24–27, 2008 is the eighth neutron star event in Saint-Petersburg (after those in 1988, 1992, 1995, 1997, 1999, 2001, 2005). Its aim is to bring together physicists and astrophysicists working on neutron stars and related problems. The conference covers all subjects relevant to theory and observations of neutron stars: radiation (from radio to hard gamma-rays), origin, evolution in binary systems, radio pulsars, X-ray pulsars, X-ray bursters, transients, soft gamma repeaters, anomalous X-ray pulsars, internal structure, atmospheres, neutrino emission, etc. The official language of the conference is Russian, but there are a few talks in English.

Scientific Organizing Committee:

D.A. Varshalovich (Chair, Ioffe Institute)
R.L. Aptekar (Ioffe Institute)
G.S. Bisnovatyi-Kogan (Space Res. Inst., Moscow)
A.M. Bykov (Ioffe Institute)
A.I. Chugunov (Ioffe Institute)
M.E. Gusakov (Ioffe Institute)
V.S. Imshennik (Inst. Theor. Exper. Phys., Moscow)
A.V. Ivanchik (Ioffe Institute)
A.D. Kaminker (Ioffe Institute)
A.M. Krassilchtchikov (Ioffe Institute)
S.B. Popov (Sternberg Astron. Inst., Moscow)
K.A. Postnov (Sternberg Astron. Inst., Moscow)
A.Y. Potekhin (Ioffe Institute)
Yu.A. Shibanov (Ioffe Institute)
D.G. Yakovlev (Ioffe Institute)

The book presents all abstracts (invited talks, contributed talks, and posters), list of participants and the programme.

Acknowledgments. The conference was supported by:

- Russian Foundation for Basic Research
- Dmitry Zimin *Dynasty Foundation*
- Physics Branch of the Russian Academy of Sciences
- Saint-Petersburg Branch of the Russian Academy of Sciences

ISBN 978-5-7422-1877-7

Contents

List of participants and their contributions

The last column shows the session number (where 'P1' and 'P2' correspond to the poster sessions 1 and 2, respectively). The schedule is given on page 96.

Review talks (30 minutes, including questions)

Name	Institution	Presentation	
G. Bisnovatyi-Kogan	*Space Research Institute* (Moscow, Russia)	Gamma ray bursts, Soft gamma repeaters, and Magnetars	5
S. Blinnikov	*Alikhanov ITEP* (Moscow, Russia)	Most Luminous Supernovae	1
Yu. Gnedin	*Pulkovo Observatory* (St.Petersburg, Russia)	XEUS and MAXIM Science: Observations of Compact Cosmic Objects	13
S. Grebenev	*Space Research Institute* (Moscow, Russia)	Supergiant Fast X-ray Transients: Observational Properties and Physical Model	9
P. Haensel	*CAMK* (Warsaw, Poland)	Deep crustal heating in accreting neutron stars	14
V. Imshennik	*Alikhanov ITEP* (Moscow, Russia)	Gravitational radiation from approaching neutron stars and problem of gravitational signal from SN 1987A	1
A. Kaminker	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	Heating and cooling of magnetars with accreted envelopes	15
M. Liebendörfer	*University of Basel* (Basel, Switherland)	Neutrino transport for 3D supernova models	1
P. Lundqvist	*Stockholm Observatory* (Stockholm, Sweden)	The origin of Type Ia supernovae	3
D. Nadyozhin	*Alikhanov ITEP* (Moscow, Russia)	Neutrino scattering in the neutrino heat conduction theory	3
V. Pal'shin	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	Gamma-ray bursts with prompt optical emission	4
F.-K. Thielemann	*University of Basel, Dept. of Physics* (Basel, Switzerland)	Explosive Hydrogen Burning during Type I X-Ray Bursts on Neutrons Stars	8
L. Titarchuk	*George Mason University and Naval Research Laboratory* (Washington D.C., USA)	On the Nonrelativistic Origin of Redskewed Iron Lines in CV, Neutron Star and Black Hole Sources	10

Regular talks (15+5=20 min)

Name	**Institution**	**Presentation**	
M. Baldo	*INFN Sezione di Catania* (Catania, Italy)	The neutron matter Equation of State at low density	11
D. Blaschke	*JINR* (Dubna, Russia); *University of Wroclaw* (Wroclaw, Poland)	Color superconducting quark matter in compact stars	8
F. Burgio	*INFN Sezione di Catania* (Catania, Italy)	Composition and structure of protoneutron stars with the Brueckner-Bethe-Goldstone theory	11
M. Chernyakova	*DIAS* (Dublin, Ireland)	Multiwavelength properties of gamma-ray-loud binary systems	9
A. Chugunov	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	Fusion reactions in dense matter: Effects of plasma screening	14
D. Dumsky	*PRAO ASC FIAN* (Pushchino, Russia)	The detection of a new RRAT (Rotating Radio Transient) class pulsar PSR J2225+35	5
T. Fischer	*Department of Physics, University of Basel* (Basel, Switzerland)	Exploring the possibility of a first order phase transition to quark matter in core collapse supernovae	2
M. Gusakov	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	The entrainment matrix of superfluid nucleon-hyperon mixture	15
V. Gvaramadze	*Sternberg Astronomical Institute* (Moscow, Russia)	High-velocity neutron stars as the remnants of high-velocity runaway stars	8
A. Harutyunyan	*Yerevan State University, Radiophysics Faculty* (Yerevan, Armenia)	On superdense stars containing quark matter	11
U. Heinzmann	*Institute of Theoretical Physics* (Frankfurt, Germany)	Neutron star structure determined by nuclear physics	11
J. Henderson	*Instituto de Astronomia, Universidad Nacional Autonoma de Mexico* (Mexico City, Mexico)	Cooling of neutron stars with strong toroidal magnetic fields II: Cooling in 2D	15

Regular talks (continued)

N. Ikhsanov	*Pulkovo Observatory* (St.Petersburg, Russia)	On the nature of long-period X-ray pulsars	10
I. Iosilevskiy	*Moscow Institute of Physics and Technology* (Moscow, Russia)	Phase transitions in neutron stars. Are they non-congruent?	13
E. Kantor	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	Damping of sound waves in superfluid nucleon-hyperon mixture	15
Vl. Kocharovsky	*Institute of Applied Physics of RAS* (Nizhny Novgorod, Russia)	Formation, structure, evolution, and radiation of current sheets and filaments in collisionless relativistic plasma	8
V. Kondratiev	*West Virginia University* (Morgantown, WV, USA)	The Magnificent Seven: New limits on radio emission	6
V. Kontorovich	*Institute of Radio Astronomy of NAS of Ukraine* (Kharkov, Ukraine)	On the nature of high brightness temperatures of pulsar giant pulses	5
K. Levenfish	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	Superfluidity in NS cores and heating in NS crusts: constraints from the data on quiescent SXTs	14
U. Lombardo	*INFN Sezione di Catania* (Catania, Italy)	Transition to deconfined phase in neutron stars	11
A. Lutovinov	*Space Research Institute* (Moscow, Russia)	X-ray pulsars through the eyes of the current cosmic observatories	9
I. Malov	*PRAO ASC FIAN* (Moscow, Russia)	"Anomalous" pulsars	8
K. Manukovskiy	*Alikhanov Institute for Theoretical and Experimental Physics* (Moscow, Russia)	3D explosion dynamics of a critical-mass neutron star in a binary system	3
S. Moiseenko	*Space Research Institute* (Moscow, Russia)	Different magnetorotational supernovae	3
P. Oleynik	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	Konus-Wind observation of short GRBs	4
I. Panov	*Alikhanov Institute for Theoretical and Experimental Physics* (Moscow, Russia)	Dynamics of proto-neutron star neutrino wind and the r-process	1

Regular talks (continued)

S. Petrova	*Institute of Radio Astronomy of NAS of Ukraine* (Kharkov, Ukraine)	On the nature of the physical connection between radio- and high-energy emissions of pulsars	6
S. Popov	*Sternberg Astronomical Institute* (Moscow, Russia)	Extragalactic magnetars and transient radio sources	5
K. Postnov	*Sternberg Astronomical Institute* (Moscow, Russia)	Observation and appearance of magnetospheric instability in flaring activity at the onset of X-ray outbursts in A 0535+26	9
J. Poutanen	*University of Oulu* (Oulu, Finland)	Time-dependent simulations of the spreading layers and the origin of quasi-periodic oscillations in accreting weakly-magnetized neutron stars	10
A. Pozanenko	*Space Research Institute* (Moscow, Russia)	Is the class of short GRB homogenous?	4
I. Sagert	*Institute for Theoretical Physics* (Frankfurt, Germany)	Soft equation of state from heavy ion data and implications for compact stars	13
P. Shternin	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	Neutron star cooling after deep crustal heating in the X-ray transient KS 1731-260	14
V. Sokolov	*SAO RAS* (Nizhnij Arkhyz, Russia)	Supernova explosions, gravitational collapse and gamma-ray bursts	4
V. Suleimanov	*Institute for Astronomy and Astrophysics* (Tuebingen, Germany); *Kazan State University* (Kazan, Russia)	Absorption features in the spectra of X-ray bursting neutron stars	10
A. Timokhin	*University of California Berkeley* (Berkeley, USA)	Rotation-powered pulsars: how do their engines work?	6
A. Tsygan	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	What determines the inclination angle of radio pulsars	6
V. Utrobin	*Alikhanov Institute for Theoretical and Experimental Physics* (Moscow, Russia)	Supernova 2005cs and the origin of type IIp supernovae	2

Regular talks (continued)

Y. Uvarov	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	Time variability of nonthermal radiation in the vicinity of the forward shock of Cas A supernova remnant	2
L. Zdunik	*CAMK* (Warsaw, Poland)	Phase transitions and core-collapse in the neutron stars	13

Posters

Name	Institution	Presentation	
M. Abubekerov	*Sternberg Astronomical Institute* (Moscow, Russia)	About the mass of the compact object in the X-ray binary Her X-1/HZ Her	P2
A. Andrianov	*Moscow Institute of Physics and Technology* (Moscow, Russia)	Limiting polarization of the pulsar radio emission	P1
N. Babkovskaya	*U. Oulu* (Oulu, Finland)	Boundary layer on the surface of a neutron star	P2
D. Badjin	*Sternberg Astronomical Institute* (Moscow, Russia)	Radio pulsars in close pairs with neutron stars	P1
S. Bastrukov	*JINR* (Dubna, Russia)	QPOs in the aftermath X-ray flare of SGRs as manifestations of quake-induced torsional elastic and hydromagnetic vibrations of magnetars	P2
A. Bilous	*Moscow Institute of Physics and Technology; Astro Space Center of Lebedev Physical Institute* (Moscow, Russia)	On the energy distribution of single pulses from radio pulsars	P1
A. Bogomazov	*Sternberg Astronomical Institute* (Moscow, Russia)	Radio pulsars in close pairs with neutron stars	P2
I. Chelovekov	*Space Research Institute* (Moscow, Russia)	Bursts detected in hard X-rays by the IBIS telescope onboard the INTEGRAL observatory in 2003-2007	P2

Posters (continued)

E. Chuikin	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	On millisecond and submillisecond hard gamma-ray pulsations from observations of the Crab pulsar with the GAMMA-1 Telescope	P2
A. Egorov	*Moscow State University* (Moscow, Russia)	Observational appearance of supernova shock interaction with neutron star magnetosphere: A model for millisecond extra-galactic radio burst	P1
A. Ershov	*PRAO ASC FIAN* (Pushchino, Russia)	A very large glitch in the pulsar PSR B2334+61	P1
A. Flanchik	*Institute of Radio Astronomy of NAS of Ukraine* (Kharkov, Ukraine)	Induced Compton gamma radiation formed in the pulsar vacuum gap	P1
M. Garasyov	*Institute of Applied Physics of RAS* (Nizhny Novgorod, Russia)	Transfer of gyroresonant radiation in neutron star atmospheres	P2
A. Gruzinov	*New York University* (New York, USA)	Dissipative pulsar magnetosphere	P2
— ” —	— ” —	Maximal magnetic field of a neutron star	P2
V. Gvaramadze	*Sternberg Astronomical Institute* (Moscow, Russia)	2+2=3	P2
A. Gvozdev	*Yaroslavl State University* (Yaroslavl, Russia)	Neutrino losses in a giant flare from SGR	P2
D. Iakubovskyi	*BITP* (Kiev, Ukraine)	Boiling of nuclear liquid in core-collapse supernova explosions	P1
I. Iosilevskiy	*Moscow Institute of Physics and Technology* (Moscow, Russia)	Plasma polarization in massive astrophysical objects	P2
V. Kauts	*Astro Space Center of the Lebedev Physical Institute (ASC FIAN)* (Moscow, Russia)	Dark matter halo around a neutron star	P2
V. Komarova	*SAO RAS* (Nizhnij Arkhyz, Russia)	Search for optical counterparts to isolated neutron stars with the 6-meter Telescope of SAO RAS	P1

Posters (continued)

V. Kondratiev	*West Virginia University* (Morgantown, WV, USA)	Probing the limits of the giant pulse population	P1
I. Korneev	*Alikhanov ITEP* (Moscow, Russia)	Can the superheavy elements be formed in the r-process?	P2
Yu. Krivosheyev	*Space Research Institute* (Moscow, Russia)	Monte-Carlo simulations of the X-ray spectrum of SS433	P2
T. Larchenkova	*Astro Space Center of the Lebedev Physical Institute (ASC FIAN)* (Moscow, Russia)	Is it possible to detect the intermediate mass black holes in centers of globular clusters with the help of milliseconds pulsars?	P2
G. Machabeli	*E.Kharadze National Abastumani Astroph. Observ.* (Tbilisi, Georgia)	Pulsar winds: transition to a force free regime	P2
D. Malyshev	*DIAS* (Dublin, Ireland); *BITP* (Kiev, Ukraine)	Electron-proton temperature equilibration mechanisms in SNRs	P1
P. Minaev	*MSU* (Moscow, Russia)	Searching for signature of extended emission in short GRBs registered by SPI-ACS of INTEGRAL observatory	P1
A. Moskvitin	*SAO RAS* (Nizhnij Arkhyz, Russia)	Gamma-ray bursts and the most distant supernovae in the Universe	P1
D. Nagirner	*Sobolev Astronomical Institute, St.Petersburg State University* (St.Petersburg, Russia)	Compton scattering of radiation in a strong magnetic field: relativistic kinetic equation and cross-sections	P2
I. Ognev	*Yaroslavl State University* (Yaroslavl, Russia)	Neutrino processes in magneto-rotational model of supernova explosion	P1
A. Okrugin	*Yaroslavl State University* (Yaroslavl, Russia)	Neutrino magnetic moment and the shock wave revival in a supernova explosion	P1
S. Petrova	*Institute of Radio Astronomy of NAS of Ukraine* (Kharkov, Ukraine)	Radio profile components outside the main pulse	P1
— " —	— " —	A model for the radio emission pattern of the Crab pulsar	P1
S. Popov	*Sternberg Astronomical Institute* (Moscow, Russia)	Tkachenko waves and precession in neutron stars	P2

Posters (continued)

K. Postnov	*Sternberg Astronomical Institute* (Moscow, Russia)	Constraints on massive gravitons from pulsar timing and astrometric measurements	P2
M. Prokhorov	*Sternberg Astronomical Institute* (Moscow, Russia)	Russian Space Astrometrical Experiment "Svecha"	P1
— " —	— " —	Russian Space Photometrical Survey "Lyra"	P1
D. Rumyan-tsev	*Yaroslavl State University* (Yaroslavl, Russia)	Influence of a photon-neutrino processes on the magnetar cooling	P2
— " —	— " —	The influence of the magnetar thermal emission on pair production	P2
N. Semenets	*ETM Company* (St.Petersburg, Russia)	Dependence of the rotation periods of millisecond pulsars on metallicity of globular clusters	P2
N. Serafimo-vich	*Stockholm Observatory* (Stockholm, Sweden)	Optical and X-ray emission from PSR 0540–69.3 and its pulsar-wind nebula	P2
T. Shabanova	*PRAO ASC FIAN* (Pushchino, Russia)	Slow and normal glitches in PSR B1822–09	P2
P. Shternin	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	Landau damping and kinetics of neutron stars	P2
D. Sobyanin	*Moscow Institute of Physics and Technology* (Moscow, Russia)	Photon splitting and pair creation in a magnetar magnetosphere	P2
D. Teplykh	*PRAO ASC FIAN* (Pushchino, Russia)	Detection of pulsed periodic radio emission from 4U 0142+62	P2
A. Tolstov	*Alikhanov ITEP* (Moscow, Russia)	Relativistic effects of radiative transfer at supernova shock breakout	P1
N. Vigdorchik	*Saint-Petersburg Technological Institute* (St.Petersburg, Russia)	Second harmonic generation of electromagnetic radiation by electron-positron vacuum	P2
A. Yudin	*Alikhanov ITEP* (Moscow, Russia)	Excluded volume approximation for supernova matter	P1
D. Zyuzin	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)	Optical identification of the 3C 58 pulsar and its wind nebula	P2
— " —	— " —	The optical detection of the pulsar wind nebula in the young galactic SNR G292.0+1.8	P2

Other participants (non-speakers)

Name	Institution
D. Barsukov	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)
V. Belyaev	*JINR* (Dubna, Russia)
A. Bukhvostov	*Petersburg Nuclear Physics Institute* (St.Petersburg, Russia)
I. Gurevich	*Institute of Informatics Problems of RAS* (Moscow, Russia)
S. Glazirin	*Moscow Institute of Physics and Technology* (Moscow, Russia)
S. Holin	*VNIIEF* (Sarov, Russia)
V. Kudryavtsev	*Petersburg Nuclear Physics Institute* (St.Petersburg, Russia)
A. Mushtukov	*Sobolev Astronomical Institute, St.Petersburg State University* (St.Petersburg, Russia)
V. Molokanov	*Alikhanov ITEP* (Moscow, Russia)
D. Svinkin	*Ioffe Physical-Technical Institute* (St.Petersburg, Russia)

About the mass of the compact object in the X-ray binary Her X-1/HZ Her

M. K. Abubekerov,[1*], E. A. Antokhina[1], A. M. Cherepashchuk[1], V. V. Shimanskii[2]

[1]Sternberg Astronomical Institute, Moscow

[2]Kazan State University

For the first time we estimate masses of the components of the X-ray binary Her X-1/HZ Her taking into account non-LTE effects during the formation of the absorption line H_γ. Our calculation is conducted in the Roche model on the basis of the observed radial-velocity curve of the HZ Her star [1]. Taking into consideration non-LTE effects during the formation of absorption lines in the spectrum of the optical star, we estimate the masses of the components as $m_x = 1.8M_\odot$ and $m_v = 2.5M_\odot$. The estimated masses of the X-ray pulsar and the optical star obtained in the LTE model are $m_x = 0.85\pm0.15M_\odot$ and $m_v = 1.87\pm0.13M_\odot$, respectively. It is demonstrated that the masses of the components of Her X-1/HZ Her, calculated on the basis of radial velocity curve, cannot be taken as final. We show that, to this aim, one should take into account high frequency variations of absorption line profiles in the spectrum of the optical companion in the non-LTE model; see Ref. [2], for details.

References

[1] A.P. Reynolds, H. Quaintrell, M.D. Still et al. MNRAS, 288, 43 (1997)

[2] M.K. Abubekerov, E.A. Antokhina, A.M. Cherepashchuk and V.V. Shimanskii. Astron. Rep., in press (2008)

*E-mail: marat@sai.msu.ru

Limiting polarization of the pulsar radio emission

A. N. Andrianov[1,2*], V. S. Beskin[1†]

[1]P. N. Lebedev Physical Institute, Moscow

[2]Moscow Institute of Physics and Technology, Dolgoprudny

In spite of forty years of extensive studies, there is no common point of view on the nature of coherent radio emission of radio pulsars [1]. Moreover, propagation effects in a pulsar magnetosphere were not analyzed carefully enough. For instance, the effect of limiting polarization was considered only in [2], where the magnetic field was assumed to be infinite. This approach does not allow one to determine correctly circular polarization of outgoing waves and, hence, restricts essentially the quantitative analysis within the hollow-cone paradigm.

We used the method of wave propagation in inhomogeneous media described in [3]. This approach allows us to include into consideration not only the transition from geometrical optics to vacuum propagation but swings of the magnetic field as well. As is well-known, the polarization of outgoing waves forms in the region, where

$$\left[\frac{1}{(1+q^2)}\frac{\mathrm{d}q}{\mathrm{d}r}\right]^2 \sim \left|\frac{\omega^2}{c^2}(\Delta n)^2 + 2i\frac{\omega}{c}\frac{\mathrm{d}\Delta n}{\mathrm{d}r}\right|. \qquad (1)$$

Here, $\Delta n = n_1 - n_2$, and the parameter q is determined as $K = iE_x/E_y = q \pm \sqrt{1+q^2}$ (see [4] for details; our approach results in the same condition). Using the hydrodynamical expression of the dielectric tensor, one can find that the polarization parameter q_∞ at infinity can be evaluated as $q_\infty \approx q(r_{\rm esc}) \approx 1/\theta(r_{\rm esc})$, where θ is the angle between the wave vector $\mathbf{k}$ and magnetic field $\mathbf{B}$. For ordinary pulsars (period $P \sim 1$ s, magnetic field $B_0 \sim 10^{12}$ G, multiplicity parameter $\lambda \sim 10^4$), polarization is formed inside the light cylinder at the distance $r_{\rm esc} \sim (100 - 1000)R$ from the neutron star, where

$$q_{\rm esc} \sim 10 - 100. \qquad (2)$$

This value corresponds to 1–10% circular polarization of observable radio pulses. Numerical simulation allows us to determine polarization characteristics for arbitrary parameters of radio pulsars.

References

[1] V. S. Beskin. Physics Uspekhi, 42, 1071 (1999)

[2] S. A. Petrova, Yu. E. Lyubarskii. A&A, 355, 1168 (2000)

[3] Yu. A. Kravtsov, Yu. I. Orlov. *Geometrical Optics of Inhomogeneous Media* (Berlin: Springer, 1990)

[4] V. V. Zheleznyakov. *Radiation in Astrophysical Plasmas* (Boston: Kluwer, 1996)

*E-mail: andrianov_andrey@mail.ru

†E-mail: beskin@lpi.ru

Boundary layer on the surface of a neutron star

N. S. Babkovskaya

University of Oulu (Oulu, Finland)

In an attempt to model the accretion onto a neutron star in low-mass X-ray binaries, we present two-dimensional hydrodynamical models of the gas flow in a close vicinity of the stellar surface. First we consider the case in which a gas pressure dominates, assuming that the star is non-rotating. For the stellar mass, we take $M_{\rm star} = 1.4 \times 10^{-2}\,M_\odot$ and for the gas temperature, $T = 5 \times 10^6$ K. Our results are qualitatively different in the case of a realistic neutron star mass and a realistic gas temperature of $T \simeq 10^8$ K, when the radiation pressure dominates. We show that to get a stationary solution in the latter case, the star most probably has to rotate with a considerable velocity.

Investigation of thermal effects appearing due to gamma-ray heating of circumstellar environment

D. A. Badjin[1], S. I. Blinnikov[2], K. A. Postnov[1]

[1]Sternberg Astronomical Institute, Moscow, Russia

[2]Alikhanov Institute for Theoretical and Experimental Physics, Moscow, Russia

The investigation of the influence of gamma-ray emission on relatively dense ($n \sim 10^{13}$ cm^{-3}) structures in the environment of GRBs ($<$ 0.1 pc) is presented. Processes of the matter heating under the effect of time-dependent ionization and processes of following plasma cooling are studied. This mechanism can be responsible for the observed irregularities of optical afterglow light curves and X-ray spectral lines.

The neutron matter Equation of State at low density

M. Baldo, C. Maieron

INFN Sezione di Catania (Catania, Italy)

Neutron matter at low density is studied within the hole-line expansion. Calculations are performed in the range of Fermi momentum k_F between 0.4 and 0.8 fm^{-1}. The following features are found:

1. The Equation of State is determined only by the $^1S_0$ channel;
2. The contribution of three-body forces is quite small;
3. The effect of the single particle potential is negligible;
4. The three hole-line contribution is below 5 per cent of the total energy and is, indeed, vanishingly small at the lowest densities.

Despite the unitary limit is actually never reached, the total energy stays very close to one half of the free gas value throughout the considered density range. To clarify the origin of this behavior, we show that a rank one separable representation of the bare NN interaction, which reproduces the physical scattering length and effective range and is actually determined only by these two physical quantities, gives results almost indistinguishable from the full Brueckner G-matrix calculations with a realistic force. The extension of the calculations below $k_F = 0.4$ fm^{-1} does not indicate any pathological behavior of the neutron Equation of State. The main correlation in the low density range appears to be the Pauli principle, whose effect is still strong even for these low values of the Fermi momentum. Comparisons with other calculations are discussed. The neutron matter Equation of State in the low density region seems to be well established.

QPOs in the aftermath of X-ray flare of SGRs as manifestations of quake-induced torsional elastic and hydromagnetic vibrations of magnetars

S. I. Bastrukov[1], H-K. Chang[2], I. V. Molodtsova[1], D. V. Podgainy[1], G.-T. Chen[2]

[1]JINR (Dubna, Russia)

[2]National Tsing Hua University (Hsinchu, Taiwan)

A brief outline of the developed theory of torsional elastic and hydromagnetic nodeless vibrations in a quaking magnetar is given with the emphasis on identification of these vibrational modes in the frequency spectra of quasi-periodic oscillations of X-ray luminosity during the flares of SGR 1806–20 and SGR 1900+14.

On the energy distribution of single pulses from radio pulsars

A. V. Bilous[1,2*], M. V. Popov[2], O. M. Ulyanov[3]

[1]Moscow Institute of Physics and Technology, Moscow, Russia

[2]Astro Space Center of Lebedev Physical Institute, Moscow, Russia

[3]Institute of Radio Astronomy of NAS of Ukraine, Kharkiv, Ukraine

In this work we study two phenomena of short abrupt increase of pulsar radio emission – Giant Pulses (GPs) and Abnormally Intensive Pulses (AIPs). Both of them are quite rare phenomena – so far they are known only for a handful of pulsars. GPs are detected in the range from 23 MHz to 15 GHz[†] and consist of the series of very short, bright and highly polarized bursts. AIPs were discovered recently [1] at decimeter wavelengths, and, similar to GPs, they are narrower and much brighter than the average profile of radio emission.

Our efforts are concentrated to determine the energy distribution of single pulses. It is known that GP energies are distributed in accordance with the power law, and the exponent depends on the pulsar, observed frequency and range of pulses widths [2]. The exponent typically varies from -0.9 to -3.2 for the cumulative distribution. In this work, we study (for the first time) the energy distribution of GPs from the Crab pulsar at 600 and 1650 MHz with respect to their widths. The energy distribution of AIPs is obtained from observations of PSR B0809+74 at 23 MHz. We compare the distributions of GPs and AIPs to the appropriate distribution of regular pulses. Other statistical properties of GPs and AIPs are also discussed. The results can be used to set the constrains on the theories of pulsar radio emission.

References

[1] O. M. Ulyanov, V. V. Zaharenko, A. A. Konovalenko et.al. The discovery of single pulses from pulsars 0809+74; 0834+06; 0943+10; 0950+08; 1133+16 at decimeter wavelengths. Radiofizika i Radioastronomiya, 11, 113–133 (2006).

[2] M. V. Popov, B. Stappers. Statistical properties of giant pulses from the Crab pulsar. A & A 470, 1003–1007 (2007).

*E-mail: hanna.bilous@gmail.com

†For example, see the results of our recent multifrequency observational campaign of the Crab pulsar at http://dunbar.phys.wvu.edu/∼vlad/projects/crab2007/

Gamma ray bursts, Soft gamma repeaters, and Magnetars

G. S. Bisnovatyi-Kogan

Space Research Institute (IKI) (Moscow, Russia)

Soft gamma repeaters (SGRs) have been collected in a separate group of objects which show gamma ray bursts (GRBs), being very close to them observationally. Only four SGRs have been discovered since 1979. They are considered as galactic objects, and two extragalactic giant SGR bursts have been recently discovered. GRBs are identified as cosmological sources with red shifts sometimes exceeding 6. The most intriguing discovery of this year was the observation of the prompt optical light curve of the GRB 080318B, which should shed an additional light to the nature of GRBs. SGRs are interpreted as highly magnetized neutron stars – magnetars. Due to a slow rotation, the magnetic field is considered as the main source of energy in magnetars, especially for their giant bursts. Observational data on SGR giant bursts are analyzed, and the magnetar concept is criticized. An alternative model, based on nuclear processes in neutron stars, is discussed.

Color superconducting quark matter in compact stars

David Blaschke[1,2]

[1]Institute for Theoretical Physics, University of Wroclaw, Poland

[2]Bogoliubov Laboratory for Theoretical Physics, JINR Dubna, 141980 Dubna, Russia

Recently, observations of compact stars have provided new data of high accuracy which put strong constraints on the high-density behaviour of the equation of state of strongly interacting matter otherwise not accessible in terrestrial laboratories [1]. Indications for high neutron star masses ($M \sim 2\, M_\odot$) and large radii ($R > 12$ km) could rule out soft equations of state and have provoked a debate whether the occurence of quark matter in compact stars can be excluded as well. We show that modern quantum field theoretical approaches to quark matter, including color superconductivity and a vector mean field, allow one to develop a microscopic description of hybrid stars which fulfill the new, strong constraints [2,3,4]. For these objects, color superconductivity turns out to be essential for a successful description of the cooling phenomenology in accordance with recently developed tests [5]. We discuss QCD phase diagrams for various conditions [6,7], thus providing a basis for a synopsis for quark matter searches in astrophysics and in future generations of nucleus-nucleus collision experiments such as low-energy RHIC Brookhaven and CBM @ FAIR Darmstadt.

References

[1] T. Klähn *et al.*, Phys. Rev. C **74** (2006) 035802.
[2] D. B. Blaschke *et al.*, Phys. Rev. **C 75** (2007) 065804.
[3] T. Klähn *et al.*, Phys. Lett. **B 567** (2007) 170.
[4] M. Alford *et al.*, Nature **445** (2007) E7 [arXiv:astro-ph/0606524].
[5] S. Popov *et al.*, Phys. Rev. C **74** (2006) 025803.
[6] D. Blaschke *et al.*, Phys. Rev. D **72** (2005) 065020.
[7] F. Sandin and D. Blaschke, Phys. Rev. D **75** (2007) 125013.

Most luminous supernovae

S. I. Blinnikov

Alikhanov Instutite for Theoretical and Experimental Physics (Moscow, Russia)

The discovery of SN2006gy demonstrates that some supernova (SN) events produce 10 or even 100 times more visible photons than other powerful explosions. SN2006gy is of the SN IIn type. It can be explained in the same way as other SN IIn events: the emission is produced by a long living radiative shock which propagates in a dense circumstellar envelope formed by a previous weak explosion (years before the SN event). Strong X-ray emission of SN IIn near the maximum of light curve may be absent since it can be either absorbed by a dense cloud or not produced at all in the radiation-dominated shock.

The problems in the theory and observations of multiple-explosion SNe IIn are briefly reviewed and new ways of using these SNe as primary distance indicators in cosmological applications are discussed.

Radio pulsars in close pairs with neutron stars

A. V. Tutukov, A. I. Bogomazov

Sternberg Astronomical Institute (Moscow, Russia)

Our presentation has two aims. First, we would like to test our model of radio pulsar birth. In this model, any radio pulsar can be born only in a close binary system. Second, we would like to reconstruct the velocity distribution of newly born radio pulsars (i.e., the birth rate, not observed directly). We show that such a model of radio pulsar birth cannot explain the observed number of “radio pulsar + neutron star” systems and other binaries (which contain a radio pulsar) and, therefore, must be rejected. Also, we calculate velocity distributions of radio pulsars, binary and single ones, under different assumptions and make satisfactory estimations of some parameters of the evolution of binary stars.

Composition and structure of protoneutron stars with the Brueckner-Bethe-Goldstone theory

Fiorella Burgio

INFN Sezione di Catania (Catania, Italy)

I discuss the finite temperature equation of state (EoS) of nuclear matter, constructed with the Brueckner-Bethe-Goldstone many-body theory, and the structure of protoneutron stars (PNSs). Some consequences of the hadron-quark phase transition will be analyzed by comparing the MIT bag and the Nambu–Jona-Lasinio models for the quark phase, as well as differences in the PNS structure predicted by those models.

Bursts detected in hard X-rays by the IBIS telescope onboard the INTEGRAL observatory in 2003-2007

I. V. Chelovekov, S. A. Grebenev

Space Research Institute (IKI) (Moscow, Russia)

All observations performed with the IBIS telescope onboard the INTEGRAL observatory during the first four years of its in-orbit operation have been analyzed to find X-ray bursts. The time history of the IBIS/ISGRI total count rate in the energy range 15–25 keV revealed several hundreds of bursts of 5–500 s duration with a high statistical significance (over the entire period of observations, only one event could be detected by chance with a probability of 20%). In addition to the events associated with cosmic gamma-ray bursts (detected in the field of view or passed through the IBIS shield), solar flares, and the activity of the soft gamma repeater SGR 1806–20, we were able to localize more than 400 bursts and, with three exceptions, to identify them with previously known persistent or transient X-ray sources (over 300 were identified with known X-ray bursters). The three exceptions were: a burst from a new burster in a low state that got the name of IGR J17364–2711; GRB 060428C; a burst from AXJ 1754.2–2754, which allowed us to identify this source as an X-ray burster. Curiously enough, around 200 bursts were detected from one X-ray burster, GX 354-0. The statistical distributions of bursts in duration, maximum flux, and recurrence time have been analyzed for this source. Some of the bursts observed with the IBIS/ISGRI telescope were also detected by the JEM-X telescope onboard the INTEGRAL observatory in the standard X-ray energy range of 3–20 keV.

Multiwavelength properties of gamma-ray-loud binary systems

M. Chernyakova, A. Neronov

Dublin Institute for Advanced Studies, DIAS (Dublin, Ireland)

Gamma-ray-loud binary systems form a newly identified class of X-ray binaries in which either accretion onto a compact object (a neutron star, or a black hole), or the interaction of an outflow from a compact object with the wind and radiation, emitted by a massive companion star, produces very-high energy (VHE) gamma-ray emission. Three such systems, PSR B1259–63, LS 5039 and LSI+61 303, have been firmly detected as persistent or regularly variable TeV gamma-ray emitters. The origin of the high-energy activity of the sources is not clear. It is possible that the three binaries detected in the gamma-ray band are fundamentally different from the accretion-powered X-ray binaries. In fact, one of the three gamma-ray loud binaries known so far, the PSR B1259–63, is known to be powered by the rotation energy of a young pulsar (instead of accretion). The similarity of the spectral energy distributions of the three gamma-ray-loud binaries makes its interesting to apply the "pulsar model" to the two other systems as well. In my talk, I will review the multiwavelength properties of these systems, including the latest X-ray observations by XMM, Chandra, Swift and Suzaku satellites. I will attempt to explain the observed temporal and spectral variability of these systems.

Fusion reactions in dense matter: Effects of plasma screening

A. I. Chugunov[1], H. E. DeWitt[2], D. G. Yakovlev[1]

[1]Ioffe Physical-Technical Institute (St.Petersburg, Russia)
[2]Lawrence Livermore National Laboratory (Livermore, USA)

We analyze fusion reactions in dense matter composed of atomic nuclei of one or two types. We pay special attention to the Coulomb tunneling problem. We compare the results of the Path Integral Monte Carlo (PIMC) calculations by Militzer and Pollock (Phys. Rev. B **71**, 134303, 2005) of Coulomb tunneling in a nuclear reaction in dense one component matter with semiclassical calculations assuming WKB Coulomb barrier penetration through the radial mean field potential. We find a very good agreement of two approaches at temperatures higher than $\sim \frac{1}{5}$ of the ion plasma temperature. We apply the mean field model to the reactions in binary ionic mixtures. We carefully analyze the results of the extensive Monte Carlo calculations of mean field potential in one component plasma and in binary ionic mixtures and describe these results by simple fitting expressions. Respective reaction rates are calculated and approximated by simple analytical expressions applicable in a wide range of parameters. We analyze Gamow-peak energies of reacting ions in various reaction regimes. We discuss theoretical uncertainties of nuclear reaction rates taking the burning in a ^{12}C-^{16}O mixture as an example.

This work was partly supported by the Russian Foundation for Basic Research (grants 08-02-00837, 05-02-22003), and by the State Program "Leading Scientific Schools of Russian Federation" (grant NSh 2600.2008.2).

On millisecond and submillisecond hard gamma-ray pulsations from observations of the Crab pulsar with the GAMMA-1 Telescope

E. I. Chuikin

Ioffe Physical-Technical Institute (St.Petersburg, Russia)

We present the results of a search for millisecond and submillisecond pulsations in hard gamma-ray emission from the Crab pulsar (PSR 0531+21) with the GAMMA-1 Telescope during one week observation in November 1990 and during a concluding stage of the GAMMA-1 performance in orbit (in December 1991). We give some arguments that the pulsations are real. In particular, we found the same pulsation period T for different observation intervals, that is possible if the pulsations were persistent. The present results on the Crab pulsar, together with data of 1996 on the Vela pulsar and the data of 2001 on the Geminga pulsar, allow us to suggest that the phenomenon of millisecond and submillisecond pulsations may be inherent to many gamma-ray pulsars, if not to all of them.

The detection of the new RRAT pulsar J2225+35

Yu. P. Shitov, A. D. Kuzmin*, D. V. Dumsky†, B. Ya. Losovsky‡

Pushchino Radioastronomy Observatory of the Astrocosmic Center of the Lebedev Physical Institute, PRAO ASC FIAN (Pushchino, Russia)

We report the detection of the new RRAT (Rotating Radio Transient) pulsar J2225+35, characterized by a burst-like periodic pulse radio emission and long silence for most of the time between.

The emission was detected only in 2 observation sessions of about 10 minutes long among 45 sessions with the total duration of about 3 hours. Pulses posses a frequency-time delay corresponding to a dispersion measure $DM = 51.8$ pc cm^{-3}, a distance to the pulsar of $d = 3.05$ pc and periodicity of $P = 0.94$ s. Pulse scatter broadening $\tau_{sc} = 7$ ms corresponds to the same distance.

The emission is polarized. The rotation measure is $RM = 49.8$ rad m^{-2}. Bursts of emission are observed as groups of individual outburst pulses.

*E-mail: akuzmin@prao.ru
†E-mail: dumsky@prao.ru
‡E-mail: blos@prao.ru

Observational appearance of supernova shock interaction with neutron star magnetosphere: A model for millisecond extra-galactic radio burst

K. A. Postnov, A. E. Egorov, B. V. Somov

Sternberg Astronomical Institute (Moscow, Russia)

We propose a possible physical model for a millisecond extra-galactic radio burst (Lorimer et al. 2007) based on the interaction of a supernova (SN) shock with a neutron star (NS) magnetosphere in a binary system. The shocked NS magnetosphere relaxes through magnetic reconnection in a cylindrical current sheet, where particles can be accelerated to relativistic energies. If the NS magnetosphere was filled with pair plasma before the explosion, the beam instability can be induced by accelerated positrons, resulting in the conversion of the beam kinetic energy into plasma oscillations. Electromagnetic radio waves with steep spectrum can thus be generated (like in pulsars). This mechanism can explain the observed properties of the enigmatic millisecond radio burst serendipitously discovered by Lorimer et al. in 2001.

A very large glitch in the pulsar B2334+61

A. A. Ershov

Pushchino Radioastronomy Observatory of the Astrocosmic Center of the Lebedev Physical Institute, PRAO ASC FIAN (Pushchino, Russia)

The pulsar B2334+61 was discovered in 1985. It has a period of 0.495 seconds, a period derivative of 1.9×10^{-13}, and a characteristic age of 4×10^4 years. The PSR B2334+61 is located very close to the center of the supernova remnant G114.3+0.3. Timing observations have been made at the Pushchino Radioastronomy Observatory since 2001 using the BSA radio telescope at the frequency of 111 MHz. Post-detection de-dispersing receiver was used with a time resolution of about one millisecond. The data between 2001.6 and 2005.7 are well fitted by a simple model consisting of the rotation frequency and its two derivatives. The timing residuals from this model have an rms of about one millisecond. On 7 September 2005 (MJD = 53620.9), the pulse rapidly drifted in phase, indicating that the rotation frequency increased drastically since the previous observation on 5 September 2005 (MJD = 53618.9). For this glitch, the rotation frequency change was $dF/F = 3.17 \times 10^{-5}$. This glitch is the largest observed in any radio pulsar.

Exploring the possibility of a first order phase transition to quark matter in core collapse supernovae

T. Fischer[1], I. Sagert[2], G. Pagliara, J. Schaffner-Bielich, F.-K. Thielemann[1], M. Liebendörfer[1]

[1]University of Basel (Basel, Switzerland)

[2]Institute for Theoretical Physics (Frankfurt, Germany)

Core collapse supernovae are one of the most energetic events in the galaxy. As massive stars reach the final stage of nuclear burning, photodisintegration and electron captures reduce the pressure and the core starts to collapse. Density and temperate increase, nuclei start to dissolve above the neutron drip line and at even higher densities nucleons start to form clusters, which dissolve again as approaching nuclear saturation. At nuclear saturation density, matter is not compressible any further and the collapse halts. The core bounces back and a sound wave forms which quickly turns into a shock front propagating outward. However, this accretion shock stalls due to the energy losses by neutrinos and the dissociation of infalling nuclei. Neutrino reactions have long been investigated to be a possible explosion mechanism, to revive this stalled shock efficiently enough, leading to so called neutrino driven explosions. Although spherically symmetric models, using three-flavor neutrino Boltzmann transport and a sophisticated equation of state for hot and dense nuclear matter, fail to explain such mechanism and multi-dimensional models have become available only recently and reveal the high complexity of such events, the input physics of core collapse supernovae is still subject of debate and can be explored via such spherically symmetric modelling most perfectly. Therefore, as the density increases even above nuclear saturation during the dynamical evolution after core bounce, the possibility of a first order phase transition from normal nuclear matter to quark matter shall be explored. We present results from spherically symmetric core collapse simulations, using three flavor Boltzmann neutrino transport, where the physical conditions after bounce favor a phase transition to strange quark matter. We include an equation of state based on the MIT Bag model with non-zero strange quark mass. The Bag constants are chosen as such to model a phase transition at 2–3 times saturation density for zero temperature.

Induced Compton gamma radiation formed in the pulsar vacuum gap

V. M. Kontorovich, A. B. Flanchik

Institute of Radio Astronomy of NAS of Ukraine (Kharkov, Ukraine)

According to the EGRET data [1], there is a powerful gamma radiation from a number of pulsars. In our model [2], such radiation can arise in the pulsar vacuum gap due to inverse Compton scattering of powerful low-frequency radiation by accelerated electrons. The low-frequency radiation is generated in the discharges in the gap which operates as a cavity-resonator. Our model allows us to relate the intensities and spectra of the gamma and radio emissions, corresponding to the observational data for some pulsars. The induced processes affect high radiation energy densities. They lead to a saturation effect in the gamma radiation intensity. The induced processes affect also the gamma ray spectrum, producing deviations from power-law spectrum [2] at low energies of gamma quanta.

References

[1] P.L. Nolan, J. M. Fierro, Y. C. Lin et al., Astron. Astrophys. Suppl. Ser. 120, 61 (1996)

[2] V. M. Kontorovich, A. B. Flanchik, ArXiv: 0801.0057 (2008)

Transfer of gyroresonant radiation in neutron star atmospheres

M. A. Garasyov, E. V. Derishev, Vl. V. Kocharovsky

Institute of Applied Physics, Russian Academy of Sciences, ul. Ulyanova 46, Nizhny Novgorod, 603950 Russia

We analyze radiation transfer and calculate radiation pressure force in the electron cyclotron line in the atmospheres of neutron stars. We specify the atmospheric parameters for which an outflow of plasma is possible under the radiation pressure in the cyclotron line. It is shown that the correct results can only be obtained using dielectric tensor for mildly relativistic plasmas in strong magnetic field, which is derived taking into account relativistic corrections to the cyclotron resonance condition, as well as the effects of vacuum polarization and recoil during photon scattering. The real and imaginary parts of the refraction indices and polarization coefficients for electromagnetic eigenwaves under the conditions, where scattering dominates absorption, are derived. We show that relativistic effects and vacuum polarization play a significant role in the radiation transfer and determine the radiation pressure on a plasma for a wide range of parameters of neutron star atmospheres. In particular, relativistic corrections to the gyroresonance condition lead to the escape of radiation from the cyclotron line and, hence, to a decrease in radiation pressure force; this effect turns out to be crucial not only in a plasma with relativistic electron temperatures, but also even in a non-relativistic plasma. It is shown that vacuum polarization contributes to the increase in radiation pressure force due to the sharp rise in the scattering cross section for an ordinary wave in the outer atmosphere. The above factors lead to an extension of the range of parameters for which the existence of a static atmosphere is not possible, i.e., they relax the conditions for the formation of flows under radiation pressure in the cyclotron line.

XEUS and MAXIM science: Observations of compact cosmic objects

Yu. N. Gnedin

Central Astronomical Observatory at Pulkovo (St.Petersburg, Russia)

I discuss the prospects of future basic missions in X-ray astronomy: The X-ray Evolving Universe Spectroscopy Mission (XEUS) and The MicroArcsecond X-ray Interferometer Mission (MAXIM). I compare these missions with the previous cosmic projects, Einstein, ROSAT and Chandra. The main astrophysical goals of the new missions are strong field relativistic effects (Doppler shifts and boosting, gravitational redshift, strong field lensing, line profiles and time variability, black hole masses and spins). For the physics of neutron stars, the main goals are to investigate spectral features from the surface of neutron stars. For magnetic fields of neutron stars, a strong-field QED (vacuum polarization) becomes important, significally changing the dependence on the phase and energy polarization and providing a measurement of magnetic field strength, test of the magnetar paradigm and a probe of the strong-field QED itself.

Supergiant fast X-ray transients: Observational properties and physical model

S. A. Grebenev

Space Research Institute (IKI) (Moscow, Russia)

We review observational properties of the Fast X-Ray Transients on the basis of INTEGRAL data. The number of known systems of this type grows strongly and, in many cases, the optical counterpart of a system turns out to be a supergiant of early (OB) spectral classes. We propose a reliable mechanism capable to explain the abrupt short X-ray outbursts of these transients and the long intervals of their quiescence. The mechanism assumes that a compact object in these systems is a neutron star with strong magnetic field that may accrete matter from the stellar wind of a donor star. The accretion usually stops because the magnitospheric radius exceeds the corotational radius although the radius excess is typically small. Thus, even a slight increase in the local density of the stellar wind, leading to the contraction of the magnetosphere, will switch-on the accretion process and an X-ray outburst.

Dissipative pulsar magnetosphere

A.V. Gruzinov

Physics Department, New York University, New York, NY 10003, USA

I introduce Strong-Field Electrodynamics and calculate the structure of a dissipative axisymmetric pulsar magnetosphere by a direct numerical simulation of the Strong-Field Electrodynamics equations. With a better numerical scheme, one should be able to calculate the bolometric lightcurves for a given conductivity.

Maximal magnetic field of a neutron star

A.V. Gruzinov

Physics Department, New York University, New York, NY 10003, USA

We prove that static fluid stars can stably support magnetic fields (within the ideal MHD approximation). We use the proof to estimate maximal magnetic field which can be stably supported by a neutron star.

The entrainment matrix of superfluid nucleon-hyperon mixture

E. M. Kantor[1], M. E. Gusakov[1], P. Haensel[2]

[1]Ioffe Physical-Technical Institute (St.Petersburg, Russia)

[2]Copernicus Astronomical Center (Warsaw, Poland)

We calculate the entrainment matrix, an important parameter of hydrodynamics of superfluid mixtures, for the matter of inner layers of neutron stars composed of nucleons (neutrons and protons), hyperons (Λ and Σ^-), as well as electrons and muons. In the approximation of zero temperature, the calculation is performed using the relativistic mean field sigma-omega-rho model and in the frame of non-relativistic Landau Fermi-liquid theory. Comparing the results of these two approaches, we find all 16 Landau parameters for the nucleon-hyperon matter. Using these Landau parameters, we determine the entrainment matrix for any temperature. The results can be important for analyzing pulsations and gravitational-radiation driven instabilities of superfluid neutron stars.

This work was partly supported by the Dynasty Foundation, by the Russian Foundation for Basic Research (grants 05-02-22003 and 08-02-00837a), by the Program "Leading Scientific Schools of Russian Federation" (grant NSh-2600.2008.2), and by the RF presidential program (grant MK-1326.2008.2).

High-velocity neutron stars as the remnants of high-velocity runaway stars

V. V. Gvaramadze, A. Gualandris, S. Portegies Zwart

[1]Sternberg Astronomical Institute (Moscow, Russia)

[2]Rochester Institute of Technology (Rochester, USA)

[3]University of Amsterdam (Amsterdam, The Netherlands)

We propose an explanation for the origin of high-velocity neutron stars based on the hypothesis that they could be the remnants of a symmetric supernova explosion of a high-velocity massive star (or its stripped helium core) which attained its peculiar velocity (similar to that of the neutron star) in the course of a strong dynamical three- or four-body encounter in the core of a young massive stellar cluster. To check this hypothesis, we investigated four dynamical processes involving close encounters between: (i) two hard massive binaries, (ii) a hard binary and a very massive star, (iii) a hard binary and an intermediate-mass black hole and (iv) a single star and a hard binary intermediate-mass black hole. We argue that dynamical processes in the cores of star clusters can contribute to the origin of pulsar velocities in addition to asymmetric supernova explosions and to disruption of binaries following supernova explosions.

2+2=3

V. V. Gvaramadze[1], D. J. Bomans[2]

[1]Sternberg Astronomical Institute (Moscow, Russia)

[2]Astronomisches Institut der Ruhr-Universitat Bochum (Bochum, Germany)

Astrometric data on the pulsars B2020+28 and B2021+51 and the massive runaway star BD+43 3654 are consistent with a possibility that these objects were ejected from the core of the Cyg OB2 association about 2 Myr ago. This fact and the relative position of the objects on the sky allow us to suggest that they were ejected via the same dynamical event – a close encounter between two compact massive binaries with a small mass ratio. One of the possible outcomes of encounters between such binaries is a coalescence of the more massive stars into a single rejuvenated star (blue straggler) and an ejection of the less massive ones with high velocities. We show that the single merged star could be associated with BD+43 3654 and the high-velocity low-mass stars (stripped helium cores of massive stars) with the progenitors of the pulsars B2020+28 and B2021+51.

Neutrino losses in a giant flare from SGR

A. A. Gvozdev, I. S. Ognev

Yaroslavl State University (Yaroslavl, Russia)

Neutrino losses in a giant flare from SGR are investigated. The emissivity in dominant neutrino processes is calculated. Two cases are considered: a hot electron-positron plasma (the magnetar model), and a plasma with baryon contamination. The limitations on magnetic field strength from neutrino cooling rates are discussed. It is shown, that in the framework of the magnetar model, a moderate neutrino cooling requires a magnetic field strength that is one order of magnitude greater than that assumed in magnetars. Therefore, some baryon contamination in a giant flare of a SGR is necessary.

Deep crustal heating in accreting neutron stars

P. Haensel*, J. L. Zdunik†

N. Copernicus Astronomical Center, Bartycka 18, 00-716 Warszawa, Poland

Heating associated with non-equilibrium nuclear reactions in accreting neutron-star crusts is reconsidered [1]. We take into account a suppression of neutrino energy losses demonstrated recently in [2]. Two initial compositions of the nuclear burning ashes, $A_{\rm i} = 56$ and $A_{\rm i} = 106$, are considered. The dependence of the integrated crustal heating on uncertainties plaguing pycnonuclear reaction models is studied. One-component plasma approximation is used, with compressible liquid-drop model of Mackie and Baym, to describe the nuclei in a neutron star crust. The evolution of a crust shell is followed from the density of 10^8 g cm^{-3} to $10^{13.6}$ g cm^{-3}. The integrated heating in the outer crust agrees nicely with the results of self-consistent multi-component plasma simulations, with large network of nuclear reactions, reported in [2]. The results of [2] fall between our curves obtained for $A_{\rm i} = 56$ and $A_{\rm i} = 106$. The total crustal heat per one accreted nucleon ranges between 1.5 MeV to 1.9 MeV for $A_{\rm i} = 106$ and $A_{\rm i} = 56$, respectively. The value of $Q_{\rm tot}$ depends weakly on the presence of pycnonuclear reactions at $10^{12} - 10^{13}$ g cm^{-3}. A remarkable insensitivity of $Q_{\rm tot}$ on the details of the distribution of nuclear processes in the accreted crust is discussed. Our results are relevant for modeling of soft X-ray transients, X-ray superbursts, and thermal relaxation observed in persistent soft X-ray transients KS 1731–260 and MXB 1659–29.

References

[1] P. Haensel, J.L. Zdunik, A & A,480, 459 (2008)

[2] S. Gupta, E.F. Brown, H. Schatz, P. Möller, K.-L. Kratz, ApJ, 662, 1188 (2007)

*E-mail: haensel@camk.edu.pl

†E-mail: jlz@camk.edu.pl

On superdense stars containing quark matter

Yu. L. Vartanyan, A. R. Harutyunyan

Yerevan State University, Radiophysics Faculty (Yerevan, Armenia)

Possible implications for quark phase transition inside superdense stars are studied, based on the series of calculated models. We consider pure quark stars (or strange stars) and hybrid stars consisting of a quark matter core with a nuclear matter crust around. The observational consequences are strongly affected by the details of the stellar structure, especially when a phase transition occurs in the interior of a star.

The detailed analysis of the parameters of calculated configurations, useful for comparison with neutron star observables, is carried out. Such comparison might help to test currently used equations of state for superdense matter.

Possible observational tests are discussed to distinguish between ordinary neutron stars, strange stars and superdense hybrid stars. With the firm future identification of low-mass stars, additional possibilities would appear to distinguish between the different models.

Neutron star structure determined by nuclear physics

Thomas Bürvenich, Uwe Heinzmann, Igor Mishustin

Institute for Theoretical Physics (Frankfurt, Germany)

Our research is related to the classical paper of Negele and Vautherin: *Neutron star matter at sub-nuclear densities* (Nuclear Physics **A 207** (1973) 298-320).

Negele and Vautherin calculated neutron star matter using density-dependent Hartree-Fock (DDHF) equations without pairing. Their aim was the construction of a reliable theory of a nucleon many-body system derived from the two-body nucleon-nucleon interaction. They obtained numerical results for nuclear configurations at various subnuclear densities.

Since this eminent work this topic has not been considered much further. On the other hand there has been considerable progress in the development of self-consistent mean-field models for nuclear structure calculations and the treatment of pairing. These phenomenology-based models containing between 6 to 12 parameters, which are adjusted to nuclear ground-state observables, allow a quantitative description of medium, heavy, and superheavy nuclei with very high accuracy. Up to now this was the only available approach that can address very heavy nuclei.

In the our research project we intend to obtain new insights into nuclear structure physics in connection with the structure of neutron stars by employing these models, predominantly by using Hartree-Fock Bogolyubov code with Skyrme forces. Special astrophysical conditions in a neutron star will be modeled by gases of free electrons and free neutrons. The nuclei subject to these conditions can be expected to possess quite different properties compared to isolated nuclei. The effects of this environment on the shell structure and on the bulk properties of these nuclei will be studied in detail. As for the choice of boundary conditions, we can compare our results with the results obtained by Baldo and Chamel. The modeling of electron and neutron gases will be systematically improved throughout this research work.

The results thus obtained will then be processed in a calculation of the neutron star crust and yield new insights in local as well as global properties of these objects. From the astrophysical point of view, we are searching for a model for the inner crust of a neutron star modeling the transition between the neutron lattice in the Wigner-Seitz approach and the neutron Fermi liquid.

Cooling of neutron stars with strong toroidal magnetic fields II: Cooling in 2D

J. A. Henderson*, D. Page†

Instituto de Astronomía, Universidad Nacional Autónoma de México, México

We continue the study of temperature distribution in neutron star crusts with various magnetic field configurations and its effect on long-term cooling from Page et al. 2007 [1]. In the case of many "Magnificent Seven" (see [2, 3]) a disagreement exists in the near-perfect black body spectra between the warm x-ray component with a small emitting radius ($\sim 3 - 5$ km) and the optical component which implies the existence of an extensive cooler surface region (assumed neutron star radius of $\sim 10 - 15$ km). It has been shown [4, 5] that the presence of a strong toroidal component in the magnetic field of the crust can resolve this apparent discord. In this work, two-dimensional heat transport within the entire star (to the density of $\rho = 10^{10}$ g cm^{-3}) is solved and matched to various envelope models in order to show the influence of crustal magnetic field on the evolution of the stellar luminosity with time. Also, surface temperature profiles are constructed in an effort to reproduce the characteristic spectra of the Magnificent Seven and other isolated neutron stars.

References

[1] D. Page, U. Geppert, M. Kuker. Ap&SS, 308, 403 (2007)

[2] F. Haberl. Proc. 2005 EPIC XMM-Newton Consortium Meeting; MPE Report 288, p. 39 (2005)

[3] F. Haberl. Ap&SS, 308, 181 (2007)

[4] J.F. Pérez-Azorín, J.A. Miralles, J.A. Pons. A&A, 433, 275 (2006)

[5] U. Geppert, M. Kuker, D. Page. A&A, 457, 937 (2006)

*E-mail: hendersj@astroscu.unam.mx

†E-mail: page@astroscu.unam.mx

Boiling of nuclear liquid in core-collapse supernova explosions

P. I. Fomin, D. Iakubovskyi, Yu. Shtanov

Bogoliubov Institute for Theoretical Physics, BITP (Kiev, Ukraine)

We investigate the possibility of the boiling instability of nuclear liquid in the inner core of a proto-neutron star formed in a core collapse of type II supernova. We derive a simple criterion for boiling to occur. Using this criterion for one of the most elaborated equations of state of supernova matter, we find that boiling is quite possible under the conditions realized inside the proto-neutron star. We discuss consequences of this process, such as the increase of heat transfer rate and pressure in the boiling region. We expect that the implementation of this effect into the conventional neutrino-driven delayed-shock mechanism of type II supernova explosions can increase the explosion energy and reduce the mass of the neutron-star remnant.

On the nature of long-period X-ray pulsars

N. R. Ikhsanov

Pulkovo Observatory (St.Petersburg, Russia)

Several relatively bright, persistent X-ray sources display regular pulses, with periods in the range of 700–10000 s. These sources are identified with massive compact binaries in which a neutron star accretes material onto its surface. The observed pulsations in all of them are unambiguously associated with the spin period of the neutron star. Analyzing possible history of these pulsars I conclude that the neutron stars in these systems undergo spherical accretion and their evolutionary tracks in a previous epoch contained three instead of two states, namely, ejector, supersonic propeller, and subsonic propeller. An assumption about a supercritical value of the initial magnetic field of the neutron stars within this scenario is not necessary. Furthermore, I show that the scenario, in which the neutron star in 2S 0114+650 is assumed to be a magnetar descendant, encounters major difficulties in explaining the evolution of the massive companion. An alternative interpretation of the spin evolution of the neutron star in this system is presented and the problem, raised by the association of the 10000 s pulsations with the neutron star spin period, is briefly discussed.

Gravitational radiation from approaching neutron stars and the problem of gravitational signal from the SN 1987A

V. S. Imshennik

Alikhanov Institute for Theoretical and Experimental Physics (Moscow, Russia)

We consider the evolution of a double neutron star binary under the effect of two factors: gravitational radiation and mass transfer between the components. The gravitational radiation is specified under the justified assumption of a circular orbit and point masses and in the approximation of a week gravitational field at nonrelativistic velocities of the binary components. During the first evolutionary phase, determined only by the gravitational radiation, the neutron stars approach each other according to a simple analytic solution. The second evolutionary phase begins at the time of Roche-lobe filling by the low-mass component, when the second factor, the mass transfer as a result of the mass loss by the latter, also begins to affect the evolution. Under the simplest assumptions of conservative mass transfer and exact equality between the Roche-lobe radius and the radius of the low-mass neutron star, it is still possible to extend the analytic solution of the problem of evolution at its second phase. We present this complete solution at both phases and, in particular, give theoretical light curves for the gravitational radiation that depend only on two parameters (total mass of the binary system and initial mass ratio). Based on our solution, we analyze the theoretical gravitational signals from the SN 1987A. The analysis includes the hypothesis about the rotational explosion mechanism for collapsing supernovae.

Plasma polarization in massive astrophysical objects

Igor Iosilevskiy

Moscow Institute of Physics and Technology, Moscow, Russia

We discuss macroscopic plasma polarization, which is created in massive astrophysical bodies by gravitation and other inertial forces. A new source of such a polarization is introduced which is the polarization caused by non-ideality effects due to strong Coulomb interaction of charged particles. This "non-ideality" polarization may be significant in comparison with the well-known gravitational polarization. The latter polarization effect was established long ago by Pannekoek, Rosseland and others for the case of ideal, isothermal and non-degenerate plasma in outer layers of a star. Later their approach has been extended (for example, by Bildsten et al.) to conditions of dense and degenerate interiors of compact stars. The present work presumes the incorrectness of this extension because it is based on partial pressures and "partial" hydrostatic equilibrium equations separately for each species of particles. The present consideration is based on the density functional approach combined with the "local density approximation". We study a simplified situation of a totally equilibrium isothermal star neglecting magnetic field and relativistic effects. The extremum condition for the thermodynamic potential results in two sets of equivalent conditions: constancy for generalized partial (electro-) chemical potentials and/or equilibrium for the forces acting on any charged particle. In this latter form, new "Coulomb non-ideality" force appears in the hydrostatic equilibrium equation, in addition to two traditionally studied gravitational and electrostatic forces. In most cases this new "force" increases the final electrostatic field in comparison with that of the standard ideal-gas solution. Our resulting formula reproduces two known limiting cases for a degenerate and non-degenerate ideal gas and leads to some additional effects. Hypothetical consequences of these effects on the structure, thermo- and hydrodynamics of neutron stars are discussed.

Phase transitions in neutron stars. Are they non-congruent?

Igor Iosilevskiy

Moscow Institute of Physics and Technology (Moscow, Russia)

Phase transitions (PTs) in neutron stars (NSs) are examined for their non-congruence. Non-congruence (or incongruence) of phase coexistence in chemical mixtures means the ability of a two-phase system to vary the chemical composition ("stoichiometry") of coexisting phases without violating total stoichiometry of the system. Non-congruence leads to an essential change in the topology of inter-phase boundaries and properties of critical point(s). A pressure-temperature phase boundary of a non-congruent phase transition (NPT) is a two-dimensional region with a non-standard critical point, in contrast to the standard one-dimensional $P-T$ curve ending with the critical point of infinite compressibility. Furthermore, isoline behavior in an NPT two-phase region differs from the standard one. Isothermal and isobaric phase transformations do not coincide in NPT. Start and finish of an isothermal phase transition correspond to different pressures and vice versa.

The base for the discussion of non-congruence for phase transitions in an NS is a non-congruent evaporation in high-temperature uranium-oxygen plasma, which has been studied thoroughly in frames of the nuclear reactor safety problem. The main point in application of these results to NSs is the dimensionality of thermodynamic equilibrium in NSs. Phase transitions are definitely non-congruent when chemical composition is an independent variable, for example, for freezing and hypothetical fluid-fluid PTs ("demixing") in multi-nuclear ionic mixture in the outer layers of an accreting NS (Horowitz et al. 2007). In deep NS interior, thermodynamic dimensionality is reduced due to equilibrium nuclear transformations. The limiting situation corresponds to a two-dimensional system with two independent variables: baryon and electron chemical potentials. Phase equilibrium of two macroscopic phases must be forcedly-congruent in this case due to the local electroneutrality conditions. At the same time, the concept of a "mixed phase transition" (Glendening et al.) relaxes the local electroneutrality constraint. The system becomes bi-variant. All phase transitions are proved to be *non-congruent*. Consequences of this non-congruency for NS phase transitions are discussed.

Heating and cooling of magnetars with accreted envelopes

A. D. Kaminker[1], A. Y. Potekhin[1], D. G. Yakovlev[1], G. Chabrier[2]

[1]Ioffe Physical Technical Institute, Politekhnicheskaya 26, 194021 St. Petersburg, Russia
[2]Ecole Normale Superérieure de Lyon, CRAL (UMR 5574 CNRS), 46 allée d'Italie, 69364 Lyon, France

We study the thermal structure and evolution of magnetars as cooling neutron stars with a phenomenological heat source in a spherical internal layer. We focus on the effect of highly magnetized ($B \gtrsim 10^{14}$ G) non-accreted and accreted envelopes composed of different elements, from iron to hydrogen or helium, taking into account neutrino emission from all layers. We calculate the cooling of magnetars with a dipole magnetic field for various locations of the heat layer, heat rates and magnetic field strengths. The joint effects of the super-strong magnetic fields and accreted envelopes simplify the interpretation of observations of magnetars as neutron stars with a heat source that is located at densities $\rho \lesssim 4 \times 10^{11}$ g cm^{-3} and has the heat intensity $W^{\infty} \sim 10^{36} - 10^{37}$ erg s^{-1}.

This work was partly supported by the Russian Foundation for Basic Research (grants 05-02-22003 and 08-02-00837a), by the Program "Leading Scientific Schools of Russian Federation", grant NSh-2600.2008.2, and by the CNRS French-Russian grant PICS 3202.

Damping of sound waves in superfluid nucleon-hyperon mixture

M. E. Gusakov, E. M. Kantor

Ioffe Physical-Technical Institute (St.Petersburg, Russia)

We consider the sound waves in superfluid matter of neutron stars composed of electrons and muons, nucleons (neutrons and protons), and hyperons (Λ and Σ^-). We show that three types of sound modes can propagate in such matter, namely the "normal" mode, analogous to sound waves in non-superfluid matter, and two "superfluid" modes. We analyse the speed of sound and its temperature dependence for each of the modes. Also, we study characteristic damping times for these modes, which are due to non-equilibrium processes of mutual transformations of particles. We demonstrate that the correct consideration of these processes leads to essentially different damping of sound modes in comparison to estimates presented in the literature. The obtained results can influence the "instability windows" of neutron stars, that is the region of spin frequencies and internal temperatures at which a star becomes unstable with respect to the emission of gravitational waves.

This work was partly supported by the Dynasty Foundation, the Russian Foundation for Basic Research (grants 08-02-00837, 05-02-22003), by the State Program "Leading Scientific Schools of Russian Federation" (grant NSh 2600.2008.2), and by the RF presidential program (grant MK-1326.2008.2).

Dark matter halo around a neutron star

V. L. Kauts

Astro Space Center of the Lebedev Physical Institute (ASC FIAN) (Moscow, Russia)

The formation of the halo of dark matter around a neutron star is connected with a collisionless focusing of particles in an arbitrary gravitational field. The expected slope of the halo density profile is -0.5 and the amplification factor near the surface of the neutron star is ~ 600.

Formation, structure, evolution, and radiation of current sheets and filaments in collisionless relativistic plasma

V. Ju. Martyanov[1], V. V. Kocharovsky[1,2], Vl. V. Kocharovsky[2]

[1]Institute of Applied Physics, Russian Academy of Sciences, ul. Ulyanova 46, Nizhny Novgorod, 603950 Russia
[2]Physics Department, Texas A&M University, College Station, USA

We review recent progress in analytic understanding of the origin and various properties of magnetic field configurations emerging in relativistic astrophysical shocks and jets. In a collisionless plasma, the main mechanism for magnetic field generation is the so-called Weibel instability, which has recently been analyzed in detail for a number of relativistic particle distribution functions. We discuss the saturation of this instability, which occurs at a sub-equipartition level of magnetic field energy and results in a substantial modification of particle distribution function.

In typical planar and cylindrical geometries, we find analytically a wide class of nonlinear stationary current structures which can be equally easy to realize in relativistic and non-relativistic collisionless plasma. These solutions are based on the method of integrals of motion, and extend far beyond the known generalizations of non-relativistic Harris model. The obtained Grad-Shafranov type equations allow us to analytically investigate and compare general properties and possible evolution of these structures. Among the properties of newly found stationary solutions we discuss the ratio of magnetic field energy to that of particles, the anisotropy of particle momentum distribution, the spatial scales and profiles, etc.

Also, we carry out the short wavelength instability analysis of these current sheets and filaments in the regions with small enough magnetic fields, where this instability is expected to be the most pronounced. We estimate typical spatial- and timescales of the instability which could develop in relativistic collisionless current configurations in active galactic nuclei, microquasars, gamma ray burst sources, and neutron star winds. We estimate the synchrotron radiation of relativistic particles in self-consistent current sheets and filaments, which makes it possible to study the structure and evolution of current structures based on their observed radiation.

We use our results for the interpretation of recent observations and numerical simulations of magnetic field evolution in relativistic plasma shocks.

Search for optical counterparts to isolated neutron stars with the 6-meter Telescope of SAO RAS

V. N. Komarova[1], V. G. Kurt[2], Yu. A. Shibanov[3]

[1]Special Astrophysical Observatory of RAS (Nizhnij Arkhyz, Russia)
[2]Institute of Nuclear Physics, Moscow State University (Moscow, Russia)
[3]Ioffe Physical Technical Institute (St.Petersburg, Russia)

Some results of the program for search and study of optical counterparts of pulsars and candidates to isolated neutron stars (INSs) with the 6-meter Telescope of SAO RAS are presented. Broadband observations of close and/or highly energetic (high velocity) neutron stars and pulsars, along with studies in the Hα line, were carried out with the prime focus focal reducer SCORPIO in the image mode. No optical counterparts have been found to RX J0007+7302, PSR B0355+54, PSR B0823+26, and PSR B2334+61; the upper limits on the detection level in the R band are $26.^m2$, $25.^m4$, $26.^m1$, $24.^m5$ and $25.^m6$, respectively. Two faint objects have been found in the circle of the RBS 1774 position using the data of XMM-Newton observations. Based on the faintness (B=26^m) and colors of the detected objects ((B–V) and (V–R) are $\approx$0.6, 0.1, 0.5 and 0.3, respectively) we do not rule out that one of them can be an optical counterpart to this INS. Futher deep multiband and polarimetric studies are needed to clarify this point.

Probing the limits of the giant pulse population

V. I. Kondratiev[1,2*], D. R. Lorimer[1,2], M. A. McLaughlin[1,2], S. M. Ransom[2]

[1]Department of Physics, West Virginia University, USA

[2]National Radio Astronomy Observatory, USA

We have carried out the radio observations of three pulsars — B0031−07, B1112+50, and J1752+2359 — with the Robert C. Byrd Green Bank Radio Telescope at 350 MHz using the pulsar SPIGOT backend. These pulsars were reported to manifest giant pulses (GPs) ([1], and references therein), the phenomena of extremely bright isolated bursts with unique properties known only for a handful of pulsars; see, e.g., [2, 3]. However, their parameters are very different from those of GP pulsars. They are long-period (0.4–1.6 s), middle-aged (10^5–10^7 yr) pulsars with very low values of magnetic field at the light cylinder (4–770 G) — the parameter supposed to be related with GP activity [4]. Thus, the question whether they are giant pulse emitters or not is crucial to ongoing efforts to constrain the elusive radio pulsar emission mechanism.

Preliminary study of single pulses from two pulsars, B0031−07 and B1112+50, revealed that they do not meet the criteria to be called giant pulses. Being broad (at least a few ms) and clustering preferentially to the center of the average profile, they resemble better the bright "spiky" emission from the pulsar B0656+14 [5]. Their pulse energy distributions do not follow the power-law as for GPs, but, rather, are exponential. We will present the results of our detailed analysis of single pulses, their energy distributions and microstructure. We will also discuss the possibility of strong subpulses being similar to giant micropulses from the Vela pulsar [6] and bursty emission seen in rotating radio transients [7].

References

[1] Ershov, A. A., & Kuzmin, A. D. 2005, A&A, 443, 593

[2] Soglasnov, V. A. 2007, in *Neutron Stars and Pulsars*, eds. W. Becker & H. H. Huang, MPE Report 291, P68

[3] Hankins, T. H., & Eilek, J. A. 2007, ApJ, 670, 693

[4] Cognard, I., Shrauner, J. A., Taylor, J. H., & Thorsett, S. E. 1996, ApJ, 457, L81

[5] Weltevrede, P., Wright, G. A. E., Stappers, B. W., & Rankin, J. M. 2006, A&A, 458, 269

[6] Johnston, S., Van Straten, W., Kramer, M., & Bailes, M. 2001, ApJ, 549, L101

[7] McLaughlin, M. A. 2007, in Neutron Stars and Pulsars, 40 yrs after the discovery, ed. W. Becker, Lecture Notes (Springer), in press

*E-mail: vlad.kondratiev@gmail.com

The Magnificent Seven: New limits on radio emission

V. I. Kondratiev[1,2*], M. A. McLaughlin[1,2], D. R. Lorimer[1,2], M. Burgay[3], A. Possenti[3], R. Turolla[4,5], S. B. Popov[6], and S. Zane[5]

[1]Department of Physics, West Virginia University, USA

[2]National Radio Astronomy Observatory, USA

[3]INAF – Osservatorio Astronomico di Cagliari, Italy

[4]University of Padua, Department of Physics, Italy

[5]Mullard Space Science Laboratory, University College London, UK

[6]Sternberg Astronomical Institute, Moscow, Russia

We have carried out a search for radio emission at 820 MHz from six X-ray dim isolated neutron stars with the Robert C. Byrd Green Bank Radio Telescope (GBT). All discovered in the *ROSAT* All-Sky Survey, these objects share very similar properties [1, 2] and are sometimes called the "Magnificent Seven" as their number has remained constant since 2001[†]. No transient or pulsed emission was found using Fast Folding Algorithm (FFA), fast Fourier transform, and single-pulse searches[‡]. The corresponding flux limits are about 20 mJy for single dispersed pulses and 0.01 mJy for pulsed emission, depending on the integration time for the particular source and assuming a duty cycle of 2%. These are the most sensitive limits to date on radio emission from X-ray dim isolated neutron stars. There is no evidence for isolated radio pulses, as seen in the newly recognized class of rotating radio transients [3, 4]. Our results imply that either the radio luminosities of these objects are lower than those of any known radio pulsars, or they could simply be long-period nearby radio pulsars with high magnetic fields beaming away from the Earth. To test the latter possibility, we would need around 40 similar sources to provide a 1σ probability of at least one of them beaming toward us.

References

[1] Haberl, F. 2004, Advances in Space Research, 33, 638

[2] Haberl, F. 2007, Ap&SS, 308, 181

[3] McLaughlin, M. A., Lyne, A. G., Lorimer, D. R., et al. 2006, Nature, 439, 817

[4] McLaughlin, M. A. 2007, in Neutron Stars and Pulsars, 40 yrs after the discovery, ed. W. Becker, Lecture Notes (Springer), in press

---

*E-mail: vlad.kondratiev@gmail.com

†The seventh object, RX J0420.0−5022, is not visible at the GBT and was not included in our study.

‡Our implementation of the FFA together with diagnostic plots for the single-pulse and FFA searches can be found at `http://astro.phys.wvu.edu/pulsar/vlad/projects/xdins`

On the nature of high brightness temperature of pulsar giant pulses

V. M. Kontorovich

Institute of Radio Astronomy of NAS of Ukraine (Kharkov, Ukraine)

One of the important problems, raised by observations of pulsar giant pulses (GPs), is the indication of ultra high energy density of GP radiation, $\sim 10^{15}$ erg cm^{-3} [1]. The explanation we propose is based on the idea that the inner vacuum gap is a resonator-cavity [2] exited by discharges in a strong longitudinal electric field that accelerates electrons to high Lorentz-factors. The energy density of the power low-frequency oscillations in the gap can reach the level necessary for GPs [3]. The GPs, in the simplest version of our model, arise due to accidental origin of cavities in magnetospheric plasma through which the radiation goes out. The high energy density of GP radiation is determined by the energy density of cavity oscillations. The duration, phases of GPs, power law distribution of GP intensities are determined by stochastic processes of cavity appearance.

References

[1] V.A. Soglasnov, et al. ApJ, 616, 439, 2004.

[2] V.M. Kontorovich. ArXiv:astro-ph:0710.4020.

[3] V.M. Kontorovich & A.B. Flanchik. ArXiv:astro-ph:0801.0057

Can superheavy elements be formed in the r-process?

I. V. Panov[1,2], I. Yu. Korneev[1*], F.-K. Thielemann[2], T. Rauscher[2]

[1]Alikhanov Institute for Theoretical and Experimental Physics, Moscow, 117259, Russia
[2]University of Basel, Klingelbergstr. 82, CH-4056 Basel, Switzerland

With the advent of up-to-date nuclear data and more accurate fission rates for actinium series [1], it becomes possible to consider the opportunity of nucleosynthesis prolongation and the formation of superheavy elements in the r-process (if neutron flow is sufficiently high).

We determine the r-process yields in the neutron star merger model [2], depending on calculation of the exploded matter composition. In this model, the r-process under high neutron density environment ($Y_e \approx 0.1$) and big neutron-to-seed ratio (about few hundred neutrons by one seed nucleus) leads to a fast conversion of seed nuclei to actinium area, to fission via neutron-induced fission and recycling fission products as new seed nuclei.

The decay of newly formed isotopes near the region of superheavy elements goes on usually via α-decay, that gives an additional evidence in favor of high values of fission barriers of nuclei with neutron numbers close to 184. Only mass predictions on the basis of the ETFSi mass model [3] lead to high barriers and, as a result, to small fission rates for the isotopes from this region. Experimental data on decay modes [4] confirm the rates calculated on the basis of the ETFSi mass predictions.

The present calculations of nucleosynthesis show, that a nucleosynthesis wave, driven by the r-process, goes though the region of nuclei with $180 < N$ and $N < 188$, where the fission rates are small; then some superheavy nuclei can be formed.

With the utilization of ETFSi mass and fission barrier predictions in the r-process model, superheavy elements (SHE) can be formed. Their yields strongly depend on a scenario and nuclear data predictions as well. A preliminary value of $Y(\mathrm{SHE})/Y(\mathrm{U})$ at the end of the r-process is $\sim 10^{-14}$ (with the uncertainty of 1–2 orders of magnitude). For more accurate results, the fission rate calculations should be performed also for $Z > 110$ region.

References

[1] I. V. Panov et al., Nuclear Physics A, 747, 633 (2005)

[2] S. Rosswog, M. Liebendörfer, F.-K. Thielemann et al., Astronomy and Astrophysics, 341, 499 (1999)

[3] A. Mamdouh et al., Nuclear Physics A, 679, 337 (2001)

[4] Yu. Oganessian, Journal of Physics G: Nuclear and Particle Physics, 34, 165 (2007)

*E-mail: Ivan_K@abbyy.com

Monte-Carlo simulations of the X-ray spectrum of SS433

Yu. M. Krivosheyev[1], G. S. Bisnovatyi-Kogan[1], A. M. Cherepashchuk[2], K. A. Postnov[2]

[1]Space Research Institute (IKI) (Moscow, Russia)

[2]Sternberg Astronomical Institute (Moscow, Russia)

We would like to present our results of Monte-Carlo simulation of SS433 spectrum. In this massive binary system, a supercritical regime of accretion onto the relativistic object, which is most likely a black hole, is maintained. It leads to the formation of a supercritical accretion disk with two strongly collimated relativistic jets. Observations of INTEGRAL in 2003 and INTEGRAL/RXTE in 2004 provided us with the data, in particular, the X-ray spectrum. A model of the object, based on the observational data, was created, and Monte-Carlo simulation was used to obtain the spectrum, provided by this model. Comparison with the data allowed us to define physical parameters of SS433. The results of simulation for various angles of observation are presented, and their properties are discussed.

Is it possible to detect the intermediate mass black holes in centers of globular clusters with the help of milliseconds pulsars?

T. Larchenkova[1], A. Lutovinov[2]

[1]Astro Space Center of the Lebedev Physical Institute, ASC FIAN (Moscow, Russia)

[2]Space Research Institute, IKI (Moscow, Russia)

The possibility of the detection of intermediate mass black holes (1000–10000 $M_{\odot}$) using the timing analysis of millisecond pulsars is discussed. The existence of such black holes in centers of globular clusters is expected from optical and infrared observations. A signal, emitted by a pulsar, will be a subject of relativistic time delay connected with trajectory curvature and the Shapiro effect. The relative contribution of these components depends on the value of the dimensionless impact parameter. We consider different pulsar positions relative to a globular cluster. For several millisecond pulsars in globular clusters, located most closely to cluster centers, the expected time delays and corresponding duration of observations, required for their registration, are calculated.

Superfluidity in NS cores and heating in NS crusts: Constraints from the data on SXTs in quiescent states

K. Levenfish[1], P. Haensel[2], D.G. Yakovlev[1]

[1]Ioffe Physical-Technical Institute (St.Petersburg, Russia)
[2]Copernicus Astronomical Center (Warsaw, Poland)

Transiently accreting neutron stars (NSs) remain hot during quiescent periods, due to deep crustal heating. X-rays from the hot NS surface can put constraints on many NS properties. We show that thermal emission from quiescent soft X-ray transients points at the presence of strong proton superfluidity and the absence of the mild neutron superfluidity in the outer NS core. The data also suggest that deep heat release in NS crusts (from nuclear transformations of the accreted matter) is about MeV per accreted nucleon.

This work was partly supported by the Russian Foundation for Basic Research (grants 05-02-22003 and 08-02-00837a) and by the Program "Leading Scientific Schools of Russian Federation" (grant NSh-2600.2008.2).

Neutrino transport for 3D supernova models

M. Liebendörfer, S.C. Whitehouse

University of Basel (Basel, Switzerland)

Important features of recent core-collapse supernova models should be explored in three dimensions in order to answer the following questions: How does the emission of neutrinos interact with fluid instabilities? How does the standing accretion shock instability couple to neutron star oscillation modes? And how are magnetic fields amplified when a neutron star is born? We present the "isotropic diffusion source approximation", a spectral neutrino transport scheme designed for three-dimensional simulations and demonstrate its accuracy in comparison with spherically symmetric Boltzmann neutrino transport. We discuss the emission of gravitational waves and the winding of magnetic field lines in preliminary three-dimensional simulations of stellar core collapse and postbounce evolution.

Transition to deconfined phase in neutron stars

Umberto Lombardo

INFN Sezione di Catania (Catania, Italy)

The effects of the transition to quark matter on the structure of neutron stars are discussed. The hadron phase is obtained including two and three body forces which makes the nuclear matter equation of state quite stiff. The quark phase is obtained from a model in which the quarks are confined by a density dependent mass according to a scaling law. The latter is required by the chiral symmetry breaking. A quenching of the neutron star mass is the main effect of the hadron-to-quark transition. The competition with other phases, such as kaon condensation and hyperons, is also discussed.

The origin of Type Ia supernovae

Peter Lundqvist

Stockholm Observatory (Stockholm, Sweden)

The origin of Type Ia supernovae (SNe Ia) is still unknown. While it is widely accepted that they result from the explosion of a white dwarf in a binary system, we know very little about the nature of a companion star. To reveal the true nature of SNe Ia and make more stringent use of them in cosmology and for nucleosynthesis yields, we therefore need stringent methods to discriminate between possible progenitor scenarios. I will discuss some possible methods and what they have revealed.

X-ray pulsars through the eyes of the current cosmic observatories

A. Lutovinov, S. Tsygankov

Space Research Institute (IKI) (Moscow, Russia)

Most accurate at the moment results of the spectral and timing analysis of several dozen X-ray pulsars in hard X-rays are reviewed and compared with results of observations in standard X-rays. The evolution of cyclotron energy with the source luminosity was studied in detail for the first time for several sources. It was shown that for V0332+53 and A535+26 this dependence is linear, but for 4U0115+63 it is more complicated. No evolution was found for GX301-2, Vela X-1, Cen X-3, etc. A strong dependence of the pulse fraction on the energy and source luminosity was revealed and studied in detail. The prominent feature in the dependence of the pulse fraction on the energy was discovered near the cyclotron frequency for several bright sources. The obtained results are discussed in terms of current models; some preliminary explanations are proposed.

Pulsar winds: Transition to a force free regime

G. Machabeli, Z. Osmanov

E. Kharadze National Abastumani Astrophysical Observatory (Tbilisi, Georgia)

The problem of reconstruction of pulsar magnetospheres near the lightcylinder surface is studied. It is shown that, on the basis of the Euler, continuity and induction equations, there is a possibility of parametrically excited process to pump rotational energy into drift modes. As a result, the toroidal component of the magnetic field increases very rapidly. The increment is analyzed for plasma parameters of a typical pulsar magnetosphere. The feedback of the excited waves on particles is considered to be insignificant. The dynamics of the reconstruction of the pulsar magnetosphere is studied analytically. It is traced from the generation of a toroidal component of the magnetic field up to the transformation of the field lines into such a configuration, when plasma particles do not experience any forces: the motion of the particles switches to the so called "force-free" regime. At this stage, the generation of the toroidal component comes to the end, and the pulsar wind reaches its stationary state.

"Anomalous" pulsars

I. F. Malov

Pushchino Radioastronomy Observatory of the Astrocosmic Center of the Lebedev Physical Institute, PRAO ASC FIAN (Pushchino, Russia)

Many astrophysicists believe that Anomalous X-Ray Pulsars (AXPs), Soft Gamma-Ray Repeaters (SGRs), Rotational Radio Transients (RRATs), Compact Central Objects (CCOs) and X-Ray Dim Isolated Neutron Stars (XDINSs) belong to different classes of anomalous objects with neutron stars as the central bodies inducing all their observable peculiarities. We have shown earlier (I.F. Malov and G.Z. Machabeli, Astron. Astrophys. Trans. 25, 7, 2006) that AXPs and SGRs could be described by the drift model assuming usual properties of central neutron stars (rotation periods $P \sim 0.1 - 1$ s and surface magnetic fields $B \sim 10^{11} - 10^{13}$ G). Here we shall try to show that some differences of considered sources can be explained by their geometry (particularly, by the angle β between their rotation and magnetic axes). If $\beta \lesssim 10°$ (the aligned rotator), the drift waves at the outer layers of the neutron star magnetosphere should play a key role in the observable periodicity. For large values of β (the case of the nearly orthogonal rotator), an accretion from the surrounding medium (for example, from the relic disk) can cause some modulation and transient events in emitted radiation. Recently Kramer et al. and Camilo et al. (Astro-ph/0702365 and Astro-ph/0802.0494v1) have shown that AXPs J1810–197 and 1E 1547.0–5408 have both small angles β, that is these sources are nearly aligned rotators, and the drift model should be used for their description. On the other hand, Wang et al. (Nature, 440, 772, 2006) detected IR radiation from a cold disk around the isolated young X-ray pulsar 4U 0142+61. This was the first evidence of a disk-like object around the neutron star. Probably there is the bimodality of anomalous pulsars. AXPs, SGRs and some radio transients belong to the population of aligned rotators with $\beta < 20°$. These objects are described by the drift model, and their observed periods are connected with the periodicity of drift waves. Other sources have $\beta \sim 90°$. Switching on or off their radiation is caused by accretion phenomena connected with a relic (debris) disc surrounding them. XDINSs and CCOs are probably neutron stars with rather low magnetic fields on their surfaces. Other known models of "anomalous" pulsars are briefly discussed.

Electron-proton temperature equilibration mechanisms in SNRs

Felix Aharonian[1], Denys Malyshev[2,3]

[1]Max-Planck-Institut für Kernphysik (Heidelberg, Germany)

[2]Dublin Institute for Advanced Studies (Dublin, Ireland)

[3]Bogoliubov Institute for Theoretical Physics (Kiev, Ukraine)

We consider supernovae at the Sedov phase and discuss the temperature equilibration between components in case of two component (electron-proton) postshock plasma. It is shown that the T_e to T_p ratio, calculated under the assumption of only Coulomb interactions between particles, is too small to satisfy observational values. Some estimates on the efficiency of required interaction are given.

3D explosion dynamics of a critical-mass neutron star in a binary system

K.V. Manukovskiy

Alikhanov Institute for Theoretical and Experimental Physics (Moscow, Russia)

In a compact double neutron star binary, a low-mass component undergoes an explosive destruction at the final evolutionary stage of the binary as a result of the collapse of the rotating iron core. We obtain a numerical solution for the three-dimensional dynamics of $0.1\,M_\odot$ iron ejecta with the energy release of 4.7 MeV per nucleon in the gravitational field of a high-mass neutron star. The numerical solution is obtained by the particle method, which is adequate for a collisionless description of the ejecta dynamics in the absence of the interstellar medium. As a test problem, the suggested model is compared with the well-known asymptotic solution (for vanishing m/M), which we also slightly improve and extend. We analyze in detail the separation of the ejecta into two categories of particles with hyperbolic and elliptical orbits. We obtain a number of results from the analytical solution, which allow us to estimate the kinetic energy of the ejecta as a function of the binary component mass ratio and the final pulsar velocity by applying momentum conservation law in the pulsar-ejecta system. Also, we carry out simulations with time-dependent energy release and a realistic profile of the ejecta velocity distribution. Further use of our calculations is promising to formulate the initial conditions for the three-dimensional hydrodynamic problem of the collision of ejecta with presupernova shells.

Different magnetorotational supernovae

S. G. Moiseenko*, G. S. Bisnovatyi-Kogan†

Space Research Institute, Profsoyuznaya 84/32, Moscow 117997, Russia

Results of 2D simulations of magnetorotational core collapse supernova explosion are presented for different core masses, angular momenta and magnetic field configurations. We show that magnetorotational mechanism allows one to get an explosion energy which corresponds to observational data. The shape of the explosion significantly depends on the initial magnetic field configuration. During the magnetic field evolution, magnetorotational instability (MRI) develops which means an exponential growth of all magnetic field components. MRI significantly reduces MR supernova explosion time. We found that the supernova explosion energy grows with the increase of the initial iron core mass and initial rotational energy[1].

References

[1] G.S. Bisnovatyi-Kogan, S.G. Moiseenko, N.V. Ardeljan. Astr. Rep. (submitted) 2008

Gamma-ray bursts and the most distant supernovae in the Universe

A. S. Moskvitin, E. Sonbas, V. V. Sokolov

Special Astrophysical Observatory, SAO RAS (Nizhnij Arkhyz, Russia)

A discovery of the connection between long-duration gamma-ray bursts (GRBs) and core-collapse supernovae (SNe) is the most important achievement in this domain in recent 10 years. Now a search for SN signatures in photometry and spectra of GRB optical transients becomes the main observational direction both for large ground-based telescopes and space platforms. The GRBs themselves are already considered as a probe for studying processes of massive star-formation at cosmological distances up to $z \sim 10$. Irrespective of specific models of this phenomenon, it can be said now that, while observing GRBs, we observe SNe which, probably, are always related to relativistic collapse of massive stellar cores in very distant galaxies.

*E-mail: moiseenko@iki.rssi.ru
†E-mail: gkogan@iki.rssi.ru

Neutrino scattering in the neutrino heat conduction theory

D. K. Nadyozhin*, A. V. Yudin†

Alikhanov Institute for Theoretical and Experimental Physics, Moscow, Russia

The neutrino heat conduction theory (NHC) has been first formulated in [1] assuming that neutrino transport is dominated by neutrino absorption. Here we generalize the NHC by taking into account neutrino scattering as well. The NHC consistently describes fluxes of energy and lepton charge emerging from the neutrino opaque core. In comoving frame, the fluxes are proportional to the gradients of temperature and neutrino chemical potential. In the case of incoherent neutrino scattering (e.g., by electrons), the factors of proportionality are averaged over the neutrino energy using weight functions that can be found by numerical solution of simple integral equations. Incoherent neutrino scattering enters the NHC through 0-th and 1-st moments of the Legendre expansion of scattering kernel. Coherent scattering is described by the transport cross-section algorithm. We suggest a new method for calculating the neutrino-electron scattering functions that is based on Fermi-Dirac functions of integer indices. Further details and bibliography can be found in [2].

References

[1] V. S. Imshennik, D. K. Nadyozhin, Zh. Eksp. Teor. Fiz. 63, 1548 (1972) [Sov. Phys. JETP 39, 583 (1972)].

[2] A. V. Yudin, D. K. Nadyozhin, Astronomy Lett. 34, 198 (2008).

*E-mail: nadezhin@itep.ru
†E-mail: yudin@itep.ru

Compton scattering of radiation in a strong magnetic field: Relativistic kinetic equation and cross-sections

D. I. Nagirner, A. A. Mushtukov

Sobolev Astronomical Institute, St.Petersburg State University (St.Petersburg, Russia)

The relativistic kinetic equation describing scattering of radiation by electrons in a strong magnetic field is derived using the methods of quantum electrodynamics and quantum kinetic theory. The cross-sections of the process and rates of absorption and redistribution over frequency, direction and polarization are calculated.

Neutrino processes in magneto-rotational model of supernova explosion

I. S. Ognev, A. A. Gvozdev

Yaroslavl State University (Yaroslavl, Russia)

The magneto-rotational model of supernova explosion has become very popular in last few years. On the one hand, this is connected with the crisis of the spherically-symmetric model, which can predict successful explosion for low-massive star progenitors only. On the other hand, fast rotation and magnetic field generation can be a solution of this problem. It is known, that the interaction of neutrinos with the matter of a core-collapse remnant can strongly affect the dynamics of the explosion. Therefore, the inclusion of this phenomenon into the magneto-rotation model is necessary for a correct simulation of core-collapse supernova explosions.

Neutrino magnetic moment and the shock wave revival in a supernova explosion

A. V. Kuznetsov*, N. V. Mikheev†, A. A. Okrugin‡

Yaroslavl State University, Sovietskaya 14, 150000 Yaroslavl, Russia

The neutrino chirality-flip process in a supernova core is investigated in detail; the plasma polarization effects in the photon propagator are taken into account [1] in a more consistent way than in earlier publications [2, 3]. In particular, it is shown that the contribution of the proton fraction of plasma dominates. The supernova core luminosity Q_{ν_R} for ν_R emission is calculated.

Assuming that the right-handed neutrino luminosity is smaller than the left-handed neutrino luminosity in ~ 0.1 s after the collapse, $Q_{\nu_R} < 10^{53}$ ergs/s, we obtain a new upper bound on the Dirac neutrino magnetic moment, $\mu_\nu < (0.7 - 1.5) \times 10^{-12}\, \mu_{\rm B}$. This limit is rather robust with respect to variations of supernova core parameters, when the product of the average value of the electron fraction Y_e on the core mass is fixed.

In this way, the best upper bound on the neutrino magnetic moment from SN 1987A is improved by a factor of 2.

Using this new approach to the neutrino chirality-flip process in the supernova core, the process of two-step conversion of the neutrino helicity, $\nu_L \to \nu_R \to \nu_L$ [4], is reanalyzed for supernova conditions. The first stage, $\nu_L \to \nu_R$, is realized due to the interaction of the neutrino magnetic moment with the plasma electrons and protons in the supernova core. The second stage, $\nu_R \to \nu_L$, is caused by the neutrino resonant spin-flip in a magnetic field of the supernova envelope. Given the neutrino magnetic moment within the interval $10^{-13}\, \mu_{\rm B} < \mu_\nu < 10^{-12}\, \mu_{\rm B}$, and assuming the existence of the magnetic field $\sim 10^{13}$ G between the neutrinosphere and the shock-wave stagnation region, we obtain an additional energy of the order of 10^{51} erg that can be injected into this region during the time of the shock-wave stagnation. This energy could be sufficient for triggering a damped shock wave.

References

[1] A. V. Kuznetsov, N. V. Mikheev, Journ. Cosmol. Astropart. Phys. **11**, 031 (2007).
[2] R. Barbieri, R. N. Mohapatra, Phys. Rev. Lett. **61**, 27 (1988).
[3] A. Ayala, J. C. D'Olivo, M. Torres, Phys. Rev. D **59**, 111901 (1999).
[4] A. Dar, Princeton, Inst. Advanced Study Preprint-87-0178 (1987, unpublished).

*E-mail: avkuzn@uniyar.ac.ru
†E-mail: mikheev@uniyar.ac.ru
‡E-mail: okrugin@uniyar.ac.ru

Konus-Wind observation of short GRBs

P. P. Oleynik, S. V. Golenetskii, D. D. Frederiks, V. D. Pal'shin,
R. L. Aptekar, E. P. Mazets, M. V. Ulanov, D. S. Svinkin

Ioffe Physical-Technical Institute (Saint-Petersburg, Russia)

Observational data on the short GRBs obtained with the Konus-Wind experiment in the period from 1994 to 2007 are presented. The data include time histories, energy spectra of GRBs and their appearance rate.

Gamma-ray bursts with prompt optical emission

V. D. Pal'shin, S. V. Golenetskii, E. P. Mazets, R. L. Aptekar, D. D. Frederiks,
M. V. Ulanov, P. P. Oleynik

Ioffe Physical-Technical Institute (St.Petersburg, Russia)

We present the Konus-Wind data on gamma-ray bursts (GRBs) with prompt optical emission and compare them with the optical data. A comparison of the gamma and optical light curves and spectra allows us to constrain the different models for the prompt optical emission and study the physics of GRBs in general. Along with the famous historical GRBs 990123, 041219a, and 050820a, we examine the recent brilliant GRB 080319B which showed unprecedentedly bright and intrinsically luminous prompt optical emission.

Dynamics of proto-neutron star neutrino wind and the r-process

I. V. Panov[1,2*], H.-Th. Janka[2]

[1]Alikhanov Institute for Theoretical and Experimental Physics, Moscow, Russia
[2]Max-Planck-Institut für Astrophysik, Garching, Germany

The conditions for the r-process in a neutrino-driven wind and the extreme values of the entropy and dynamical timescale needed for a successful nucleosynthesis are numerically evaluated. A number of parametric calculations of the r-process nucleosynthesis for typical conditions in a neutrino wind of a hot proto-neutron star is made, and some critical conditions, to be achieved for a successful creation of the platinum peak during r-process, are determined. We confirm (see [1]) that the r-process is only possible under the conditions of moderate entropy we are interested in, for a very short expansion timescale. The dependence of heavy element yields on the type of the asymptotic behavior of temperature and density is explored. Extreme cases of zero and constant velocity of the wind expansion are studied. It is shown that during the expansion with a constant velocity the sensitivity of the r-process calculation on initial parameters is much weaker than under constant boundary conditions.

Time-dependent asymptotic temperature and density behavior, as well as the model with reduced mass ejection rate [2], are more favorable for the r-process when the time-dependent asymptotic temperature T_9^f is based on the concept of steady expansion, instead of introducing constant boundary conditions [3, 4].

Variations in initial values of the asymptotic temperature $T_9^f(t_0)$ (and corresponding initial density $\rho^f(t_0)$) within the discussed limits ($0.1< T_9^f(t_0) < 1.4$) significantly – up to three orders – affect the initial neutron density. However, because of a rapid temperature decline, the balance between (n,γ) and (γ,n)-processes is changed into the balance between (n,γ)-captures and beta-decays. Then the r-process transforms to the rβ-process (like in n-process of [5]) with the total number of captured neutrons being close for different initial $T_9^f(t_0)$ values.

The asymptotic temperature and density expansion, produced by the expansion of matter in winds with constant velocity, shows a weak sensitivity of the third peak formation to the initial values of $T_9^f(t_0)$ and $\rho^f(t_0)$. This fact probably gives evidence of the same robust r-process pattern for SN explosions with different characteristics.

References

[1] T. A. Thompson, A. Burrows, B. S. Meyer. ApJ, 562, 887 (2001)
[2] Sh. Wanajo, T. Kajino, G. J. Mathews, K. Otsuki. ApJ, 554, 578 (2001)
[3] Sh. Wanajo, N. Itoh, Yu. Ishimaru, S. Nozawa, et al. ApJ, 577, 853 (2002)
[4] M. Terasawa, K. Sumiyoshi, T. Kajino, G. Mathews, et al. 2001, ApJ, 562, 470
[5] J. B. Blake, D. N. Schramm. ApJ, 209, 846 (1976)

*E-mail: igor.panov@itep.ru

A model for the radio emission pattern of the Crab pulsar

S. A. Petrova

Institute of Radio Astronomy of NAS of Ukraine (Kharkov, Ukraine)

The Crab pulsar is known for its exceptionally complex radio profile with pronounced frequency evolution. In addition to the interpulse and precursor, similar to those seen in some other pulsars, it shows several peculiar components, which are spread out over the whole pulse period and exhibit substantially distinct spectral and polarization properties. The nature of these components is still obscure.

We extend our physical model of the precursor and interpulse to include the rest components of the Crab pulsar profile. Our generalization of the induced scattering of the main pulse into background is concerned with the specification of the type of motion of the scattering plasma particles. In the outer magnetosphere, the particles participate in the resonant absorption of radio waves and are known to acquire substantial transverse momenta. Therefore, we consider the induced scattering by the particles performing relativistic helical motion.

The scattering from different harmonics of the particle gyrofrequency takes place at different altitudes in the magnetosphere and, because of the rotational effect, may give rise to different components in the pulse profile. It is demonstrated that the induced scattering from the first harmonic into the state under the resonance can account for the so-called low-frequency component (LFC) in the radio profile of the Crab pulsar. This idea is strongly supported by the polarization data observed. Then the high-frequency components (HFC1 and HFC2) may result from the subsequent backward induced scattering of the LFC emission in weaker magnetic fields. Similarly, the high-frequency interpulse, which is shifted to the earlier pulse phase, may arise as a result of the backward induced scattering of the precursor component.

Based on an analysis of the fluctuation behavior of the scattering efficiencies, the transient components of similar nature are predicted for other pulsars.

Radio profile components outside the main pulse

S. A. Petrova

Institute of Radio Astronomy of NAS of Ukraine (Kharkov, Ukraine)

The profiles of some pulsars contain the additional components (e.g. interpulses, precursors, etc) outside the main pulse. These components show peculiar spectral, polarization and fluctuation properties. At the same time, there is a growing observational evidence that the precursor and interpulse emissions interact with each other and with the main pulse.

The additional components are usually interpreted in terms of several geometrical models, which place their origin well apart from the emission region of the main pulse. With the assumption of a favorable orientation of the pulsar with respect to an observer, the component location in the pulse profile is readily reproduced. However, it is still unclear how these independently generated components can be affected by the main pulse emission and by each other.

We, for the first time, propose a physical model of the precursor and interpulse components. It allows us to explain the peculiarities of these components as well as their connection to the main pulse. The precursor and interpulse are considered as consequences of the main pulse propagation through the secondary plasma flow in the open field line tube of a pulsar. Namely, they are assumed to result from the induced scattering of the main pulse into background. Although the initial intensities of the background are expected to be extremely small, the main pulse intensities are so high that the induced scattering can be very efficient and a significant part of the radio pulse energy can be transferred into the background.

The scattered radiation tends to concentrate in the direction corresponding to the maximum scattering probability and can form a separate component in the pulse profile. In the regime of a superstrong magnetic field, the scattered component appears nearly aligned with the local magnetic field direction. Taking into account the effect of rotational aberration in the scattering region, one can identify the scattered component with the precursor. In the regime of a moderately strong magnetic field, the scattered component is antiparallel to the velocity of the scattering particles and can be recognized as an interpulse.

The spectral evolution, fluctuation behavior and polarization properties of the additional components will be examined. A detailed comparison with the observational results will be given, and the perspectives of the multifrequency studies of complex profiles will be outlined.

On the nature of physical connection between the radio- and high-energy emissions of pulsars

S. A. Petrova

Institute of Radio Astronomy of NAS of Ukraine (Kharkov, Ukraine)

The radio emission and the non-thermal high-energy emission of pulsars are undoubtedly generated by different mechanisms, which are still a matter of debate. At the same time, the recent simultaneous observations indicate the existence of the radio – optical/X-ray correlation in pulsars. Namely, the high-energy profiles and intensities appear to be affected by the radio pulse intensity. This strongly supports the high-energy emission mechanisms based on the reprocessing of radio photon by ultra-relativistic plasma particles in the open field line tube of a pulsar.

One of the ways of the photon reprocessing is concerned with the resonant absorption of pulsar radio emission by the secondary plasma particles. The process occurs in the outer magnetosphere and can strongly modify particle momenta. As a result, the spontaneous synchrotron emission of particles falls into the optical/X-ray range and can account for the observed characteristics of the pulsar high-energy emission. Within the framework of this mechanism, the radio and high-energy luminosities are believed to correlate.

Recently we have examined an additional mechanism, which can transfer radio photons into the high-energy band. The particles participating in the resonant absorption can efficiently scatter the radio photons, which are still below the resonance. These under-resonance photons are chiefly scattered to the high harmonics of the particle gyrofrequency, into the range of the spectral maximum of the particle synchrotron emission, and the total scattering cross-section of a gyrating particle is much larger than that of the particle at rest. Based on a detailed study of the low-frequency scattering by gyrating particles we conclude that although the scattered power never exceeds the synchrotron power of the particle, it is the process that can explain a specific change of the X-ray light curve with the radio pulse intensity, which is observed in the Vela pulsar.

Tkachenko waves and precession in neutron stars

S. B. Popov

Sternberg Astronomical Institute (Moscow, Russia)

I note that the proposed precession period of the isolated neutron star RX J0720.4–3125 is consistent with the period of Tkachenko waves for the spin period of 8.4 s. Based on a possible observation of a glitch in RX J0720.4–3125 (van Kerkwijk et al. 2007), I propose a simple model, in which long period precession is powered by Tkachenko waves generated by a glitch. The period of free precession, determined by a neutron star oblateness, should be equal to the standing Tkachenko wave period for an effective energy transfer from the standing wave to the precession motion. A similar scenario can be applicable also in the case of the PSR B1828–11.

Extragalactic magnetars and transient radio sources

S. B. Popov[1*], K. A. Postnov[1,2]

[1]Sternberg Astronomical Institute, Moscow

[2]Moscow State University, Department of Physics, Moscow

We start with a discussion of the observability of giant flares of extragalactic magnetars following [4]. After this we discuss the hypothesis that the bursting activity of magnetars evolves with time analogously to the glitching activity of normal radio pulsars (i.e., sources more active at smaller ages), and that the increase of the burst rate follows one of the laws established for glitching radio pulsars. If the activity of soft gamma repeaters decreases with time in the way similar to the evolution of core-quake glitches ($\propto t^{5/2}$), then it is more probable to find the youngest soft gamma repeaters, but the energy of giant flares from these sources should be smaller than observed 10^{44} – 10^{46} ergs as the total energy stored in a magnetar's magnetic field is not enough to support thousands of bursts similar to the prototype 5 March 1979 flare. These results are published in [3].

Then we propose [5] that the strong millisecond extragalactic radio burst (mERB) discovered by Lorimer et al. [1] may be related to a hyperflare from an extragalactic soft gamma-ray repeater. The expected rate of such hyperflares, $\sim$ 20–50 d^{-1} Gpc^{-3}, is in good correspondence with the value estimated by Lorimer et al. A possible mechanism of radio emission can be related to the tearing mode instability in the magnetar magnetosphere, as discussed by Lyutikov [2], and can produce the radio flux corresponding to the observed 30 Jy from the mERB using a simple scaling of the burst energy.

Finally, we discuss different models to explain properties of the source GCRT J1745–3009.

References

[1] D. Lorimer et al. Science, 318, 777 (2007)
[2] M. Lyutikov. ApJ, 580, L65 (2002)
[3] S. Popov. AN, 329, 15 (2008)
[4] S. Popov, B. Stern. MNRAS, 365, 885 (2006)
[5] S. Popov, K. Postnov; arXiv: 0710.2006

*E-mail: polar@sai.msu.ru

Constraints on massive gravitons from pulsar timing and astrometric measurements

K. A. Postnov, M. Pshirkov, A. Tuntsov

Sternberg Astronomical Institute (Moscow, Russia)

We show that the modern accuracy of pulsar timing (about 0.2 mcs) and astrometric measurements (about 100 microarcsec) put strong constraints on a possible mass of gravitons in some theories of gravitation (in particular, developed by Dubovsky et al. 2005) predicting a strong monochromatic stochastic gravitational wave background. The bounds are especially strong when taking into account the surfing effect for gravitons (the difference in the velocity of graviton propagation and the speed of light). We conclude that massive gravitons are excluded as viable candidates for cold dark matter.

Observation and appearance of magnetospheric instability in flaring activity at the onset of X-ray outbursts in A 0535+26

K. A. Postnov[1], R. Staubert[2], A. Santangelo[2], D. Klochkov[2], P. Kretschmar[3], I. Caballero[2]

[1]Sternberg Astronomical Institute (Moscow, Russia)

[2]Institute for Astronomy and Astrophysics (Tübingen, Germany)

[3]European Space Agency, European Space Astronomy Center (Madrid, Spain)

We study the spectral and temporal behavior of the High Mass X-ray Binary A 0535+26 during a 'pre-outburst flare' which took place ∼5 days before the peak of a normal (type I) outburst in August/September 2005. We compare the studied behavior with that observed during the outburst. We analyse RXTE observations that monitored A 0535+26 during the outburst. We complete spectral and timing analyses of the data. We study the evolution of the pulse period, present energy-dependent pulse profiles both at the initial pre-outburst flare and close to the outburst maximum, and measure how the cyclotron resonance-scattering feature (hereafter CRSF) evolves. We present three main results: a constant period $P = 103.3960(5)$ s is measured until periastron passage, followed by a spin-up with a decreasing period derivative of $\dot{P} = (-1.69 \pm 0.04) \times 10^{-8}$ s/s at MJD 53618, and P remains constant again at the end of the main outburst. The spin-up provides the evidence for the existence of an accretion disk during the normal outburst. We measure a CRSF energy of $E_{\rm cyc} \sim 50$ keV during the pre-outburst flare, and $E_{\rm cyc} \sim 46$ keV during the main outburst. The pulse shape, which varies significantly during both pre-outburst flare and the main outburst, evolves strongly with photon energy.

We argue that X-ray flaring variability observed in the transient X-ray pulsar A 0535+26 is due to a low-mode magnetospheric instability. This instability develops at the onset of accretion, in a thin boundary layer between the accretion disk and neutron star magnetosphere. As a result, the matter collected in the boundary layer can rapidly fall onto the neutron star surface close to the magnetic poles, but not exactly along the field lines by which the stationary accretion proceeds. This explains the shift in the cyclotron line energy measured using RXTE data in a pre-outburst spike, with respect to the line energy observed during the main outburst. Furthermore, the instability can account for the difference in pulse profiles, and for their energy evolution that is different in the pre-outburst flare and the main outburst.

Time-dependent simulations of the spreading layers and the origin of quasi-periodic oscillations in accreting weakly-magnetized neutron stars

J. Poutanen, A. Spitkovsky

University of Oulu (Oulu, Finland)

Matter accreting on weakly-magnetized neutron stars decelerates from the nearly Keplerian rotation to a slower stellar rotation due to the interaction with the star. The deceleration can happen in the classical boundary layer or in the spreading layer as was recently proposed by Inogamov & Sunyaev (1999). In the spreading layer model it is assumed that the average rotational velocity of gas in the layer at the equator is close to the Keplerian one. In addition, the set of equations allows, as usual, various solutions and the specific steady-state solution is chosen from that set. We performed time-dependent simulations of the spreading layer and showed that the actual solution is very far from the Inogamov & Sunyaev (1999) solution. We obtain solutions for various accretion rates and rotational velocities of the star. We also discuss the relation between the rotational rates of the accreting matter and the frequencies of quasi-periodic oscillations observed from accreting weakly-magnetized neutron stars.

Is the class of short gamma ray bursts homogenous?

A. Pozanenko[1], V. Loznikov[1], R. Preece[2]

[1]Space Research Institute (IKI) (Moscow, Russia)
[2]University of Alabama (Huntsville, USA)

A morphological classification of short duration Gamma-Ray Bursts (GRBs) is now in crisis. Short duration GRBs consisting of a single short activity episode ($T_{90} \sim 0.5$) at mid cosmological distances ($z \sim 0.1 - 1$) are still observing. On the other hand, searching for Soft Gamma Repeaters (SGRs) from nearby galaxies seems to be successful with the detection of GRB 070201 from M31 and GRB 051103 from M81. Indeed, the giant flare of SGR 1806–20 on December 27, 2004 would be observable as a short GRB and could be detected at a distance of 50 Mpc. Finally, bursts with an extended emission have been detected in both BATSE and Swift/BAT experiments. Initial episode of these events looks like a classical short duration burst, while intense emission registered up to 100 s puts the event into long duration mode (i.e., into the mode of classical long duration GRBs) if based only on the observable duration. The best known representative of such events is GRB 060614.

Based on BATSE, BAT/Swift and INTEGRAL bursts we investigate common features of short GRBs and bursts with the extended emission. We also discuss the nature of GRBs with extended emission and estimate a number of SGR events in the BATSE catalog.

Russian Space Photometrical Survey "Lyra"

M. E. Prokhorov

Sternberg Astronomical Institute (Moscow, Russia)

"Lyra" is a high precision 10-band (in 200–1000 nm) all sky photometrical survey in the frame of the Basic Research Program on the Russian Segment of International Space Station. Photometric precision is $0.003 - 0.001^m$ to 12^m and 0.01^m to 16^m. The project is on the conceptual design stage.

Russian Space Astrometrical Experiment "Svecha"

M. E. Prokhorov

Sternberg Astronomical Institute (Moscow, Russia)

General goals of the "Svecha" space experiment are:
1). Astrometrical catalog of all objects (coordinates, proper motions and parallaxes) with precision of 25 μas for objects to 16^m and with precision of 100 μas for objects to 20^m.
2). Catalog of multiband photometry (10–16 filters) with precision of 0.001^m for all objects to 18^m and with precision of 0.01^m for objects to 22^m.
3). Catalog of radial velocities for all objects brighter than $18 - 19^m$ in 4–6 spectral intervals independently.
4). Medial resolution spectral catalog ($R = 1/1000 - 1/3000$) for all objects to 12^m (and to $16 - 18^m$ selectively).
The experiment will be based on an autonomous satellite on geosynchronous orbit.
The mission is at the theoretical stage of development.
The construction of the satellite and astrophysical applications will be discussed.

Influence of photon-neutrino processes on the magnetar cooling

M. V. Chistyakov*, D. A. Rumyantsev†

Yaroslavl State University (Yaroslavl, Russia)

The photon-neutrino processes $\gamma e^\pm \to e^\pm \nu\bar{\nu}$, $\gamma \to \nu\bar{\nu}$ and $\gamma\gamma \to \nu\bar{\nu}$ are investigated in the presence of a strongly magnetized dense electron-positron plasma. The amplitudes of the reactions $\gamma e^\pm \to e^\pm \nu\bar{\nu}$ and $\gamma\gamma \to \nu\bar{\nu}$ are obtained for the first time. In the case of a cold degenerate plasma, contributions of these processes to the neutrino emissivity are calculated. It is shown, that the contribution of the process $\gamma\gamma \to \nu\bar{\nu}$ to the neutrino emissivity is suppressed in comparison with the contributions of the processes $\gamma e^\pm \to e^\pm \nu\bar{\nu}$ and $\gamma \to \nu\bar{\nu}$. The constraint on the magnetic field strength in the magnetar outer crust is obtained.

The influence of magnetar thermal emission on pair production

M. V. Chistyakov, D. A. Rumyantsev

Yaroslavl State University (Yaroslavl, Russia)

The influence of the magnetar thermal emission on the electron-positron pair creation is investigated taking into account photon dispersion and large radiative corrections. The comparison of the two reactions, one-photon and photon – thermal photon pair production, is made. The importance of the process under consideration for the magnetar radio emission is discussed.

*E-mail: mch@uniyar.ac.ru
†E-mail: rda@uniyar.ac.ru

Soft equation of state from heavy ion data and implications for compact stars

I. Sagert[1*], J. Schaffner-Bielich[1†], Ch. Sturm[2‡]

[1]Institute for Theoretical Physics, University of Frankfurt, Germany
[2]Institute for Nuclear Physics, University of Frankfurt, Germany

Recent results from measurements of Kaon production at subthreshold densities in heavy ion collisions imply a soft nuclear equation of state for densities below 3 saturated nuclear matter densities with compressibilities $K_0 \leq 200$ MeV [1]. We apply these results to study the implications on compact star properties. As a probe for the nuclear matter compressibility, maximum masses of neutron stars are calculated using a phenomenological equation of state as well as a Skyrme-Hartree-Fock approach. Furthermore, we explore the consequences of a soft nuclear equation of state for the highest possible mass of compact stars following the approach of Rhoades and Ruffini [2] (see also [3]). Finally, we test low mass neutron star measurements as a probe for the symmetry energy of nuclear matter.

References

[1] Ch. Sturm et al. (KaoS), PRL, 86, 39 (2001)
[2] C. E. Rhoades, R. Ruffini, PRL, 32, 324-327 (1974)
[3] V. Kalogera, G. Baym, ApJL, 470, L61 (1996)

*E-mail: sagert@th.physik.uni-frankfurt.de
†E-mail: schaffner@th.physik.uni-frankfurt.de
‡E-mail: c.sturm@gsi.de

Dependence of the rotation periods of millisecond pulsars on metallicity of globular clusters

N.V. Semenets

ETM Company (St.Petersburg, Russia)

In recent years, many new millisecond pulsars have been discovered in globular clusters (Hessels et al. 2007; Freire et al. 2008). Using these data, we show that in metal-poor globular clusters millisecond pulsars, on average, have shorter spin periods than in metal-rich clusters. Most likely, this is due to the differences in ages of such globular clusters, and, accordingly, the differences in the duration of pulsar acceleration.

Optical and X-ray emission from PSR 0540–69.3 and its pulsar-wind nebula

N. Serafimovich[1], S. Pires[2], P. Lundqvist[1], J.-L. Starck[2], D. A. Zyuzin[3], Yu. A. Shibanov[3], J. Sollerman[1]

[1]Stockholm Observatory (Stockholm, Sweden)

[2]Service d'Astrophysique, CEA/Saclay (Gif-sur-Yvette Cedex, France)

[3]Ioffe Physical-Technical Institute (Saint-Petersburg, Russia)

HST/WFPC2 has observed PSR 0540–69.3 and its pulsar-wind nebula (PWN) on several occasions. In particular, the most recent data are contaminated by Charge Transfer Efficiency (CTE) problems, which can lead to high uncertainties in flux end proper motion estimates. We have used a wavelet filtering analysis of the images to reconstruct the structure of the PWN. This reveals that the structure shows remarkable time variability. The same is seen in X-rays after correction for the data pile-up effect. Different physical scenarios to explain these results are discussed.

Slow and normal glitches in PSR B1822−09

T. V. Shabanova*

Pushchino Radio Astronomy Observatory

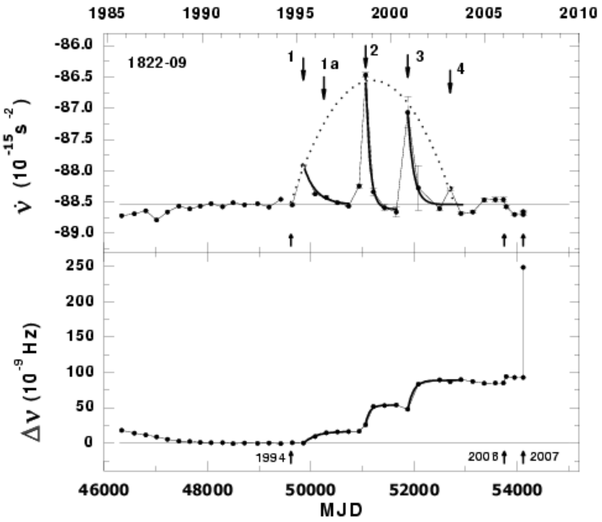

Figure: Signatures of five slow and three normal glitches. Arrows pointing upwards indicate the normal glitches.

The glitching behaviour of the pulsar B1822−09 (J1825−0935) has been investigated at the Pushchino Observatory since 1991. The pulsar exhibits two classes of glitches in its spin rate – normal glitches with a short rise time and slow glitches with a long rise time [1, 2]. Signatures of these glitches are shown in Fig. . A series of five slow glitches, that occurred over the 9-yr time interval, from 1995 to 2004, is well seen in the center of this plot. A charateristic feature of the slow glitches is a gradual exponential increase in the spin frequency ν over some hundreds of days. The corresponding changes in the frequency derivative $\Delta\dot{\nu}$ are responsible for the steepness of the front in the frequency residuals $\Delta\nu$. The existence of the envelope for the peaks of $\Delta\dot{\nu}$ indicates that all slow glitches are the components of one process which took place during 9 years, in 1995–2004. No clear frequency relaxation after a slow glitch is observed. Slow glitches have a certain recurrence interval inside a series which can be estimated to be $\sim$ 1000 days.

The largest normal glitch occurred in January 15, 2007 and was characterized by a fractional increase in the spin frequency of $\Delta\nu/\nu = 1.2 \times 10^{-7}$. As is seen in the rightmost side of the plot, the size of the 2007 glitch is $\sim$ 1.7 times greater than the total effect from all the previous seven glitches. The existence of different types of glitches in the spin rate of one pulsar provides a useful way to study the pulsar glitch mechanisms and the internal structure of a neutron star. It is possible that slow and normal glitches in PSR B1822−09 are triggered by two different mechanisms. Apparently, the most attractive model for the explanation for the origin of slow and normal glitches in this pulsar is a solid quark star model [3].

References

[1] T. V. Shabanova. A&A, 337, 723 (1998)
[2] T. V. Shabanova. ApSS, 308, 591 (2007)
[3] C. Peng, R. X. Xu. MNRAS, 384, 1034 (2008)

*E-mail: tvsh@prao.ru

Landau damping and kinetics of neutron stars

P. S. Shternin*

Ioffe Physical-Technical Institute, Saint-Petersburg, Russia

Kinetic properties (thermal and electric conductivity, shear viscosity) of neutron star matter are analyzed taking into account the exchange of transverse plasmons in collisions of charged particles. In contrast to direct Coulomb scattering via the exchange of longitudinal plasmons (leading to a static Debye-like screening), the exchange of transverse plasmons via relativistic current-current interaction leads to the dynamical Landau damping. In the relativistic degenerate matter, characteristic scales of transverse interactions are much higher than those for longitudinal interactions. The importance of transverse plasmon exchange was pointed out by Heiselberg and Pethick [1] in their studies of ultrarelativistic quark plasma. This effect has never been considered in the kinetics of neutron stars. The dynamical nature of plasma screening in the transverse channel suppresses all the kinetic coefficients, mediated by collisions of charged particles, and modifies their temperature dependence. For example, the electron and muon thermal conductivity in neutron star cores becomes temperature independent (instead of usual Fermi-liquid dependence $\kappa \propto T^{-1}$) and several orders of magnitude lower than has been thought before. The temperature dependence of the shear viscosity η and electrical conductivity along the magnetic field $\sigma_\parallel$ becomes $\eta \propto \sigma_\parallel \propto T^{-5/3}$, in contrast to the standard Fermi-liquid behavior ($\propto T^{-2}$).

We reconsider the thermal conductivity and shear viscosity owing to electron-electron collisions in a neutron star crust [2, 3], the thermal conductivity [4] and shear viscosity in a neutron star core, and the electric conductivity in a magnetized core [5]. The results in the core include the effects of proton superfluidity and are valid for any equation of state of dense matter. All results are approximated by analytic expressions to facilitate their implementation in computer codes.

We discuss several manifestations of updated kinetic coefficients, particularly, the effect of thermal conductivity on the cooling of young neutron stars.

This work was partly supported by the Dynasty Foundation, by the Russian Foundation for Basic Research (grants 08-02-00837, 05-02-22003), and by the state program "Leading Scientific Schools of Russian Federation" (grant NSh 2600.2008.2).

References

[1] H. Heiselberg and C.J. Pethick, Phys. Rev. D. **48**, 2916 (1993).

[2] P.S. Shternin and D.G. Yakovlev, Phys. Rev. D **74**, 043004 (2006).

[3] P.S. Shternin, J. Phys. A. **41**, 205501 (2008).

[4] P.S. Shternin and D.G. Yakovlev, Phys. Rev. D **75**, 103004 (2007)

[5] P.S. Shternin, Sov. Phys. JETP **134**, issue 2(8) (2008), accepted.

*E-mail: pshternin@gmail.com

Neutron star cooling after deep crustal heating in the X-ray transient KS 1731–260

P. S. Shternin[1]*, D. G. Yakovlev[1], P. Haensel[2], A. Y. Potekhin[1]

[1]Ioffe Physical-Technical Institute, Saint-Petersburg, Russia

[2]N. Copernicus Astronomical Center, Warsaw, Poland

We simulate the cooling of the neutron star in the X-ray transient KS 1731–260 after the source returned to quiescence in 2001 from a long ($\gtrsim$ 12.5 yr) outburst state. We show that the cooling can be explained assuming that the crust underwent deep heating during the outburst stage. In our best theoretical scenario the neutron star has no enhanced neutrino emission in the core, and its crust is thin, superfluid, and has the normal thermal conductivity. The thermal afterburst crust-core relaxation in the star may be not over.

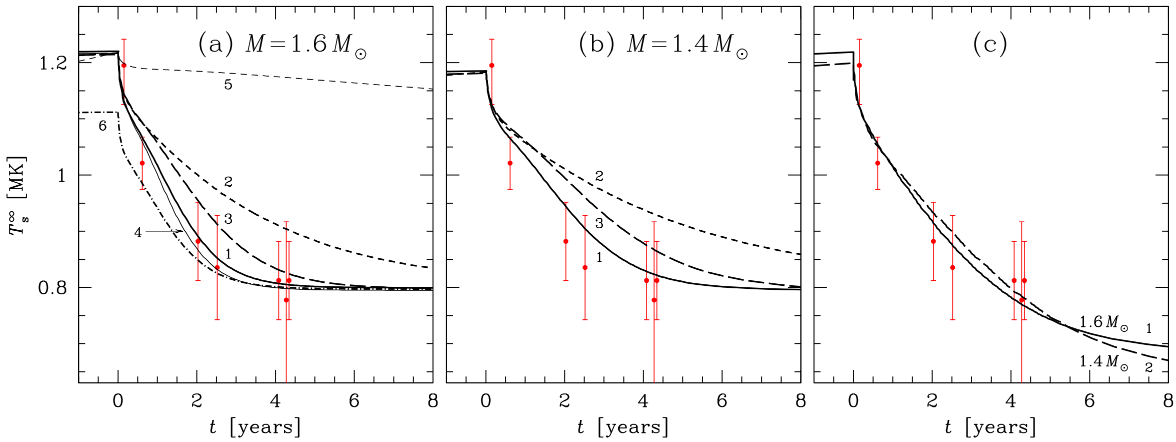

Figure: Theoretical cooling curves for (a) $M = 1.6\,M_\odot$ and (b) $1.4\,M_\odot$ neutron stars, and (c) for stars with both M compared with observations. The curves are explained in Ref. [1].

This work was partly supported by the Dynasty Foundation, by the Russian Foundation for Basic Research (grants 08-02-00837, 05-02-22003), and by the state program "Leading Scientific Schools of Russian Federation" (grant NSh 2600.2008.2).

References

[1] P. S. Shternin, D. G. Yakovlev, P. Haensel, and A. Y. Potekhin, MNRAS **382**, L43 (2007)

*E-mail: pshternin@gmail.com

Photon splitting and pair creation in a magnetar magnetosphere

Ya. N. Istomin[1*], D. N. Sobyanin[2†]

[1]Lebedev Institute of Physics, Russian Academy of Sciences, Leninskii pr. 53, Moscow, 119991 Russia

[2]Moscow Institute of Physics and Technology, Institutskii per. 9, Dolgoprudnyi, Moscow oblast, 141700 Russia

We consider the electron-positron plasma generation processes in the magnetospheres of magnetars. Until recently, the absence of observable radio emission from magnetars has been attributed to the absence of dense plasma in their magnetospheres. The inefficiency of creation of an electron-positron plasma, whose flows would generate radio emission, has been related to photon splitting, which becomes important in a superstrong magnetic field exceeding the quantum critical value $B_c \approx 4.4 \times 10^{13}$ G.

However, we have shown [1] that photon splitting, which was previously considered as a suppression factor for pair generation, is not suppressing at all. Although the splitting undoubtedly takes place in the superstrong magnetic fields of magnetars, it leads only to a strong polarization of the curvature photons, but not to a decrease in their number or energy.

Curvature photons, which are generated by primary particles accelerated in the polar gap, move in a magnetic field, and their distribution function changes so that all photons become $\|$-polarized before the pair generation threshold is reached. These photons create the first-generation particles, with the multiplicity of $\lambda = N/N_{GJ} \lesssim 10^3{-}10^4$. A high magnetic field strength does not give rise to the second generation of particles produced by synchrotron photons. However, the density of the first-generation particles can exceed their density in the magnetospheres of ordinary radio pulsars.

The plasma generation inefficiency can be attributed only to slow magnetar rotation, which narrows the energy range of the produced particles. We conclude that for each specific rotation period P, there exists some minimum surface magnetic field strength at which an effective generation of secondary plasma begins. We have found a boundary in the $P{-}\dot{P}$ diagram that defines the plasma generation threshold in a magnetar magnetosphere. This allows us to shed some light on the recent discovery of pulsed radio emission from several magnetars.

References

[1] Ya. N. Istomin, D. N. Sobyanin. Pis'ma Astron. Zh., 33, 740 (2007) [Astron. Lett., 33, 660 (2007)]

*E-mail: istomin@lpi.ru

†E-mail: sobyanin@gmail.com

Supernova explosions, gravitational collapse and gamma-ray bursts

V. V. Sokolov

Special Astronomical Observatory, SAO RAS (Nizhnij Arkhyz, Russia)

(1) If the formation of massive ($\gtrsim 3M_\odot$) and compact remnants of core-collapse supernovae (with the massive progenitors, $M > 30-40\,M_\odot$) can always be accompanied by the gamma-ray burst (GRB) phenomenon, and (2) if we take into account that the threshold for e^-e^+ pair production in a GRB source depends on an angle between photon momenta, and (3) if the γ-rays are collimated right *in* a GRB source, then another model of GRB source is possible. In such a model (Sokolov et al., 2006, Astronomy Reports, 50, 612) the compact source ($< 10^7$ cm) must always have some radiating *surface* (but not an event horizon) and, respectively, always occupy some finite volume. Such an object can have both a strong regular magnetic field and a nonuniformly-radiating surface connected with it. The list of basic assumptions of the scenario describing the GRBs with the energy release $< 10^{49}$ ergs is given and observational consequences of the compact GRB model are considered.

Absorption features in the spectra of X-ray bursting neutron stars

T. Rauch[1], V. Suleimanov[1,2], K. Werner[1]

[1]Institute for Astronomy and Astrophysics (Tübingen, Germany)
[2]Kazan State University (Kazan, Russia)

Spectral analysis using model-atmosphere techniques is an adequate tool to determine photospheric parameters of neutron stars. Our aim is to identify iron lines in the X-ray range in order to determine $T_{\rm eff}$ of individual neutron stars with low magnetic fields and check the observational results reported early by Cottam et al. (2002). We investigate deviations of LTE and NLTE model atmospheres in the $T_{\rm eff}$ range of neutron stars with a low magnetic field. We have calculated grids of non local thermodynamic equilibrium (NLTE) model atmospheres with different chemical composition at $T_{\rm eff}$ between 1 and 20 MK and compare them with LTE models which, in addition, take into account Compton scattering. Synthetic spectra of LTE and NLTE model atmospheres with identical parameters at wavelengths > 2 Å are in good agreement. Variation of chemical composition (including heavy elements and model atmospheres without hydrogen) does not change the theoretical spectra qualitatively. Compton scattering is very important for hottest ($T_{\rm eff} \geq 15$ MK) model atmospheres. Atmospheres of neutron stars with solar chemical composition can be considered without Compton scattering at lower $T_{\rm eff}$. It is shown that absorption lines of FeXXIV – FeXXVI ions dominate at wavelengths 8–14 Å and at $T_{\rm eff} = 5 - 12$ MK. The absorption lines within this band are very weak at higher temperatures. The identification of FeXXV and FeXXVI absorption lines formed at the stellar surface of EXO 0748−676 cannot be verified, neither by NLTE nor by LTE model-atmosphere spectra. If real, they stem rather from FeXXIV at $z \approx 0.24$.

Detection of pulsed periodic radio emission from 4U 0142+62

V. M. Malofeev, D. A. Teplykh, O. I. Malov, A. E. Rodin

Pushchino Radio Astronomy Observatory, PRAO ASC FIAN (Pushchino, Russia)

Anomalous X-ray Pulsars (AXPs) form a small group (5–7 objects) of exotic young neutron stars; about half of them are observed in supernova remnants. We report the detection of radio emission from the AXP 4U 0142+61. The observations were performed using two sensitive transit radio telescopes of the Pushchino Observatory at frequencies 111 and 41 MHz. The pulse profiles, the flux densities and the dispersion measures are presented, as well as the estimations of distance, spectral indices and integral luminosities. The barycentric periods and period derivatives during the 3 and 2 year intervals have been determined. The comparison of our data and X-ray data showed large differences in the mean pulse widths and luminosities.

Explosive hydrogen burning during type I X-ray bursts on neutrons stars

Friedrich-Karl Thielemann[1], Jacob Lund Fisker[2], Hendrik Schatz[3]

[1]University of Basel, Dept. of Physics (Basel, Switzerland)

[2]University of Notre Dame (Notre Dame, USA)

[3]Michigan State University (East Lansing, USA)

Hydrogen accretion in close binary stellar systems from a companion star onto a neutron star results in the accumulation of unburned matter up to a critical mass of the order $5 \times 10^{-13}\,M_{\odot}$. The ignition under pycnonuclear conditions leads to a thermonuclear runaway and causes an X-ray burst. Explosive hydrogen burning in type I X-ray bursts (XRBs) is driven by charged particle reactions, creating isotopes with masses up to $A = 100$ via proton captures. Since charged particle reactions in a stellar environment are very temperature sensitive, we use a realistic time-dependent general relativistic and self-consistent model of type I X-ray bursts to provide accurate values of the burst temperatures and densities. This allows a detailed and accurate time-dependent identification of the reaction flow from the surface layers through the convective region and the ignition region to the neutron star ocean. Using this, we determine the relative importance of specific nuclear reactions in the X-ray burst.

Rotation-powered pulsars: How do their engines work?

A. N. Timokhin

University of California Berkeley (Berkeley, CA, USA)

I review the last achievements in modeling of pulsar magnetosphere and their implications for constructing a self-consistent model of radio pulsars. By the example of the magnetosphere of an aligned pulsar, I discuss in details the properties of a pulsar magnetosphere and argue that the global magnetosphere structure plays a crucial role in setting of the physical conditions in the "heart" of the pulsar emission machine – the polar cap acceleration zone. I consider physical processes of particle acceleration in the polar cap and their coupling to the global magnetosphere properties. I discuss implication of the polar cap – magnetosphere coupling for pulsar emission mechanisms.

On the nonrelativistic origin of redskewed iron lines in CV, neutron star and black hole sources

L. Titarchuk[1], P. Laurent[2], N. Shaposhnikov[3]

[1]George Mason University and Naval Research Laboratory (Washington D.C., USA)

[2]Fédération Astroparticule et Cosmologie, Collège de France (Paris, France)

[3]Goddard Space Flight Center (Greenbelt, USA)

We present an XMM-Newton data analysis of the K_α line detected in the cataclysmic variable (CV) GK Per. We discover, using data from EPIC PN, that the iron K_α emission line of GK Per has a noticeable redskewed profile. We compare the GK Per asymmetric line with the redskewed lines observed by XMM-Newton in the neutron star (NS) source Serpens X-1 and the black hole (BH) source BH GX 339–4. The observations of the K_α emission with redskewed features in CV GK Per indicate that the red skewness of the line cannot be a BH particular signature related to the redshift effects of General Relativity (GR). If the mechanism of the K_α-line formation is the same in CVs, NSs and BHs, then it is evident that the GR effects would be ruled out as a cause of red skewness of the K_α line. Moreover, recently an alternative model for broad red-shifted iron line formation in the outflowing wind has been suggested. The outflow is a common phenomenon for CVs, NSs and BHs. In this presentation, we demonstrate that the asymmetric shapes of the lines detected from these CV, NS and BH sources are well described with the wind (outflow) model that strongly supports a wind origin of the line in all these sources. Furthermore, we demonstrate that, when the strong redskewed iron line is observed in GX 339–4, the power spectrum is featureless and noisy. However, when the line is weak and almost symmetric, the power spectrum shows a clean feature of a broken power-law (white-red noise component) and two Lorentzians! The strong redskewed iron line is presumably formed in the strong extended wind due to its illumination by the radiation emanating from the innermost part of the object. On the other hand, this strong wind should wash out all particular features of the power spectrum making it highly noisy at all frequencies.

Relativistic effects of radiative transfer at supernova shock breakout

A. G. Tolstov

Alikhanov Institute for Theoretical and Experimental Physics (Moscow, Russia)

Radiative transfer is a key point of light curves and spectra modeling at supernova shock breakout. Due to high energy of the phenomenon, relativistic effects should be taken into account. Using our 1D radiative hydrodynamics code, we succeeded in numerical simulations of the breakout of shock propagation through a stellar envelope. To determine the intensity at the radiation surface we solve numerically the full time-, angle-, and frequency-dependent special relativistic transfer equation in the comoving frame using the method of characteristics. We discuss some relativistic effects of the radiation transport, present a numerical model which has been used and, finally, discuss our results of light curves modeling comparing with calculations in non-relativistic models.

What determines the inclination angle of radio pulsars

D. P. Barsukov, P. I. Polyakova, A. I. Tsygan*

Ioffe Physical-Technical Institute of the Russian Academy of Sciences, Saint-Petersburg, Russia

If one can describe a pulsar spin-down as a sum of magnetic dipole braking and current momentum losses (in the regime of free electron emission) then the angle χ between the magnetic dipole axis and the spin axis comes to an equilibrium state at $\chi \approx 45^\circ$. This equilibrium is stable. It is important that the shape of a pulsar tube cross section depends on χ.

Taking into account a nondipolar magnetic field at the neutron star surface (near the polar cap) we can decrease the current in a pulsar tube which decreases χ. We will characterize deviations from the dipole magnetic field by the ratio ν of the nondipolar to dipolar magnetic fields components at the polar cap. By changing this parameter from $\nu = 0$ to $\nu = 0.8$, we can change the equilibrium angle from $\chi \approx 45^\circ$ to $\chi = 0^\circ$. The majority of pulsars have angles $\chi \sim 10^\circ - 30^\circ$. In our model, they correspond to $\nu \sim 0.7 - 0.8$. We can assume that the pulsars with $\chi \sim 45^\circ - 80^\circ$ were born close to orthogonal state; their angles have already reached equilibrium values.

It is interesting that pulsars with a nondipolar magnetic field and certain values of χ may have the negative Goldreich-Julian density near polar cap surface. In this case, the pulsar diode must be placed close to the zero charge density point (at the altitude of $0.01 - 0.2$ of the neutron star radius). The tube below the diode is filled by unmoving positively charged particles, like the area of close magnetic field lines. They create a potential barrier for electrons, that prohibits the normal free charge emission current in the pulsar diode and allows only a weak thermo-emission electron current. As a result, the diode begins to mimic the Ruderman-Sutherland regime diode, with possible generation of sparks.

The work was supported by the Program "Leading Scientific Schools of Russian Federation" (grant NSh-2600.2008.2).

References

[1] J. D. Biggs. "The magnetospheric structure and emission mechanisms of radio pulsars," Proc. IAU Coll. No. 128, p. 22 (1990)

[2] A. G. Muslimov, A. I. Tsygan. Mon. Not. R. Astr. Soc., 255, 61 (1992)

[3] E. M. Kantor, A. I. Tsygan. Astronomy Reports, 47, 615 (2003)

[4] L. Davis, M. Goldstein. ApJ, 159, L81 (1970)

[5] P. Goldreich. ApJ, 160, L11 (1970)

[6] P. B. Jones. ApJ, 209, 602 (1976)

[7] A. Melatos. Mon. Not. R. Astr. Soc., 313, 217 (2000)

[8] S. A. Eliseeva, S. B. Popov, V. S. Beskin; astro-ph/0611320

*E-mail: tsygan@astro.ioffe.ru

Supernova 2005cs and the origin of type IIp supernovae

Victor P. Utrobin[1], Nikolai N. Chugai[2]

[1]Alikhanov Institute for Theoretical and Experimental Physics (Moscow, Russia)
[2]Institute of Astronomy (Moscow, Russia)

Type IIP SNe are thought to originate from main-sequence stars in the range of 9–25 $M_{\odot}$. Two approaches can be used to check this conjecture. The first is a detection of pre-SN in archival images. Alternatively, hydrodynamic modeling of light curve can be used to determine the mass. The ejecta mass combined with the mass of a neutron star and the mass lost by the stelar wind gives the progenitor mass. At present, the hydrodynamic mass is measured for only three type IIP SNe. We present results of hydrodynamic modeling of sub-luminous supernova 2005cs. The derived parameters of SN 2005cs fall between those of low-luminosity and normal type IIP SNe. Surprisingly, the mass distribution of progenitors of all studied type IIP SNe is strongly skewed towards the upper limit of stars responsible for this class of SNe, contrary to the expectations based on the Salpeter distribution. We discuss the implications of this intriguing fact.

Time variability of nonthermal radiation in the vicinity of the forward shock of Cas A supernova remnant

Y. A. Uvarov, A. M. Bykov, A. M. Krassilchtchikov

Ioffe Physical-Technical Institute (St.Petersburg, Russia)

A detection of time variability in the radiation flux and spectral evolution of X-ray clumps and filaments in the vicinity of a forward shock in the Cas A supernova remnant is presented. The Chandra Observatory data obtained in 2000–2004 are used in this analysis. The variability was found in the emission of a few clumps and filaments at the 3σ confidence level. It was also found that clumps with increasing flux are more rare than clumps with decreasing flux. We discuss a possible interpretation of these results.

Second harmonic generation of electromagnetic radiation by electron-positron vacuum

N. E. Vigdorchik*

Saint-Petersburg Technological Institute, Moskovsky pr.26, Saint-Petersburg, Russia

Investigation of the gamma-ray burst GB 870303, observed by the Ginga satellite, confirms the existence of spectral features at 20 kev and 40 kev. These are interpreted as the fundamental and the second cyclotron harmonics [1, 2]. This leads to the problem of determining the source of radiation at the second harmonic. In the present work, we show that a nonlinear dependence of electric and magnetic permeabilities on the strength of an electromagnetic wave, which propagates in magnetized electron-positron vacuum, can result in the generation of the second harmonic in gamma-ray emission. It is well known, that electron-positron vacuum in the presence of a constant magnetic field behaves as an anisotropic medium with birefringence characteristics. Then the equations of electromagnetic wave propagation in a magnetic field become nonlinear at $B \geq B_c = m^2c^3/e\hbar = 4.4{\cdot}10^{13}$ G. As a result, vacuum polarization leads to an extra nonlinear term in a Lagrange function for an electromagnetic field [3]. The dependence of polarization and magnetization of electron-positron vacuum on the strength of electromagnetic wave is examined up to the second order terms. The nonlinear equation for electromagnetic waves propagating in the medium "vacuum plus rarefied plasma" is obtained. The problem of the second harmonic generation by electron-positron vacuum is analogous to the same problem in nonlinear optics of single-axis crystals [4]. A simplified system of equations for fundamental and second harmonics is derived using the method of a slowly changing profile. In the case of "pure" magnetized vacuum, phase synchronism occurs between an ordinary electromagnetic wave and a nonlinear medium polarization. It leads to an absolute conversion of the first harmonic energy to the second harmonic. In the presence of a very rarefied plasma, where magnetized vacuum dominates, wave disorder appears between the first harmonic and square polarization, which leads to spatial periodic beatings of amplitudes.

References

[1] T. Murakami et al., Nature 335,234 (1988)

[2] V. V. Zheleznyakov. Radiation in Astrophysical plasmas (Dordrecht: Kluwer, 1996)

[3] V. L. Ginzburg. Theretical Physics and Astrophysics (Moscow: Nauka, 1981)

[4] J.A. Armstrong, N. Bloembergen, J. Ducuing et al., Phys. Rev. 127, 1918 (1962)

*E-mail: nevig@lti-gti.ru

Excluded volume approximation for supernova matter

A. V. Yudin*

Alikhanov Institute for Theoretical and Experimental Physics, Moscow, Russia

Starting from a simple modification of the ordinary Fermi-gas description [1], we develop a general approach to the excluded volume approximation (EVA). The approach is valid for any degree of particle degeneracy and permits the inclusion of other interactions (in addition to EVA). We introduce the effective excluded volume function, whose form can be chosen in different ways to obtain various models. For example, it is easy to obtain the EVA described in [2] which was used in the studies of heavy ion reactions [3, 4] and in the description of extreme states of matter in astrophysics [5].

By implementing our general approach to the case of the Boltzmann limit, we can reproduce such results of well-elaborated theory of hard-sphere particles as, for example, the behavior of many-component different-size mixtures ([6] and references therein).

By adding to the EVA the long-ranged Yukawa-like attractive potential, we have obtained a quasi van der Waals equation of state and used it to explore thermodynamic properties and chemical composition of matter in collapsed supernova cores. The ability of the above approach to describe a phase transition to uniform nuclear matter is also considered.

References

[1] L. D. Landau, E. M. Lifshitz. *Statistical physics*, Vol. 5, part 1 (Pergamon, 1980)

[2] D.H. Rischke, M.I. Gorenstein, H. Stöcker, W. Greiner, Z. Phys. C 51, 485 (1991)

[3] C.M. Hung, E. Shuryak, Phys. Rev. C, 57, 1891 (1998)

[4] M.I. Gorenstein, S.N. Yang, Chinese J. Phys., 34, 3 (1996)

[5] R.M. Aguirre, A.L. De Paoli, Phys. Rev. C, 68, 5 (2003)

[6] M. López de Haro, S.B. Yuste, A. Santos, "Alternative Approaches to the Equilibrium Properties of Hard-Sphere Liquids", arXiv:0704.0157v1 (2007)

*E-mail: yudin@itep.ru

Phase transitions and core-collapse in the neutron stars

J. L. Zdunik[1*], P. Haensel[1†], M. Bejger[1‡], E. Gourgoulhon[1,2]

[1]N. Copernicus Astronomical Center, Bartycka 18, 00-716 Warszawa

[2]LUTH, UMR 8102 du CNRS, Observatoire de Paris, F-92195 Meudon Cedex, France

Some models of dense matter predict the possibility of phase transition at very high densities which can be reached in the center of neutron stars. Evolutionary processes as an accretion of the matter onto a neutron star or slowing down of an isolated pulsar can lead to the increase of the central density. A first-order phase transition allows for a metastability of the pure "normal" (lower density) phase at densities larger than the density corresponding to the equilibrium between the two phases. Consequently, a metastable core could form during the neutron-star evolution, where the central pressure increases due to accretion or spin-down. Then, nucleation of the exotic (higher density) phase implies the formation of a core of the exotic phase and is accompanied by a core-quake and energy release. The possibility of developing the metastable core in the neutron star due to the evolutionary processes and the consequences of the core collapse are discussed.

References

[1] Zdunik J. L., Bejger M., Haensel P., Gourgoulhon, E. 2007 A&A 465, 533

[2] Zdunik J. L., Bejger M., Haensel P., Gourgoulhon, E. 2008 A&A 479, 515

*E-mail: jlz@camk.edu.pl

†E-mail: haensel@camk.edu.pl

‡E-mail: brejger@camk.edu.pl

Optical identification of the 3C 58 pulsar and its wind nebula

Yu. A. Shibanov[1], N. Lundqvist[2], P. Lundqvist[2], J. Sollerman[2], D. A. Zyuzin[1]

[1]Ioffe Physical-Technical Institute (St.Petersburg, Russia)

[2]Stockholm Observatory (Stockholm, Sweden)

We performed deep broadband imaging of the 3C 58 field to detect the optical counterpart of the pulsar and its wind nebula. The imaging was carried out in the U, B, V, R, and I optical bands with the Nordic Optical Telescope and the 6-meter Telescope of the Special Astrophysical Observatory. We have also analyzed the archival images of the field obtained with the Chandra/ACIS and the HRC in X-rays and with the Spitzer/IRAC in the mid-infrared. We detect a faint extended elliptical object whose peak brightness position is consistent at the sub-arcsecond level with the X-ray position of the pulsar. The morphology of the object and the orientation of the major axis are in excellent agreement with the torus region seen almost edge-on in the X-rays, although its size is only about a half of the X-ray size. This suggests that in the optical we see only the brightest central part of the torus nebula. Also, we identify the object in all broadband mid-infrared archival images obtained at 3.6, 4.5, 5.8, and 8 μm, where it has the similar morphology as in the optical range. We do not resolve any point-like source within the nebula that could be identified with the pulsar and estimate that the contribution of the pulsar to the observed optical flux is $\lesssim 10\%$. Using the archival Chandra/ACIS-S data, we analyse the spectrum of the pulsar+nebula X-ray emission extracted from the spatial region identical to the optical/infrared source position and size. We find that a single absorbed power-law provides an acceptable spectral fit. Combining this fit with the optical and infrared fluxes of the detected candidate counterpart, we compile a tentative multiwavelength spectrum of the central part of the pulsar nebula. Within the uncertainties of the interstellar extinction towards 3C 58, it is reminiscent of either the Crab or the PSR B0540–69 wind nebula spectra. The position, morphology and spectral properties of the detected source suggest it to be, indeed, the optical/mid-infrared counterpart of the pulsar wind nebula system. This makes 3C 58 the third (after the Crab pulsar and PSR B0540–69) member of such a system identified in the optical and mid-infrared.

The optical detection of the pulsar wind nebula in the young galactic SNR G292.0+1.8

S. V. Zharikov[1], Yu. A. Shibanov[2], D. A. Zyuzin[2], R. E. Mennickent[3], V. N. Komarova[4]

[1]Institute of Astronomy, UNAM (Ensenada, Mexico)
[2]Ioffe Physical-Technical Institute (St.Petersburg, Russia)
[3]Stockholm Observatory (Stockholm, Sweden)
[4]Special Astrophysical Observatory (Nizhnij Arkhyz, Russia)

G292.0+1.8 is the Cas A-like SNR containing the young pulsar J1124–5916, which powers a compact torus-like pulsar wind nebula with a jet visible in X-rays. We have performed deep optical observations of the pulsar field in an attempt to detect the optical counterpart of the pulsar and its wind nebula. The observations were carried out using the direct imaging mode of FORS2 at the ESO VLT/UT1 telescope in the V, R, and I bands. Employing the Chandra/ACIS archival data, we revised the position of the PSR J1124–5916 X-ray counterpart using a dozen of USNO stars visible in the Chandra FOV. In all three optical bands we detect a faint extended elliptical object, whose peak brightness and center position are consistent at a sub-arcsecond level with the X-ray position of the pulsar. The morphology of the object and the orientation of its major axis are in a good agreement with the central part of the torus region of the pulsar wind nebula seen almost edge on in X-rays. We do not resolve any point-like object within the nebula that could be identified with the pulsar; we estimate that its contribution to the observed optical flux is less than 10%. Extracting the X-ray spectrum from the physical region equivalent to the optical source size, we combine the multiwavelenth spectrum of the central part of the nebula. Within uncertainties of the interstellar extinction towards G292.0+1.8 it reminds the spectrum of the Crab pulsar wind nebula. The position, morphology and spectral properties of the detected object strongly suggests that we have detected the optical counterpart of the pulsar plus its wind nebula in G292.0+1.8.

Summary of the program			
24.06, Tuesday	**25.06,Wednesday**	**26.06, Thursday**	**27.06, Friday**
09:00 *Registration* 09:30 *Opening* **1. SNe, SNRs (1)** 09:40 Blinnikov 10:10 Liebendörfer 10:40 Panov	**5. PSRs, RRATs, SGRs, and magnetars (1)** 09:30 Bisnovatyi-Kogan 10:00 Dumsky 10:20 Popov 10:40 Kontorovich	**9. LMXBs and HMXBs (1)** 09:30 Grebenev 10:00 Chernyakova 10:20 Lutovinov 10:40 Postnov	**13. EOS and structure (2)** 09:30 Gnedin 10:00 Zdunik 10:20 Sagert 10:40 Iosilevskiy
11:00 *Coffee*	11:00 *Coffee*	11:00 *Coffee*	11:00 *Coffee*
2. SNe and SNRs (2) 11:30 Imshennik 12:00 Utrobin 12:20 Fischer 12:40 Uvarov	**6. PSRs, RRATs, SGRs, and magnetars (2)** 11:30 Kondratiev 11:50 Petrova 12:10 Timokhin 12:30 Tsygan	**10. LMXBs, HMXBs (2)** 11:30 Titarchuk 12:00 Poutanen 12:20 Suleimanov 12:40 Ikhsanov	**14. Crustal heating and XRTs** 11:30 Haensel 12:00 Levenfish 12:20 Shternin 12:40 Chugunov
13:00 *Lunch*	12:50 *Lunch*	13:00 *Lunch*	13:00 *Lunch*
3. SNe and SNRs (3) 14:30 Lundqvist 15:00 Nadyozhin 15:30 Moiseenko 15:50 Manukovskiy	**7. Poster presentations (1)** 14:30 Oral-poster session (1)	**11. EOS and structure (1)** 14:30 Baldo 14:50 Burgio 15:10 Lombardo 15:30 Heinzmann 15:50 Harutyunyan	**15. Cooling and superfluidity** 14:30 Kaminker 15:00 Henderson 15:20 Gusakov 15:40 Kantor
16:10 *Coffee*	16:00 *Coffee*	16:10 *Coffee*	16:00 *Coffee*
4. GRBs 16:40 Pal'shin 17:10 Sokolov 17:30 Oleynik 17:50 Pozanenko	**8. PSRs, magnetars, XRBs, and others** 16:30 Thielemann 17:00 Blaschke 17:20 Gvaramadze 17:40 Kocharovsky 18:00 Malov	**12. Poster presentations (2)** 16:30 Oral-poster session (2) 18:40 *Wine and snacks*	*Closing*