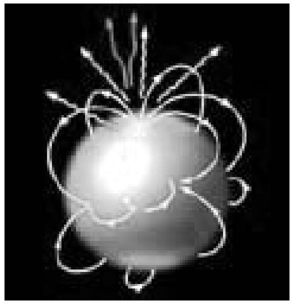
COLLOQUIUM ON

Physics of Neutron Stars



Programme
and
Abstracts

Ioffe Physico-Technical Institute

St. Petersburg, Russia, 25–26 May 1999

275 лет РОССИЙСКАЯ АКАДЕМИЯ НАУК Основана в 1724 году

The Coloquium is held in the year of the 275th anniversary of the Russian Academy of Sciences—highest scientific society and principal coordinating body for research in natural and social sciences, technology and production in Russia. Founded in St. Petersburg in 1724 by Peter the Great, the Academy was later known under various names and regained the present name in 1991. The first Academy building in St. Petersburg is shown in the centre of the anniversary logo.

The Colloquium
is organized by
the Ioffe Physico-Technical Institute

in collaboration with
the All-Moscow Seminar of Astrophysicists

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the Russian Foundation for Basic Researches
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the Ioffe Physico-Technical Institute
(St. Petersburg)

This is the fifth meeting on the neutron star physics organized in Leningrad–St. Petersburg (after those in 1988, 1992, 1995 and 1997)

The Organizing Committee:

- ◇ **D.A. Varshalovich** (*Chair,* Ioffe Physical Technical Institute, St. Petersburg)
- ◇ R.L. Aptekar (Ioffe Physical Technical Institute)
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- ◇ M.E. Prokhorov (Sternberg Astronomical Institute)
- ◇ Yu.A. Shibanov (Ioffe Physical Technical Institute)
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The Colloquium was held at the Big Hall of the Main Building
of the A.F. Ioffe Physical-Technical Institute
for two days, from May 25 to May 26, 1999.

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Second edition improved, corrected and updated after Colloquium

Contents

CCD-observations of "middle-aged" pulsars with the 6m telescope

V.N. Komarova

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The results of the program for the study of the optical counterparts of pulsars at the 6m telescope of the Special Astrophysical Observatory are presented. The photometric observations of two "middle-aged" pulsars PSR B1951+32 (CTB80) in the R band and PSR J0633+17 (Geminga) in the R and I bands of Cousins system yielded the images of the CTB80 and Geminga fields and magnitude estimates of the objects under investigation and their surroundings.

PROGRAMME

MAY 25, TUESDAY

Session 1. WELCOME. SOFT-GAMMA REPEATERS AND PULSARS
D.A. Varshalovich — chairman

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10.20–10.50 D.D. Frederiks *(A.F. Ioffe Physical Technical Institute)*
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10.50–11.10 Yu.P. Shitov *(Pushchino Radioastronomy Observatory)*
Detection of the radio pulsar PSR J1907+0919 associated with the magnetar SGR 1900+14

11.10–11.30 V.S. Beskin *(P.N. Lebedev Physical Institute)*
On the Energy Loss of Radio Pulsars

11.30–11.50 E.I. Chuikin *(A.F. Ioffe Physical Technical Institute)*
On separation of submillisecond pulsations in hard gamma radiation of the pulsar PSR 0833-45 from observations with the GAMMA-1 telescope in autumn of 1990

11.50–12.20 *Coffe break*

Session 2. CONTINUATION
E.P. Mazets — chairman

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Unique spectrum, mean and individual pulses of Geminga radio emission

12.40–13.00 I.F. Malov *(Pushchino Radio Astronomy Observatory)*
On magnetic fields and $\dot{P} - P$ diagram of radio pulsars

13.00–13.20 V.D. Palshin, A.I. Tsygan *(Ioffe Physical Technical Institute)*
The effect of magnetic anomalies at the surfaces of neutron stars on X-ray luminosity of radio pulsars

13.20–13.40 S.V. Zharikov, V.H. Chavushyan, R. Mújica, and G.G. Valavin *(Special Astrophysical Observatory of RAS, Instituto Nacional de Astrofísica Optica y Electrónica)*
The distance to the millisecond pulsar PSR J1024-0719 and the nature of the pulsar optical counterpart

13.40–14.00 T.V. Smirnova, V.I. Shishov *(Pushchino Radio Astronomical Observatory)*
Pulsar distances from interstellar scintillation data

LUNCH

Session 3. FORMATION AND EVOLUTION
V.S. Beskin — chairman

15.00–15.20 M.E. Prokhorov, K.A. Postnov *(Sternberg Astronomical Institute)*
Close binary black holes: kick versus common envelope

15.20–15.40 S.B. Popov, M. Colpi, R. Turolla, A. Treves, V.M. Lipunov, M.E. Prokhorov *(Sternberg Astronomical Institute, University of Milan, University of Padova, University of Como)*
Old neutron stars in the Galaxy

15.40–16.00 A.G. Kuranov *(Sternberg Astronomical Institute)*
The formation of low-mass X-ray binaries with black holes from triple stars

X-RAY PULSARS

16.00–16.20 N.I. Shakura, M.E. Prokhorov, K.A. Postnov, N.A. Ketsaris *(Sternberg Astronomical Institute)*
On the nature of 35-day cycle in Her X-1

16.20–16.40 A.A. Lutovinov, S.A. Grebenev, R.A. Sunyaev *(Space Research Institute)*
Observations of wind-fed X-ray pulsars with the telescope ART-P on board GRANAT

16.40–17.00 A.N. Baushev, G.S. Bisnovatyi-Kogan *(Space Research Institute)*
The cyclotron emission of anisotropic electrons in the X-ray pulsars

17.00–17.30 *Coffe break*

Session 4. QUASIPERIODIC AND PERIODIC HIGH-ENERGY RADIATION
M.E. Prokhorov — chairman

17.30–18.00 Yu.N. Gnedin, S.O. Kiikov *(The Central (Pulkovo) Astronomical Observatory)*
Quasi-periodic oscillations of X-ray brightness of neutron stars: new physical mechanisms

18.00–18.20 S.I. Kuznetsov, E.M. Churazov, M.R. Gilfanov, R.A. Sunyaev *(Space Research Institute, Max-Planck-Institute für Astrophysik)*
Thermal disc instability and constrains on binary system parameters in application to GRANAT/SIGMA observations of GRS 1758-258

18.20–18.40 D. Litvin et al. *(Space Research Institute)*
Quasiperiodic oscillations of the source A0535+262 in different spectral channels

Populations of close binaries in galaxies with recent bursts of star formation

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This paper is a continuation and development of our previous articles (Popov et al., 1997, 1998). We use "Scenario Machine" (Lipunov et al., 1996b) – the population synthesis simulator (for calculations of single binary systems, the program is accessible through internet: **http://xray.sai.msu.su/sciwork/scenario.html** (Nazin et al., 1998) – to calculate evolution of populations of several types of X-ray sources during the first 20 Myrs after a star formation burst.

We examined evolution of 12 types of X-ray sources in close binary systems (both, with neutron stars and with black holes) for different parameters of the initial mass function (IMF) – slopes: $\alpha = 1$, $\alpha = 1.35$ and $\alpha = 2.35$ and upper mass limits: 120 $M_{\odot}$, 60 $M_{\odot}$ and 40 $M_{\odot}$. The results, especially for the sources with black holes, are very sensitive to variations of the IMF, which should be taken into account while fitting parameters of star formation bursts.

The results are applied to several regions of recent star formation in different galaxies: Tol 89, NGC 5253, NGC 3125, He 2-10, NGC 3049. Using known ages and total masses of star formation bursts (Shaerer at al., 1998), we calculate the expected numbers of X-ray sources in close binaries for different parameters of the IMF. Usually, X-ray transient sources consisting of a neutron star and a main sequence star are most abundant, but for very young bursts (of ages less than ≈ 4 Myrs) the sources with black holes may become more abundant.

References

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4. Popov, S.B., Lipunov, V.M., Prokhorov, M.E., & Postnov, K.A., 1998, AZh, **75**, 35 (astro-ph/9812416)
5. Schaerer, D., Contini, T., & Kunth, D., 1998, A&A **341**, 399 (astro-ph/9809015)

The distance to the millisecond pulsar PSR J1024-0719 and the nature of the pulsar optical counterpart

S.V. Zharikov[1], V.H. Chavushyan[2], R. Mújica[2], and G.G. Valavin[1]

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The coordinates of the PSR J1024-0719 pulsar coincide with those for an optical object in the Digital Sky Survey within $\sim 0.1''$. The optical companion is a star-like object with $V = 19.78 \pm 0.02$, $B - V = 1.35 \pm 0.03$, $V - R_c = 0.84 \pm 0.01$, $R_c - I_c = 0.80 \pm 0.02$ as follows from the photometric observations with the 6m telescope BTA SAO RAS. The spectrum of the optical object was obtained with the 2.1 m telescope of the "Guillermo Haro" Observatory in Cananea, Sonora, Mexico, using the Landessternwarte Faint Object Spectrograph and Camera (LFOSC) on 17 April 1999. The color indices and spectrum of the object correspond to a star of K7V spectral class. For an interstellar extinction in this direction $E_{(B-V)} = 0.05$, a distance to the pulsar binary system is 1.9 ± 0.2 pc for a K7V star.

Hydrodynamic model of noncentral explosion of collapsing supernovae

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The non-one-dimensional rotational mechanism of supernova explosion was proposed earlier as the main mechanism of collapsing supernovae of type II (Imshennik, 1992). This mechanism includes hydrodynamic asymmetric explosion model formulated and solved in the two-dimensional approximation. As was shown by Aksenov et al. (1997), at final moment of calculations $t \simeq 0.75$ s the front of a shock wave (SW) reaches the radius ~ 10000 km without SW stagnation or conversion into accreting SW, contrary to another non-one-dimensional mechanism of type II supernovae, the neutrino – convective mechanism (Yanka, Müller, 1996). The features of hydrodynamic motion obtained both by Eulerian Method (PPM) and Lagrangian Method (LM) are in good agreement with each other. The LM calculations with realistic equation of state (Fermi-Dirac statistics for electron-positron gas and iron dissociation-recombination processes in nuclear gas) are also presented. In this case, the mass of synthesized radioactive ^{56}Ni can be estimated in the range (0.040 — 0.055) $M_\odot$. These values are in accord with the mass $M(^{56}Ni) = 0.075 M_\odot$ determined for SN 1987A (Nadyozhin, 1991).

MAY 26, WEDNESDAY

Session 5. SUPERNOVAE
A.I. Tsygan — chairman

10.00–10.40 V.S. Imshennik *(Institute for Theoretical and Experimental Physics)*
Hydrodynamic model of noncentral explosion of collapsing supernovae

10.40–11.00 A.F. Zakharov *(Institute for Theoretical and Experimental Physics)*
Rotating neutron stars and unstable modes of vibrations as possible sources of gravitational radiation magnified by gravitational lenses

11.00–11.20 A.G. Aksenov *(Institute for Theoretical and Experimental Physics)*
Gravitational radiation from a collapse of a rotating stellar core

11.20–11.40 A.V. Kuznetsov, N.V. Mikheev *(Yaroslavl State P.G. Demidov University)*
Variation of the energy and momentum of a neutrino propagating in a strongly magnetized e^-e^+ plasma

11.40–12.00 A.A. Gvozdev, I.S. Ognev *(Yaroslavl State University)*
Influence of neutrino reemission processes in strong magnetic field on the dynamics of collapsing star envepole

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Session 6. ISOLATED NEUTRON STARS
V.M. Malofeev — chairman

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Neutrino emission due to Cooper pairing of nucleons in cooling neutron stars

12.50–13.10 K.P. Levenfish, Yu.A. Shibanov, D.G. Yakovlev *(A.F. Ioffe Physical Technical Institute)*
Cooling of neutron stars with superfluid cores: theory vs. observations

13.10–13.30 A.B. Koptsevich, S.V. Zharikov, Yu.A. Shibanov, V.V. Sokolov, V.G. Kurt *(Ioffe Physical Technical Institute, Special Astrophysical Observatory of RAS, Astro Space Center of the Russian Academy of Sciences)*
Optical photometry of PSR B0656+14 and its neighbourhood

13.30–13.50 G.M. Beskin, V.G Debur, V.L. Plokhotnichenko, A. Shearer *(Special Astrophysical Observatory, National University of Ireland)*
High time resolution panoramic system for variability investigation of faint astronomical objects

LUNCH

Session 7. GAMMA-RAY BURSTS
V.G. Kurt — chairman

15.00–15.30 I.G. Mitrofanov et al. *(Space Research Institute)*
Cosmic gamma-ray bursts in comoving reference frames

15.30–15.50 D.A. Anfimov et al. *(Space Research Institute)*
Spectral properties of radiation of cosmic gamma-ray bursts

15.50–16.10 M.S. Briggs *(University of Alabama, Hunstville)*
GRB 990123

16.10–16.30 V.V. Sokolov, V.G. Kurt, S.V. Zharikov, J. Greiner *(Special Astrophysical Observatory, Astro Space Center, Astrophysical Institute Potsdam)*
A blue object in GRB 790613 error box

16.30–16.50 E.V. Derishev, V.V. Kocharovsky, Vl.V. Kocharovsky *(Institute of Applied Physics)*
Decoupling of neutron component and two-flow model of relativistic winds

16.50-17.20 *Coffe break*

Session 8. CONTINUATION
I.G. Mitrofanov — chairman

17.20–17.40 M. Litvak et al. *(Space Research Institute)*
Emission time of cosmic gamma-ray bursts

17.40–18.00 A.N. Timokhin, G.S. Bisnovatyi-Kogan, H.C. Spruit *(Sternberg Astronomical Institute, Space Research Institute, Max-Planck-Institut für Astrophysik)*
Magnetosphere of oscillating neutron star. Nonvacuum treatment

18.00–18.20 E.V. Derishev, V.V. Kocharovsky, Vl.V. Kocharovsky *(Institute of Applied Physics)*
Neutrino transfer in a cold neutron star

18.20–18.40 S.I. Blinnikov, A.V. Kozyreva, I.E. Panchenko *(Institute for Theoretical and Experimental Physics, Sternberg Astronomical Institute, Max Planck Institut für Astrophysik)*
GRB: when do blackbody spectra look like non-thermal ones?

Magnetosphere of oscillating neutron star. Nonvacuum treatment

A.N. Timokhin[1,2,3]**, G.S. Bisnovatyi-Kogan**[2]**, H.C. Spruit**[3]

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We generalize a formula for the Goldreich-Julian charge density (ρ_{GJ}), originally derived for rotating neutron star, for arbitrary oscillations of a neutron star with arbitrary magnetic field configuration under assumption of low current density in the inner parts of the magnetosphere. As an application we consider toroidal oscillations of a neutron star with dipole magnetic field and calculate energy losses. For some oscillation modes, the longitudinal electric field cannot be canceled by putting of charged particles in the magnetosphere without presence of strong electric current ($j \simeq c/(\omega r)\, \rho_{GJ} c$) there. It is shown that the energy losses are strongly affected by plasma in the magnetosphere, and cannot be described by vacuum formulas.

Rotating neutron stars and unstable modes of vibrations as possible sources of gravitational radiation magnified by gravitational lenses

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Rotating neutron stars and r-modes of neutron star vibrations have been discussed recently as possible sources of gravitational radiation. Moreover, the question about the existence of these periodic sources of gravitational radiation is very important since not only the sources are perspective but also the probability of a strong amplification of these sources by gravitational lenses is high enough. We discuss an amplification of these sources by binary gravitational microlenses.

Pulsar distances from interstellar scintillation data

T.V. Smirnova, V.I. Shishov

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The use of the Dispersion Measure for estimating pulsar distances can give us large errors: more than 100%. The errors are connected with the nonuniform distribution of ionized material along the line of sight to a pulsar. We present a different method to estimate the distances to pulsars and the location of the effective layer of turbulent medium along line of sight. The method is based on the analysis of the diffractive and refractive scintillations of pulsars. In some cases our estimates of the distances to pulsars are more than 3 times different from the values quoted in the catalogue by Taylor, Manchester and Lyne.

A blue object in GRB 790613 error box

V.V. Sokolov[1], V.G. Kurt[2], S.V. Zharikov[1], J. Greiner[3]

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We present optical observations of the IPN gamma-ray error box of GRB790613 (GBS 1412+79) with the 6-m telescope in the B, V, R, and I photometrical bands. A blue star-like object with $V = 24.12$ was found in the error region of the GRB790613 event. The ROSAT X-ray data were utilized for the interpretation.

POSTERS

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   Detection of middle-aged optical pulsars at the 6m telescope
2. G.M. Beskin, V.N. Komarova, V.L. Plokhotnichenko *(Special Astrophysical Observatory)*
   The results of the Crab pulsar photometrical investigations with time resolution of 3.3 μs
3. E.V. Derishev, V.V. Kocharovsky, Vl.V. Kocharovsky *(Institute of Applied Physics)*
   100 Gev and sub-Gev features in the spectra of relativistic winds from compact stellar objects
4. S.O. Kiikov *(The Central (Pulkovo) Astronomical Observatory)*
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6. D.Y. Konenkov and U. Geppert *(A.F. Ioffe Physical Technical Institute, Astrophysikalisches Institut Potsdam)*
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7. I.E. Panchenko, D.N. Drozdova, V.M. Lipunov *(Sternberg Astronomical Institute)*
   Search for a pulsar-like mechanism powered by orbital motion
8. S.B. Popov, M.E. Prokhorov, V.M. Lipunov *(Sternberg Astronomical Institute)*
   Populations of close binaries in galaxies with recent bursts of star formation
9. A.S. Pozanenko et al. *(Space Research Institute)*
   Aperiodic properties of gamma-ray bursts
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    Cosmological invariants of gamma-ray bursts

On the nature of 35-day cycle in Her X-1

N.I. Shakura, M.E. Prokhorov, K.A. Postnov, N.A. Ketsaris

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A strong X-ray illumination of the optical star atmosphere in Her X-1, asymmetric because of a partial shadowing by the tilted twisted accretion disk around central neutron star, leads to the formation of matter flows coming out of the orbital plane and crossing the line of sight before entering the disk. We suggest that the absorption of X-ray emission by this flow leads to the formation of pre-eclipse and anomalous dips of type I. These dips are observed during several orbits after turn-on both in the main-on and short-on state. Almost coherent action of tidal torques and matter streams enhances the disk wobbling which causes the disk edge to shield the X-ray source after the turn-on. Anomalous dips of type II and post-eclipse recovery appear due to this process only on the first orbit after turn-on.

Detection of the radio pulsar PSR J1907+0919 associated with the magnetar SGR 1900+14

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The soft-gamma-ray repeater SGR 1900+14 was observed since 1998 Dec. using the Pushchino BSA radiotelescope at 111 MHz. In many observation days (BSA transit time is about 200 s) we have detected the pulsed radio emission with the same period (5.161 ± 0.001 s) as that reported for SGR 1900+14 in IAUC 7001. The width of the integrated pulse profile at half maximum intensity is about 100 ms. The estimated mean flux density at 111 MHz is about 50 mJy from the best records. The dispersion measure value was determined as $281.4 \pm 0.9\,\mathrm{pc\,cm^{-3}}$, which gives the estimate of the distance to the object as about 6 kpc. From the timing analysis of the records obtained we find the following best-fit parameters: barycentric period P= 5.161297854 (83) s, period derivative $\dot{P} = 1.23228\ (34) \times 10^{-10}$ s/s, epoch (MJD)= 51159.4605 . Thus our results show that SGR 1900+14 is identical with the radio pulsar PSR J1907+0919, representative of a new class of pulsars with a superstrong magnetic fields on the order of 8×10^{14} G, thereby confirming that this object is a “magnetar”.

Close binary black holes: kick versus common envelope

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The formation and evolution of binary black holes (BH) is studied using the modern evolutionary scenario for very massive stars with high mass loss (Vanbeveren et al. 1998). Main sequence stars with masses $M > 35M_\odot$ are assumed to form a BH in the end of their nuclear evolution. The mass of BH formed is parameterized as $M_{bh} = k_{bh} \times M_{SN}$, where M_{SN} is the mass of the pre-supernova star taken from evolutionary calculations, $k_{bh} \leq 1$. The possibility is explored that a newly formed BH acquires a kick velocity 0-250 km/s. Binary BH are found to merge within the Hubble time at an appreciable rate only for non-zero kick velocities. We calculate the galactic merging rates of binary BH systems, their detection rate by the initial laser interferometers, and the distributions of merging binary BH over orbital eccentricities at different frequencies. The distribution of angles between BH spins and the orbital angular momentum is also presented.

Cosmological invariants of gamma-ray bursts

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An observable parameter of gamma-ray bursts is proposed which is invariant with respect to transformation from the observer's reference frame to the reference frames comoving with the emission sources. Distribution of gamma-ray bursts over this parameter is obtained.

ABSTRACTS

Old neutron stars in the Galaxy

S.B. Popov[1], M. Colpi[2], R. Turolla[3], A. Treves[4], V.M. Lipunov[1], M.E. Prokhorov[1]

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In this paper we present a computer modelling of the distribution of isolated neutron stars (INS) over types. Four types of neutron stars, depending on interaction between magnetosphere and surrounding plasma, are considered: Ejector, Propeller, Accretor and Georotator. We analyse the dependence of the distribution on kick velocity of neutron stars, for the maxwellian velocity distribution and for two values of the initial magnetic field of neutron stars without field decay. The case of the magnetic field decay is also investigated.

For reasonable mean velocities, about 150-300 km/s, most of isolated neutron stars are at the Ejector stage. The number of accreting stars with these velocities is less than 10 percents.

In general, the ROSAT observations which showed that only few accreting INSs are observed, can be explained simply by the presence of moderately high, about 300 km/s, mean kick velocities of NSs (in the case of the maxwellian velocity distribution).

We also briefly discuss other manifestations of old isolated neutron stars in the Galaxy.

Aperiodic properties of gamma-ray bursts

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Aperiodic properties of GRB time profiles were investigated on the basis of the BATSE catalog. Power spectra obtained with FFT procedure for each GRB were averaged for all GRB. As a result, the power spectra spanning more 3 decade in frequency for 1300 GRBs were obtained. We analyze continuum, “red noise” and high frequency part of averaged spectra. The averaged spectra of different brightness group and two modes of bi-modal T_{90} distribution were compared. The implications of results obtained are discussed.

Cosmic gamma-ray bursts in comoving reference frames

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Properties of cosmic gamma-ray bursts in the reference frames comoving with the radiation sources are discussed. Physical constraints on the gamma-ray emission mechanisms are proposed. The effect of cosmological evolution of the sources is checked.

The effect of magnetic anomalies at the surfaces of neutron stars on X-ray luminosity of radio pulsars

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We study the effect of magnetic anomalies in the form of magnetic spots on the surfaces of neutron stars on the parameters of X-ray emission of polar regions of radio pulsars. We employ the Goldreich–Julian model in the regime of free emission of electrons from the neutron star surface. In this case, the electric field is generated by general relativistic effect of dragging inertial reference frames. If the magnetic fields affect only the curvature of magnetic field lines then the temperature and X-ray luminosity of the polar regions is considerably lower than for the purely dipolar field.

Search for a pulsar-like mechanism powered by orbital motion

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We suspect that there can be a mechanism of particle acceleration and electromagnetic emission, similar to that of radio pulsars, but powered by orbital motion. This mechanism can work in close neutron star binaries and be a precursor of gamma-ray bursts. We perform estimates of the mechanism efficiency and its observational detectability.

Gravitational radiation from a collapse of a rotating stellar core

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The rotational mechanism of a supernova explosion proposed by Imshennik includes fragmentation of a rotating core probably into two pieces during the collapse, followed by the coalescence of neutron stars in the binary system. These processes are accompanied by powerful gravitational radiation. We present calculations of the evolution of a rotating neutron star that is unstable with respect to the growth of a sectorial mode which causes the fragmentation. The equation of state was chosen to be that of a cold degenerate neutron gas, $P \propto \rho^{5/3}$. The mass and angular momentum of the star were taken to be the same as those of a collapsing, rigidly rotating, iron-oxygen stellar core: $M = 2M_\odot$ and $J \approx 8 \cdot 10^{49}$ erg · s, respectively. The choice of the rotation law for which the ratio of the centrifugal force to the gravity is constant completes construction of the initial model. As a result of the evolution, the star loses some part of its mass and angular momentum, and the ratio of the rotational to the gravitational energy, $-E_\mathrm{k}/E_\mathrm{gr}$, decreases from 0.35 to 0.19. The gravitational radiation calculated in the quadrupole approximation carries away the energy of $8.4 \cdot 10^{49}$ erg and the angular momentum of $1.0 \cdot 10^{47}$ erg · s. The typical metric perturbation is $rh \sim 10^4$ cm, and the wave frequency is ~ 1 kHz. The gravitational radiation due to coalescence of neutron stars in a binary system is estimated on the basis of calculations by other authors.

Spectral properties of radiation of cosmic gamma-ray bursts

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It is shown that one should use the integrated spectrum of a gamma-ray burst accumulated during a time interval which corresponds to an emission time of the burst in order to describe the burst by a unified spectral dependence. The distributions of the key spectral parameters of gamma-ray bursts are studied. These distributions are compared separately for rise fronts and for back slopes of the bursts.

The cyclotron emission of anisotropic electrons in the X-ray pulsars

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The spectrum of cyclotron radiation is calculated for anisotropically distributed relativistic electrons having a nonrelativistic velocity across the magnetic field. It is shown that if such electrons are responsible for the formation of the "cyclotron" line in the spectrum of Her X-1, then the value of the magnetic field, $(3-6)\times 10^{10}$ G, advocated by this interpretation, is in a good agreement with some other observations and theoretical estimates. Observations of time dependence of the energy of this "cyclotron" line in the spectra of several X-ray pulsars is explained by a variability of the mean longitudinal energy of the electrons, which decreases with increase of the luminosity due to radiational deceleration of the accretion flow.

On the Energy Loss of Radio Pulsars

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We consider the model of axisymmetric neutron star magnetosphere including the matching condition along the separatrix. We demonstrate that it is the stability condition on the separatrix that allows us to obtain a unique solution of the problem. Moreover, the hypothesis of the existence of the nonlinear Ohm's Law (Beskin, Gurevich & Istomin 1983) connecting the potential well in the pair creation region and the longitudinal electric current flowing in the magnetosphere is confirmed. The two–fluid effects on the radial 2D outflow of relativistic electron–positron plasma are considered. For the case in which the longitudinal electric current corresponding to "Ohm's Law" is smaller than the Goldreich–Julian one, it is shown that (as in 1D case considered earlier) almost all electromagnetic energy is transformed into the energy of particles in the narrow boundary layer $\Delta\varpi/\varpi \sim \lambda^{-1}$ $(\lambda = n/n_{GJ})$ near the light surface $|\mathbf{E}| = |\mathbf{B}|$.

Unique spectrum, mean and individual pulses of Geminga radio emission

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The results of radio emission observations at 102.5, 87, 58 and 39 MHz are presented. We show individual pulses for the first time. The detailed analysis of the flux density, forms, widths, phases of pulse time of arrival shows the unique nature of the Geminga radio emission. Most impressive peculiarities are the following: very steep spectrum between 80 and 400 MHz with the spectral index ¿ 4.5 and with the low-frequency turnover at 50-70 MHz, rare cases of strong emission during entire period, the presence of giant pulses, the large changes of the widths and the phases. Some of these features can be explained by the co-axial rotator model.

On magnetic fields and $\dot{P} - P$ diagram of radio pulsars

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Various models of pulsar spin down are analyzed. It is shown that these models give very different $\dot{P} - P$ dependences and pulsar characteristic ages $\tau = P/2\dot{P}$ (P being the rotation period). The braking index $n = (\ddot{\ }PP/\dot{P}^2 - 2)$ can vary from 0 to 3 for different models. The characteristic age is not the measure of the real pulsar age for some models. For instance, in the case of neutrino emission inside a neutron star τ vanishes at some moment of time and becomes negative afterwards. The observed $\dot{P} - P$ diagram can be divided into three parts: $P < 0.1$ s, $0.1 < P < 1.25$ s, and $P > 1.25$ s. The pulsars with short periods cannot be described by any known spin down model. The braking index is $n = -1$ for this group. We analyse the processes which lead to such unusual behaviour of these pulsars. The magnitudes of the magnetic fields calculated for such objects from the magnetodipole model are wrong; they need to be recalculated in the future after an adequate theory is worked out.

The distribution of pulsars with $P > 0.1$ s can be explained in the framework of the hybrid model taking into account the magnetodipole torque and the neutrino emission processes inside a neutron star. The magnetic field values commonly accepted for these pulsars have to be corrected by a factor $1/(1+5P^3)$. The magnetic fields in the sources of pulsed soft gamma-rays ("magnetars") are equal to $(1.7–2.9)\times 10^{13}$ G, i.e. they are less than the critical magnetic field 4.4×10^{13} G.

Quasiperiodic oscillations of the source A0535+262 in different spectral channels

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Quasiperiodic oscillations (QPOs) of the source A0535+262 are studied during a powerful burst in different spectral channels. It is shown that the peak parameters of QPOs varied during the burst. A shift of QPO phase in different spectral channels is discovered. Physical interpretation of this phenomenon is proposed.

Observations of wind-fed X-ray pulsars with the telescope ART-P on board GRANAT

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We report some results obtained with the telescope ART-P on board the *GRANAT* observatory under the program of timing and spectroscopy of X-ray pulsars. We detected strong X-ray variability of Vela X-1 on a time-scale of $\sim 10^3$ s accompanied by changes in its spectral parameters. The spectrum of GX301-2 was found to be very hard and extended without an obvious break to $\sim$40 keV. The pulse profile for this pulsar was obtained with a good phase resolution in the hard energy band (30-40 keV). We found two cyclotron absorption lines in the spectrum of 4U0115+634 during the source outburst in 1990 Feb and revised some of parameters of its binary orbit.

High time resolution panoramic system for variability investigation of faint astronomical objects

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Development and laboratory testing of panoramic high temporal resolution system is completed in the Special Astrophysical Observatory. The system includes coordinate-sensitive detector (CSD), amplifier and analog–digital conversion units, multichannel time–code converter “Quantochron” and PC AT Pentium. The main component of the system is CSD, a vacuum detector, which comprises photo-cathode S20, with diameter of 22 mm, micro-channel plates, ensuring 10^7 gain factor, and wedge–strip anode. The system measures coordinates and arrival times of separate photons at the photo-cathode within the range of 3600 – 8000 Å with quantum efficiency 4% – 8%. Spatial resolution is 150 μm (20 000 pixels in total), time resolution is 2μs, maximum rate of photo-count flux registered without statistical properties distortion is 100 000 phcount/s.

Data are processed and analyzed by the special software MANIA (Multichannel Analysis of Nanosecond Intensity Alterations) for investigating rapid variability of astronomical objects. Possibilities of detection of optical periodical brightness variations from pulsars at the level of 25 – 27^m and stochastic variability of various relativistic objects (black holes, optical counterparts of γ–bursts and X–rays sources) at the level of 20 – 21^m are discussed.

The results of the Crab pulsar photometrical investigations with time resolution of 3.3 μs

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We have analyzed the data obtained from observations of the Crab pulsar with the 6 m telescope simultaneously in the UBVR bands with temporal resolution of 10^{-7} s. Special software has been developed, that has allowed us to build folded light curves without using the exact ephemeris of the pulsar period. We have obtained folded light curves with a temporal resolution of 3.3 μs. The analysis of their shapes indicates the absence of the fine time structure on the time–scales of 3.3–50 μs (the intensity modulations were of purely statistical nature), the duration of the flattened part of the main pulse maximum does not exceed 50–70 μs, the emission intensity in the inter–pulse interval amounts for about 1% of the main pulse maximum. A comparison of the light curves in the U, B, V, and R bands led to the detection, for the first time, of the optical spectrum variations with pulsar phase. In particular, the forward wing of the main pulse and the backward wing of the secondary one are significantly “redder” than their peaks ($\Delta(B-R) \sim 0^m.03 - 0^m.04$ at significance level $\leq 1\%$).

Cooling of neutron stars with superfluid cores: theory vs. observations

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Cooling of neutron stars (NSs) with superfluid cores is simulated taking into account neutrino emission due to Cooper pairing of nucleons. Two cooling regimes of NSs with the same moderately stiff equation of state of internal layers are studied: the standard cooling (for a $1.30\,M_\odot$ star as an example) and the cooling enhanced by the direct Urca process (for a $1.48\,M_\odot$ star). The temperatures of appearance of neutron and proton superfluidities, T_{cn} and T_{cp}, are assumed to be constant over a NS core, and treated as free parameters. They are constrained using the surface temperatures T_s of isolated NSs (RX J0822-43, PSR 1055-52, 1E 1207-52, Vela, Geminga, PSR 0656+14, RX J0002+62), obtained by interpretation of observed thermal radiation with the black body spectrum and with the hydrogen atmosphere models.

The temperatures T_s given by the atmospheric interpretation for the last five objects can be explained by cooling of one NS, with the same T_{cn} and T_{cp} for all objects. The allowed values of T_{cn} and T_{cp} are rather restricted and depend on the cooling regime. The standard cooling requires moderately strong neutron and proton superfluids, while the enhanced cooling requires a moderate neutron and strong proton superfluids. If observations are interpreted with the black body spectrum, it is possible to explain only three last objects in the same manner. For both, standard and enhanced, coolings the confidence ranges of T_{cn}–T_{cp} appear to be wider than for “atmospheric” values of T_s and become twofold. None of the models requires simultaneously strong neutron and proton superfluids ($T_{cn}\,T_{cp} \gtrsim 3 \times 10^9$ K), which is an argument against very soft equations of state in NS cores.

Emission time of cosmic gamma-ray bursts

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It is shown that duration of generation of gamma rays in a cosmic gamma-ray burst is conveniently described by the emission time parameter. Distribution of gamma-ray bursts detected by BATSE over the emission time parameters is determined. A comparison of these distributions for the groups of gamma ray bursts of different intensity is made.

Variation of the energy and momentum of a neutrino propagating in a strongly magnetized e^-e^+ plasma

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An influence of the magnetized electron - positron plasma on the pick-up and loss of the energy and momentum in a process of neutrino propagation is investigated. The total contribution of all crossed processes, $\nu \to \nu e^- e^+$, $\nu e^- \to \nu e^-$, $\nu e^+ \to \nu e^+$, $\nu e^- e^+ \to \nu$, is found for the first time, which appears to be independent of the chemical potential of electron-positron gas. Relatively simple expressions for the probability and mean losses of the neutrino energy and momentum are obtained, which are suitable for a quantitative analysis.

Thermal disc instability and constrains on binary system parameters in application to GRANAT/SIGMA observations of GRS 1758-258

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In contrast to most of the known black hole candidates, which are X-ray transients, GRS 1758–258 was detected by SIGMA during most of the observations in 1990–1998. Assuming that this behavior of the sources implies the suppression of accretion-disk instability in the region of partial hydrogen ionization through X-ray heating, we impose constraints on the mass of the optical companion and on the orbital period of the binary system.

Detection of middle-aged optical pulsars at the 6m telescope

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The observations were conducted at the 6 m telescope of the Special Astronomical Observatory (SAO) of the Russian Academy of Sciences using the Galway University (Ireland) two-dimensional photometer TRIFFID with high temporal resolution in the V and B bands. Data accumulation times amounted for 3.5 and 10 hours for PSR 0656+14 and Geminga, respectively. Arrival time for every photon was measured with accuracy of 1 μs, while its coordinates were determined with accuracy of 25 μm, which, for the 6 m telescope, yields $0''.22$. The timing data in the B band were used to build the light curves folded with the period ephemeris in radio (PSR 0656+14) and gamma (Geminga) ranges. Pulses (one for PSR 0656+14 and two for Geminga) are clearly seen on the light curves, which indicate the detection of the periodical variation of the optical emission. Confidence levels for the registered effects are 10^{-3}–10^{-4}. In order to determine the stellar magnitudes and fluxes we constructed images of PSR 0656+14 and Geminga in the B band and used stars from Geminga field for the calibration. The stellar magnitudes were $25^m.1 \pm 0^m.3$ and $26^m.0 \pm 0^m.4$ for PSR 0656+14 and Geminga, respectively. The shapes of the light curves of these pulsars are virtually identical in the optical and gamma bands (being very different from the light curves in X–rays!). In addition, extrapolations of power–law gamma–spectra to the optical frequency range give estimates of fluxes which are very close to those that we obtained taking account of errors and possible variations of the intensities of the sources on large time–scales. Thus, the emission from middle-aged pulsars PSR 0656+14 and Geminga is likely to be a combination of thermal radiation of hot nonuniform surface (or atmosphere) of a neutron star and non–thermal radiation generated in the magnetosphere.

GRB: WHEN DO BLACKBODY SPECTRA LOOK LIKE NON-THERMAL ONES?

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We argue that a nonthermally looking spectrum of a gamma-ray burst (GRB) can be formed as a superposition of a set of thermal blackbody spectra. This superposition may result from the time integration which is present even in 'time resolved' GRB spectroscopy. To explain GRB location at a cosmological distance it is necessary to assume relativistic motion of matter (the high value of Lorentz factor Γ of the GRB ejecta). It is also important to solve the compactness problem. It is well known that if the emitter is moving towards the observer with the velocity v corresponding to $\Gamma = (1 - v^2/c^2)^{-1/2}$ then the emitter and observer time-scales differ by a factor of $2\Gamma^2$. This means, for example, that the time $\tau = 10$ ms of integration by an observer corresponds to $\tau' \sim 5$ hours of emission time. During this long time the emitting object can expand and cool significantly, so that the spectra it produces in the beginning and in the end of the observation interval τ can drastically differ. Therefore, the observed spectrum is formed by an integration of some cooling sample of instantaneous spectra. With the assumption of power-law temporal dependence of the temperature (cooling law), the area (the expansion law of the ejecta) and blackbody instantaneous spectra we obtain the power-law integrated spectrum. We propose a model of the gamma-ray burst spectrum formation based on this idea. This model allows the GRB radiation to be optically thick and to have higher values of the baryon load. Thus the latter is limited by the energy considerations only, and not by the condition of a small optical depth.

DIFFERENCE OF MILLISECOND PULSARS COMPARED TO "NORMAL" ONES BY THE FREQUENCY DEPENDENCE OF A WIDTH OF INTEGRATED PROFILES

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Millisecond pulsars form a special population of pulsars, which differ from 'normal' pulsars by period, its derivative, magnetic field, age and evolutionary history. Therefore one can expect that parameters of radio emission of the millisecond pulsars are different from those of 'normal' pulsars. However, comparison does not reveal any difference in their pulsed emission [1].

Based on our low frequency observations at 102 MHz [2], which extend the frequency range for studying the millisecond pulsars by four times, and on the higher frequency data we have performed an analysis of the frequency dependence of the width of integrated profiles of a number of millisecond pulsars. At low frequencies, the observed integrated profiles of the majority of the millisecond pulsars are distorted by interstellar scattering. In order to reduce this distortion we performed descattering compensation [3]. High frequency profiles were taken from literature using the European Pulsar Network Data Archive. For analysing the frequency dependence of integrated profiles we used decomposition of the pulse profiles into sums of Gaussian components [4].

We find that millisecond pulsars differ from the 'normal' ones having much weaker frequency dependence of the width of integrated profile $W_{10}(f)$. For a power–low approximation $W_{10}(f) \propto f^{\beta}$, the mean value of β is $\bar{\beta} = -0.02$ with a standard deviation of 0.03.

For a similar analysis of the 'normal' pulsars from the catalogue by Kuzmin et al. [5]. in the same frequency interval 0.1–1.4 GHz we obtain $\bar{\beta} = -0.17$ with a standard deviation 0.08.

The weak frequency dependence of the width of integrated profiles indicates that the standard radius-to-frequency mapping model with dipole magnetic field does not explain the structure of the emission region of the millisecond pulsars. We suggest that this behaviour indicates proximity of the emitting levels at different frequencies and (or) small divergence of the cone of open field lines. It can be caused by the fact that, due to a small radius of the light cylinder, the emission region is "compressed", and (or) by the magnetic field near the star being multipole leading to the small divergence of the field lines.

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Optical photometry of PSR B0656+14 and its neighbourhood

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We present the photometric observations of the nearby radio pulsar PSR B0656+14 and its neighbourhood with the 6m telescope of the Special Astrophysical Observatory. We also incorporate into our analysis available data obtained with the HST WFPC2 and NICMOS.

Previous observations of the pulsar have led to the conclusion that its optical spectrum consists of two components: the thermal component which dominates in the UV region and the power-law non-thermal component whose contribution increases monotonously with wave length in BVRI bands. New data, including recent NICMOS observations, show that the spectrum is more complicated: the power-law spectrum actually dominates in the infrared range while the spectrum is generally flatter in the visible range with an excess in the I_c band.

The pulsar $5''$–neighbourhood consists of four objects, detected by Kurt et al. (1998). Three of them are extended red objects. The nearest one is rather elongated and its structure is well resolved in the NICMOS images. We discuss the nature of the object and its possible relation to the pulsar activity.

The formation of low-mass X-ray binaries with black holes from triple stars

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The formation and evolution of low-mass X-ray binaries (LMXB) with black holes is studied using the modern evolutionary scenario for binary and triple stars. In this scenario, the progenitor of short-period LMXB is a triple star in which a massive close binary contains also a dwarf star at a large distance. After the evolution of the close binary into an ordinary X-ray binary, the compact object is engulfed by its expanding massive companion, and spirals in to settle at its center. The resulting Torne-Zytkow supergiant gradually expands until it attains the size of the late-dwarf orbit. Then a second spiral-in phase ensues, leading to the formation of a LMXB (P.P. Eggleton, F. Vebunt). Using Monte Carlo simulation we estimate the total number of LMXBs with black holes in the Galaxy and study its dependence on the initial conditions.

On separation of submillisecond pulsations in hard gamma radiation of the pulsar PSR 0833-45 from observations with the GAMMA-1 telescope in autumn of 1990

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The methods to distinguish pulsations are discussed (by analysing either phasegrams of the luminosity within the interval of pulsation periods of study or discrete temporal Fourier series). In the both cases a time of any detected event is determined in the coordinate frame co-moving with the spinning pulsar. Temporal and energy parameters of pulsations are presented. It is shown that high accuracy of phase analysis of radiation (not only in gamma-rays) is determined by slow temporal variations of the pulsar spin period and its derivatives. It is suggested that curvature radiation by ultrarelativistic electrons trapped in the pulsar magnetosphere may link the radiation source with the spinning neutron star.

100 GeV and sub-GeV features in the spectra of relativistic winds from compact stellar objects

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It is shown that in a relativistic wind (fireball) from a compact source, such as a neutron star, a neutron component is initially present and has the energy on the order of that of proton-electron plasma component. Decoupling of the neutron flow results in the pion production via inelastic nucleon collisions and, consequently, in the electromagnetic cascade started by energetic quanta from the pion decay [1]. In the wide range of physically interesting conditions the cascade proceeds in one-step regime, for which we develop an analytic theory. The cascade produces a power-law spectrum with a break near 2 MeV, where most of its emission is concentrated.

The effect of neutron decoupling is of particular interest in the case of cosmological GRBs because the decoupling threshold falls in the expected range of the fireball Lorentz factors, 200 – 1500, depending of the model. In this case, the unprocessed photons from the pion decay are blueshifted to the energy range around 100 GeV, accessible for modern ground-based telescopes. According to our calculations, such photons constitute about 10^{-3} of the total energy budget and the luminosity of burst sources in 100 GeV energy range is well above the sensitivity of modern telescopes.

Pion-induced electromagnetic cascade, along with other emission mechanisms, generates a certain amount of sub-GeV photons. We show that the sub-GeV photons may be a useful probe of the surrounding matter. Absence of the absorption of these photons by soft X-ray quanta scattered off the ambient medium places a rather strong limit on its density. Accordingly, the Lorentz factor in fireballs of cosmological gamma-ray bursts must exceed several hundreds.

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Magnetocavitation model of quasi-periodic oscillations of X-ray radiation of neutron stars

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Quasi-periodic oscillations of X-ray radiation of neutron stars are investigated. Magnetocavitation model of these oscillations is developed. According to this model the oscillations of X-ray radiation of a neutron star are produced due to nonlinear oscillations of the magnetosphere interacting with accreting plasma. The magnetosphere is treated as a magnetized gaseous cavern, and the accreting plasma is considered as a fluid. Formulas for oscillation periods are obtained, and the periods are estimated. The results agree with observations.

The effect of the neutron star crust on the evolution of a core magnetic field

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We consider the expulsion of the magnetic field from the superconducting core of a neutron star and its subsequent decay in the crust. Particular attention is paid to a strong feedback of the distortion of magnetic field lines in the crust on an expulsion of the flux from the core. This causes a considerable delay of core flux expulsion if the initial field strength is larger than 10^{11} G. It is shown that the hypothesis about magnetic field expulsion induced by the spin down of the neutron star is adequate only in the case of relatively weak initial magnetic field $B \approx 10^{11}$ G. The timescale of the expulsion depends not only on the conductivity of the crust of the neutron star, but also on the magnetic field strength itself. The considered model of the field evolution naturally explains the existence of the residual magnetic field of the neutron stars. Its strength is correlated with the impurity concentration within the crust and is anticorrelated with the initial field strength of the neutron star.

Influence of neutrino reemission processes in strong magnetic field on the dynamics of collapsing star envepole

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Dominating processes of neutrino reemission (URCA-reactions and neutrino scattering off nucleons) in a collapsing star envelope with strong magnetic field are investigated. It is shown, that in the toroidal magnetic field, these processes can develop a torque which quickly unwinds the envelope. A general expression for the force density along the field is obtained. Numerical estimates are presented. The effect of the "neutrino unwinding" mechanism on the dynamics of the collapsing star envelope is discussed. In particular, a possibility to amplify the toroidal magnetic field by this mechanism is outlined.

Neutrino emission due to Cooper pairing of nucleons in cooling neutron stars

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The neutrino energy emission rate due to formation of Cooper pairs of neutrons and protons in the superfluid cores of neutron stars is studied. The cases of singlet-state pairing with isotropic superfluid gap and triplet-state pairing with anisotropic gap are analysed. The neutrino emission due to pairing of neutrons is shown to be very important in the superfluid neutron-star cores with the standard neutrino luminosity and with the luminosity enhanced by the direct Urca process. The non-relativistic emission rate due to pairing of protons is found to be numerically small. The relativistic correction enhances this process by a factor $10-50$ and reduces great difference between the neutrino emission due to pairing of protons and neutrons. Contrary to the non-superfluid stellar cores, where the main neutrino emission is produced either by the modified or by the direct Urca processes, very different neutrino mechanisms can dominate in the superfluid cores depending on temperature T and superfluid critical temperatures of neutrons T_{cn} and protons T_{cp}. Our analysis shows that the neutrino emission due to pairing of neutrons can be very important for $T \lesssim T_{cn} \ll T_{cp}$, while the emission due to pairing of protons is especially important for $T \lesssim T_{cp} \ll T_{cn}$. Under certain conditions neutrinos generated due to pairing of neutrons can greatly accelerate both, standard and enhanced, cooling of neutron stars with superfluid cores.

Decoupling of neutron component and two-flow model of relativistic winds

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We consider the general case of neutron-proton-electron-positron fireballs and find an analytic expression for the Lorentz factor of a relativistic wind as a function of distance from the central compact object. With the help of this expression, we analyze the relative motion of neutrons and protons in the relativistic wind paying particular attention to fireballs of cosmological gamma-ray bursts (GRBs).

Specific effects of the neutron component depend on whether the final Lorentz factor of a plasma wind exceeds some critical value or not. In the first case, velocity decoupling of the neutron and proton flows takes place giving rise to an electromagnetic cascade induced by pion production in inelastic collisions of nucleons. Otherwise, all nucleons in the wind behave as a single fluid. In both cases neutrons can strongly influence a GRB by changing dynamics of a shock initiated by protons in the surrounding medium.

Conditions for decoupling of the neutron flow are found, and the critical value of Lorentz factor is estimated to lie in the range expected for cosmological GRBs, thus there possibly exist four different populations of bursts [1]. They correspond to all possible combinations given by two independent alternatives: (i) the neutron flow may decouple from the proton one or may not, and (ii) the lifetime of a free neutron either exceeds or is smaller than the deceleration time of the proton shock.

The results obtained for the radiation-driven wind allow straightforward generalization for winds driven by other mechanisms, e.g., for the MHD winds.

References

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Neutrino transfer in a cold neutron star

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The problem of neutrino transfer from the hot quark-gluon plasma in the neutron star (NS) core to the surface of a cold NS naturally arises in the studies of NS collapse induced by a primordial black hole captured in its core [1]. We take into account that in the course of the induced collapse the neutrino-emitting phase transition boundary moves towards the stellar surface. It is also important that in the cold outer part of NS the thermal component of the effective scattering cross-section of degenerate neutrinos appears to be outweighed by the nonthermal component (the residual in the zero–temperature limit, $T \to 0$). While the former component is well-known, we calculate the latter assuming a dipole deviation of the neutrino Fermi surface from the equilibrium level due to non-zero flux.

On this basis, we show that in the most interesting case of quasi-stationary neutrino flow and negligible neutrino losses, the problem is reduced to a system of three ordinary differential equations: one transfer equation for the neutrino chemical potential plus two continuity equations for the neutrino flux density and for the nucleon thermal energy.

We investigate numerically the neutrino transfer equations and find that a hot nucleon matter with $T \sim 10$ MeV is localized within several hundreds meters above the emitting quark surface, while the rest of NS remains cold, $T < 1$ MeV, allowing neutrino to escape almost freely. There is an interesting effect of the descending dependence of the nonthermal cross-section on Fermi energy, $\Sigma_N \propto \mu^{-5}$ at a given flux: more opaque surrounding leads to higher Fermi energy at the NS surface and larger neutrino flux. Inclusion of an outer scattering layer in our modelling increases the total energy output by several times if the transparency coefficient $k_{tr} \sim 0.1$.

Such a source could be a good candidate for the energy supply in cosmological gamma-ray bursts; it provides up to 10^{51} erg during several milliseconds at the final stage of the induced collapse and naturally solves a number of problems, such as the origin of a fireball with a Lorentz factor larger than 100.

References

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The Activity of SGR 1900+14 and SGR 1627-41 from Konus-Wind Observations

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Results are presented of the observations of the soft gamma repeaters SGR 1900+14 and SGR 1627-41 with the Wind spacecraft during period from May 1998 to January 1999. Individual characteristics of recurrent bursts, such as their time histories, energy spectra, peak fluxes and fluencies, are considered as well as some statistical distributions. The observations of the giant outbursts in SGR 1900+14 (August 27) and SGR 1627-41 (June 18) are analysed. A comparison is made of these two extremely intense events with the well known outburst of SGR 0526-66 (March 5, 1979). The striking similarity between the outbursts on August 27 and March 5 stresses their common but peculiar nature, while the June 18 event seems to be a giant in a sequence of recurrent bursts.

Quasi-periodic oscillations of X-ray brightness of neutron stars: new physical mechanisms

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We present the review of current status of quasi-periodic oscillations (QPOs) in X-ray radiation of neutron stars. The basic physical models are considered including the model of photon bubble instability in a magnetized radiation-dominated atmosphere of a neutron star. We consider two new mechanisms of QPOs: nonlinear cavitation process of photon bubbles and nonlinear oscillations of current sheets in magnetized envelopes and atmospheres of neutron stars. The nonlinear collapse of photon bubbles is analyzed as a phenomenon of soft gamma repeaters.