CURRICULUM VITAE

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Birth date:	July 31, 1971
Place of birth:	Klimovsk, Moscow Region, USSR

Education and scientific degrees:

1994	graduated from Moscow Institute of Physics and Technology
1994–1997	post-graduate student at Moscow Institute of Physics and Technology
1997	Candidate of Sciences (Physics and Mathematics) — equivalent of PhD, degree from Space Research Institute, Russian Academy of Sciences

Positions:

1994–1998	Junior Scientific Researcher, Space Research Institute, Russian Academy of Sciences
1998–2000	Scientific Researcher, Space Research Institute, Russian Academy of Sciences
2000–	Senior Scientific Researcher, Space Research Institute, Russian Academy of Sciences

Specialization:

main field	theoretical astrophysics, interaction of matter and radiation under extreme astrophysical conditions
other fields	X-ray and gamma-ray astronomy, cosmology

Visiting positions:

During 1995–2001	spent in total more than 2 years as a visitor at the Max-Planck Institute for Astrophysics in Garching, Germany

Publications:

Number of papers in refereed scientific journals: 25

Biography

Sergey Yurievich Sazonov was born in Klimovsk, Moscow Region in the Soviet Union in 1971. He graduated from the Moscow Physical-Technical Institute in 1994 after six years of training in physics. During 1992–1997 he was an undergraduate and graduate student of Academician Rashid Sunyaev at the Space Research Institute of the Russian Academy of Sciences. He got his degree "Candidate of Sciences" (equivalent of Ph.D.) in astrophysics from the Space Research Institute in 1997. He has held different positions in the High Energy Astrophysics Department of this institute since 1994 (currently senior scientific researcher).

During 1992–1997 S. Sazonov worked with the data of the Danish/Russian all-sky X-ray monitor WATCH on board the Granat observatory. He was responsible for regular checking the instrument status, quick-looking the scientific information coming from the instrument and reporting on transient X-ray phenomena via circulars of the International Astronomical Union. As a result, more than 10 IAU circulars appeared, which were usually followed up by observations with sensitive instruments at different wavelengths. Most of these reports were about outbursts of the unique transient sources GRS 1915+105 and GRO 1655-40, which are now known as galactic microquasars. One of the X-ray outbursts reported by S. Sazonov resulted in the discovery by Mirabel and Rodrigez of the superluminal motion of radio components in GRS 1915+105. During the same period S. Sazonov published several papers in which he analyzed long-term WATCH data for several X-ray sources. He participated in the discovery of the X-ray nova of 1993 in Vela.

The Granat/WATCH catalog of gamma-ray bursts, which was published in 1998 with S. Sazonov as the first author, was the result of a laborious work of instrument calibration and analyzing archival data which was carried out in 1996–1997. This catalog contains celestial positions (with uncertainties in some cases of only a few arcmin) of the sources of 47 bursts and information on the properties of the X-ray emission accompanying the gamma-ray events. The GRB locations were used by the CGRO/BATSE team for calibrating their burst localization methods. The results obtained by S. Sazonov using WATCH data formed the basis for his PhD thesis.

After receiving his PhD degree (in 1997) S. Sazonov has been working in the field of theoretical astrophysics. Among his current scientific interests are the interaction of matter and hot matter, the Sunyaev-Zel'dovich effect, the formation of energy spectra and X-ray variability in low-mass X-ray binary systems. This theoretical work has by now resulted in 8 papers published or accepted for publication in leading astrophysical journals. Among recent results are the derivation of relativistic corrections to the kinematic Sunyaev-Zel'dovich effect, the calculation of the polarization signal toward galaxy clusters induced by the quadrupole component of the CMB angular distribution, analytical formulae for the Compton scattering kernel in the mildly-relativistic limit, the calculation of the effect of scattering in the accretion disk on the waveforms of millisecond X-ray oscillations in LMXBs.

S. Sazonov is married to Irina Sazonova (born 1976 in Klimovsk) and has a daughter, Victoria Sazonova (born 2000 in Moscow).

Sergey Sazonov's Plan of Research

Subject: Interaction of radiation with hot astrophysical plasmas

1 Background

Interaction of radiation with low-density hot (millions of K) plasma has been one of the central problems of astrophysics over the last 40 years. Such plasmas are present in different classes of cosmic sources: binary systems in which one of the components is a relativistic compact object, clusters of galaxies, active galactic nuclei, the early universe and others. One of the main processes responsible for the energy exchange between photons and electrons is Compton scattering.

After receiving his PhD degree three years ago, Sergey Sazonov began a long-term theoretical study of astrophysical problems dealing with the interaction between radiation and mildly relativistic astrophysical plasmas. The first results of this study are presented in 8 papers. The proposed research is seen as a continuation of this previous work.

The main results obtained by now are as follows:

- Relativistic corrections to the S-Z effect in the direction of a galaxy cluster with hot gas of temperature T, moving with a peculiar velocity V are derived analytically and confirmed by Monte Carlo simulations. These corrections are proportional to $(V_r/c)(kT/mc^2)$ and V^2, and complement corrections proportional to $(kT/mc^2)^2$ which were found earlier by Rephaeli et al., Lasenby & Challinor, and Itoh et al. using other methods. These results should be useful in analyzing the data of upcoming microwave experiments (e.g. interferometers) aimed at measuring the thermal and kinematic S-Z effects with high precision (Sazonov & Sunyaev 1998, ApJ; 1998, Astron. Lett.).
- The polarization microwave signal in the direction of a galaxy cluster due to the presence of a quadrupole component in the CMB temperature distribution is calculated, and the distribution of this signal over the sky is predicted for the local population of clusters. It is shown that there are two extended regions in the sky where the polarization is maximal, $\sim 0.1(\tau/0.02)$ μK (τ being the Thomson optical depth across the cluster). Measuring the polarization toward distant clusters may provide the unique opportunity to observe the evolution of the CMB quadrupole at moderate redshifts ($z \sim 0.5$–3) and can help solve the cosmic variance problem (Sazonov & Sunyaev 1999, MNRAS).
- The photon frequency distribution that results from single Compton scattering of monochromatic radiation on thermal electrons is derived in the mildly relativistic limit. Algebraic expressions are given for (1) the photon redistribution function,

$K(\nu, \Omega \rightarrow \nu', \Omega')$, and (2) the spectrum produced in the case of isotropic incident radiation, $P(\nu \rightarrow \nu')$. These formulae describe the profiles of X-ray and low-frequency lines upon scattering in hot, optically thin plasmas. Such line profiles, if observed by future X-ray observatories, can be used for diagnostics of hot astrophysical plasmas. More generally, the formulae obtained describe the Compton scattering kernel (Sazonov & Sunyaev 2000, ApJ).

- Measured values of the brightness temperature of low-frequency synchrotron radiation emitted by powerful extragalactic sources reach 10^{11}–10^{12} K. If some amount of nonrelativistic ionized gas is present within such sources, it should be heated as a result of induced Compton scattering of the radiation. It is shown that the plasma can be heated up to mildly relativistic temperatures $kT \sim$10–100 keV (Sazonov & Sunyaev 2001, Astron. Lett.).

- The scattering by the inner accretion disk of X-ray radiation generated near the surface of a spinning neutron star in a low-mass X-ray binary (LMXB) has observable effects on the waveforms of millisecond X-ray flux oscillations produced e.g. during type-I bursts or in the millisecond pulsar SAX J1808.4–3658. These effects permit direct testing of the presence of standard thin disks near the neutron stars in LMXBs and should be observable with future X-ray timing experiments having a few times better sensitivity than RXTE and also with sensitive X-ray polarimeters (Sazonov & Sunyaev 2001, A&A).

The Max-Planck Institute for Astrophysics appears to be a perfect place to perform the proposed research. It provides an excellent library (in comparison with today's Russia, where a great deal of astrophysical literature is inaccessible), and access to the libraries of the Max-Planck Institute for Plasma Physics and Max-Planck Institute for Quantum Optics. A lot of seminars take place on a regular basis at MPA, ESO and MPE. There is a possibility to communicate with people from the large astronomical community of Garching, one of the largest centers of astrophysics in Europe. Over the several recent years Sergey Sazonov visited MPA more than ten times (for 1–2 months) and has established good working contacts withing the Institute.

2 The Plan

The proposed research will be mostly of theoretical character, and implies analytical and computational work. Also, some analysis of observational (public) data from the Rossi X-Ray Timing Explorer, gamma-ray-burst missions and, perhaps, the XMM observatory is planned to be implemented in close relation to the theoretical part of the work.

During the period covered by the grant the following major topics will be addressed:

1. Formation of radiation spectra and X-ray variability in LMXBs, ways to distinguish

accreting black holes from weakly magnetic neutron stars.

2. Comptonization and spectral distortions of the CMB connected with early energy release in the universe.

3. Physical processes influencing the spectral shape of gamma-ray bursts and their afterglows.

Below the items given above are described in more detail.

1. The recently constructed theory (Inogamov & Sunyaev 1998; Sunyaev & Popham 2000) of the accretion flow near the surface of a spinning low-magnetic-field neutron star marks an important step toward our understanding of the observed properties of the X-ray emission from LMXBs. One of the main predictions of this theory is that the infalling matter after hitting the neutron star near its equator spreads over a substantial portion of the stellar surface, gradually losing its momentum and liberating energy in the form of X-rays.

On the other hand, following the launch of the Rossi X-Ray Timing Explorer in 1995, a major progress has been achieved in observations of galactic accreting compact objects. In particular, millisecond X-ray variability phenomena, including coherent pulsations, burst oscillations and kilohertz quasi-periodic oscillations, have been discovered.

We plan to use the spreading layer theory together with the existing accretion disk theory to formulate detailed predictions for the properties, both spectral and timing, of the X-ray emission produced in neutron-star LMXBs, both in intervals of persistent luminosity and during thermonuclear bursts. The interaction of the central emission with the inner regions of the disk and of the disk emission with the neutron star will be considered, taking into account the Doppler effects due to the fast Keplerian and stellar-spin motions, general relativistic effects, and the details of Compton interaction of radiation with matter. In particular, we want to obtain predictions for different toy models of spreading of thermonuclear burning on the neutron star surface.

We then plan to compare these results with observations.

2. There are two possible forms of distortions of the primeval spectrum produced during the plasma epoch before recombination. Energy release or conversion in the redshift range $10^5 < z < 3 \cdot 10^6$ produces a Bose-Einstein distribution, where the Planck law is modified by a chemical potential μ. Energy release at late times, $z < 10^5$, produces a Comptonized spectrum, a mixture of blackbodies at a range of temperatures. The data of the FIRAS experiment on board the COBE satellite have allowed to place upper limits on the corresponding μ and y parameters, which impose stringent constraints on theories of the early universe and the development of cosmic structure.

We plan to improve the early calculations of the μ and y distortions using the cosmological model accepted today, in which the mass density of barionic matter is small compared to that of dark matter, and including more details. In particular, it should be found how and at which z Bose-Einstein distortions transform to y distortions.

3. Based on the various existing models of a relativistic fireball, we plan to investigate in detail the relatively unexplored role of Compton scattering, including the induced process, in the formation of the emission spectra of GRBs and their early afterglows. The necessity in such a study is motivated by the numerous reports of observed GRB spectra that are at variance with simple models which assume pure optically-thin synchrotron emission and instead require multiple emission mechanisms to be operative at least during the early stages of GRBs. Only crude (and sometimes contradictory) estimates of the importance of Compton processes for the GRB phenomenon are available in the literature.

Our results will be confronted with observational data.