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PERSONALIA

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Evgenii Mikhailovich Churazov (on his 60th birthday)

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November 1, 2021 was the 60th birthday of the well-known astrophysicist, academician of the Russian Academy of Sciences (RAS), Evgenii Mikhailovich Churazov.

E M Churazov was born in the town of Snezhinsk into the family of theoretical physicist and Lenin Prize laureate Mikhail Dmitrievich Churazov. He went to school in the town of Sarov (then Arzamas-16) and then to the famous Second Physico-Mathematical School in Moscow.

In 1985, Evgenii Churazov graduated with honors from the Department of Problems of Physics and Energetics (DPPE) of the Moscow Institute of Physics and Technology (MIPT).

As a fourth-year student, he did internship at the Space Research Institute (a.k.a. IKI) of the USSR Academy of Sciences at the Department of Theoretical Astrophysics established by Ya B Zel'dovich and headed by R A Sunyaev. This department, then renamed the Department of High-Energy Astrophysics, soon became deeply engaged in X-ray astronomy, and the students and postgraduate theoreticians came to know in practice all the difficulties and problems in working with orbital observatories. The theoretical education at MIPT and the knowledge of physical processes operating in X-ray sources were indispensable support in this new area of research. Work with the Roentgen Observatory (on the Kvant module of the Mir space station), which discovered hard X-ray radiation from supernova 1987A in the Large Magellanic Cloud and the satellite Granat, which made maps of X-ray radiation in the central galactic region, were an excellent school that further on proved useful and allowed concentrating on the physics of investigated objects rather than the analysis of data only.

In this department, E M Churazov prepared his diploma and, as a postgraduate student at IKI, defended his Ph.D. in 1989 and doctoral thesis in 1996.

The next experimental project of the department was the Integral Observatory — a project of the European Space Agency — orbited by a Russian Proton rocket in 2002 and still working to date. Russian scientists received the right to 25% of observational time. E M Churazov played the key role in several very important programs of the Integral Observatory. Measured, in particular, was the spectrum of hard X-ray background generated by numerous accreting supermassive black holes located at cosmological distances. Remarkably, for this measurement, the observatory telescopes were directed towards Earth, which served as a screen blocking the background radiation. The total contribution of all distant sources was determined precisely by the flux decrease towards the Earth disk.

The possibility of constructing spectra in the gamma-range by the Integral Observatory turned out to be indispensable for studying electron–positron pair annihilation in our galaxy, where every second some 2×10^{43} positrons annihilate. Although all the main positron production mechanisms (and they are numerous) predict that the initial positron energy is comparable to or much higher than their rest energy of 511 keV, the central region of the Galaxy radiates in a narrow line with exactly the same energy. Moreover, a tail is observed in the spectrum at energies below 511 keV. All this is indicative of the fact that positrons have time to cool before annihilation. Cold positrons capture electrons to form positronium 'atoms' in a singlet or triplet state. A positronium lives negligible fractions of a second and annihilates, giving birth to two quanta with an energy of 511 keV (singlet state) or a three-photon continuum (triplet state). And the Integral telescopes observed both the narrow line and the three-photon continuum.

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These data allowed E M Churazov and his colleagues to measure the temperature (about 10 thousand degrees) and the degree of ionization (nearly 10%) of the medium, where

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annihilation takes place at a distance of 20 to 30 thousand light years.

Another very important result from the Integral Observatory was the discovery of gamma-ray lines of radioactive cobalt ^{56}Co from supernova SN 2014J in the near starforming galaxy M82. SN 2014J is classified as a type Ia thermonuclear supernova. It is precisely studies of such supernovae that gave the first convincing evidence of an accelerating expansion of the universe and the existence of 'dark energy'. The theory, formulated over 70 years ago, relates type Ia supernovae to thermonuclear explosions of white dwarfs in binary systems. Their optical radiation is due to reprocessing of energy released in the decay of radioactive isotopes such as ^{56}Ni.

However, it was only in 2014 that E M Churazov and his colleagues obtained direct and undoubted proof of the origin of these objects. They managed to measure not only the mass of radioactive ^{56}Ni (decaying into ^{56}Co and then into ordinary iron ^{56}Fe) synthesized in the course of explosion but also the shell expansion velocity from line broadening and the mass of the shell itself by comparing the calculations of gamma-ray radiation transfer and observations. All the parameters are indicative of a thermonuclear explosion of a white dwarf with a mass close to the Chandrasekar limit (1.4 times the solar mass).

One of E M Churazov's most important theoretical results was the conception of gas heating in centers of galactic clusters by mechanical energy of relativistic plasma jets from supermassive black holes. Over dozens of years, the following paradox was actively discussed in extragalactic astrophysics: the cooling time of a hot gas with a temperature of tens or hundreds of millions of degrees in deep gravitational potential wells of galactic clusters is much less than the age of the Universe, and therefore the gas must get colder. Nevertheless, observations of X-ray radiation testify that the gas temperature remains high! The solution to this paradox was proposed in a series of E M Churazov's studies, which showed that the energy source compensating the gas bremsstrahlung losses is the substance accretion onto supermassive black holes. The gas heating is due to mechanical interaction with bubbles of relativistic plasma inflated by the black hole. We now see more and more new examples of how this theory, which has already become conventional, works in galactic clusters and in individual galaxies.

This does not exhaust the list of Churazov's important results. Also noteworthy are measurements of the density of cosmic rays and other nonthermal components in the gas of elliptical galaxies; constraints on the decay rate of sterile neutrino the signal from which was considered as one of the interpretations for the X-ray line at ~ 3.5 keV; progress in the theoretical description of electron thermal conductivity in a hot gas; examination of molecular gas and energy release of the supermassive black hole in the center of our Galaxy; predictions of scattered X-ray polarization in this region; and many other things.

At the present time, his main scientific interests is the physics of hot gas in galactic clusters with 'dark matter' occupying 80% of their mass. He has already made and keeps doing a very important contribution to advances with the remarkable orbital X-ray observatory Spectrum-Roentgen-Gamma (SRG), orbiting around the second Lagrange point of the Sun–Earth system at a distance of 1.5 mln km from Earth. SRG was constructed, launched and is operated by the State Space Corporation 'Roscosmos'. There are two X-ray telescopes with grazing incidence optics working aboard the SRG: the Russian M N Pavlinskii ART-XC, sensitive to hard X rays, and eROSITA, designed in Germany and sensitive to X-ray photons of lower energies. E M Churazov is a co-chair of scientific working groups of the Russian consortium of the SRG/eROSITA telescope for galaxy clusters, cosmology, and diffuse sources of X-ray radiation in our Galaxy.

E M Churazov is one of the most prominent Russian scientists of world authority on observational X-ray astronomy and theoretical high-energy astrophysics. His work has been cited over 20,000 times, the Hirsch index being equal to 75 (according to NASA ADS data).

In 2008, E M Churazov was elected a corresponding member and in 2019 a full member of RAS. He is a principal researcher at IKI RAS, a research fellow at the Max Planck Institute for Astrophysics (Garching, Germany), and deputy chairman of the Academic Council for Astronomy of the RAS Division of Physical Sciences.

E M Churazov is a laureate of the 1994 Ya B Zel'dovich medal for young scientists of the Space Research Committee of the International Council for Science, COSPAR, a laureate of the 2014 COSPAR Sir Harrie Messy Award, and the 2017 A A Belopol'skii Prize of RAS.

E M Churazov is a member of editorial boards of the journal *Uspekhi Fizicheskikh Nauk* (*UFN*) [*Physics – Uspekhi*] and the journal *Pis'ma v Astronomicheskii Zhurnal* [*Astronomy Letters*].

Colleagues, friends, and former students of Evgenii Mikhailovich wish him health, happiness, and further success in science!

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