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PERSONALIA

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Rashid Alievich Sunyaev (on his sixtieth birthday)

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Academician Rashid Alievich Sunyaev, whose name is associated with a number of fundamental results in modern theoretical astrophysics and cosmology, had his 60th anniversary on March 1, 2003.

R A Sunyaev was born in Tashkent into a family of natives of the Penza region of Russia — a construction engineer Ali Sunyaev and a pharmacist Saida Davlet-Kildeeva. R A Sunyaev remembers the tremendous role his father played in the formation of his views and the development of his interests. As a result of his origin and the exile of his family, R A Sunyaev's father was not allowed to enter the field he loved, but devoted all his life to self-education; he had very broad interests and a deep respect for science, especially the humanities and medicine, he loved history, literature and poetry, and knew them well. After graduating from a school in Tashkent, R A Sunyaev graduated *cum laude* from the Moscow Physico-Technical Institute (now Moscow Institute of Physics and Technology) in 1966.

In 1965 R A Sunyaev became a graduate student and later a postgraduate of academician Ya B Zel'dovich at the Institute of Applied Mathematics of the Academy of Sciences of the USSR. Meeting Ya B Zel'dovich and then having almost daily contact with him for the next 22 years played a crucial role in R A Sunyaev's life; it helped him to become a scientist working at the interface of theory and experiment. Ya B Zel'dovich's students knew that working with him meant not only never-ending studies with maximum devotion to the process but also bringing daily the joy of the new and the unknown. Yakov Borisovich knew how to keep the young going and how to imbue in them the profoundest interest in science and the belief in the capabilities of the experiment. There is no doubt that R A Sunyaev was a lucky student — he had a wonderful and unique Teacher.

R A Sunyaev's interests in science cover a wide range of astrophysical problems, from elementary processes to physical cosmology. Among his results, which have become an essential part of today's astrophysics, are the 'standard' theory of disk accretion onto black holes and neutron stars (Shakura and Sunyaev 1973, 1976), the Sunyaev – Titarchuk formula (1980) for the radiation spectra generated by Comptonization of low-frequency photons in hot low density plasma, and the Sunyaev – Zel'dovich effect (1972) which makes it possible to use clusters of galaxies as a powerful tool of observational cosmology. Students studying astrophysics all over the world recognize R A Sunyaev's name from these results, which are found in all textbooks and courses.

The Shakura – Sunyaev theory of accretion disks has long been universally accepted for describing matter transfer and energy release in close binary systems, and the accretion of matter onto supermassive black holes. In modern astrophysics, this paper is one of the two most cited (among nearly a million publications). The accreting neutron stars and black holes are observed as powerful X-ray and gamma-ray sources. Comptonization is the basic mechanism for the formation of the spectra of their hard emission. The Sunyaev – Titarchuk formula is the key tool for describing the results of observation of such objects. The accuracy of the formula was confirmed by detailed computations carried out using Monte-Carlo techniques (Pozdnyakov, Sobol', and Sunyaev, 1983).

Rashid Alievich Sunyaev

Thirty years have passed since the publication of R A Sunyaev's and Ya B Zel'dovich's papers devoted to the decrease of brightness of cosmic microwave background (CMB) in the direction of rich clusters of galaxies. During this period the Sunyaev – Zel'dovich effect evolved from a beautiful theoretical idea into one of the most productive methods of observational cosmology; it opens the possibility of determining fundamental cosmological parameters, interpreting the role of 'dark energy' in the Universe and directly

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measuring the Hubble constant. This effect was discovered and is actively studied now in the direction of nearly a hundred clusters of galaxies. In 1980 R A Sunyaev and Ya B Zel'dovich showed that the observation of the relic (CMB) radiation in the direction of clusters of galaxies makes it possible to measure their peculiar velocities relative to the CMB radiation (the kinematic effect). Various manifestations of the 'effect' are now in observational programs of the largest radio telescopes in the world. Satellites and ground-based telescopes on the South Pole and in Chile will be able to detect — and make use of for cosmology — tens of thousands of clusters that would have otherwise remained unobservable by other methods.

In 1968 R A Sunyaev together with Ya B Zel'dovich and V G Kurt calculated the kinetics of hydrogen recombination in the early Universe, having shown that this process was dominated by the two-photon decay of the 2s level. In 1970 Sunyaev and Zel'dovich noted the importance of the recombination delay on the formation of primary angular fluctuations of the CMB radiation.

In 1969 – 1970 R A Sunyaev and Ya B Zel'dovich investigated in detail the thermalization of the CMB radiation and the formation of the Planck spectrum in the early Universe. They were able to show that any energy release after the stage of electron – positron annihilation and the completion of nuclear reactions must lead to specific imprints on the spectrum of microwave background radiation. Sunyaev and Zel'dovich (1970) predicted the existence of acoustic (Doppler) peaks in the angular distribution of the CMB and called them Sakharov oscillations (see also Doroshkevich, Sunyaev, and Zel'dovich 1978). The positions and relative intensities of these peaks are determined by the key parameters of the Universe: the Hubble constant, the Λ-term, the baryon density, and the dark matter density in the Universe. In 2000 the first acoustic peaks were detected in balloon experiments. The satellites "WMAP" and "Planck Surveyor", together with the anticipated ground-based experiments, will allow a detailed investigation of these peaks. Sunyaev (1977) was the first to consider fluctuations of the CMB radiation due to the secondary ionization of matter in the Universe, and evaluated their amplitude and angular scale. In 1968 R A Sunyaev predicted the existence of zones in galaxies ionized by external radiation and showed that the observations of neutral hydrogen in peripheral regions of galaxies may provide information on the flux of the ionizing background radiation. In 1970 R A Sunyaev and E V Levich showed the importance of Compton heating and cooling under astrophysical conditions and introduced the concept of induced heating and induced light pressure due to Compton scattering near bright radio sources. In the same year Sunyaev showed the importance of Bose condensation of photons, resulting from induced Compton scattering, for the spectra of bright radio sources.

In 1973 T M Éneev, N N Kozlov, and R A Sunyaev carried our a pioneer numerical computation of the tidal interactions of galaxies. R A Sunyaev and Yu N Gnedin (1974) predicted the existence of cyclotron lines in X-ray spectra of accreting X-ray pulsars. R A Sunyaev, together with V M Lyutyi and A M Cherepashchuk, (1973, 1976) explained the optical photometric effects observed in close binary X-ray systems Her X-1 = HZ Her (X-ray heating of the star and the disk) and Cyg X-1 (tidal distortion of the surface of a normal star). M M Basko and R A Sunyaev (1973) were the first to consider the interaction of X-ray radiation with the surface of a normal star in a close binary system: the heating of the stellar surface, reflection of X-rays, and the formation of induced stellar wind. In 1974, together with L G Titarchuk, they calculated for the first time the X-ray spectrum of radiation reflected by a cold stellar atmosphere. In 1980 L A Vainstein and R A Sunyaev predicted powerful emission in the iron K_α-line from interstellar gas in the central regions of our Galaxy and in other galaxies. In 1975 R A Sunyaev and A F Illarionov demonstrated the importance of the 'propeller' effect in binary systems that contain a neutron star with a strong magnetic field.

In 1974 R Z Sagdeev invited Ya B Zel'dovich and R A Sunyaev to organize the Department of Theoretical Astrophysics at the Space Research Institute (IKI) of the Academy of Sciences of the USSR. In 1974 – 1982 R A Sunyaev headed the laboratory in this department and in 1982 founded the Department of High-Energy Astrophysics at IKI. This began for him an intense period of entering in the experimental X-ray and gamma-ray astronomy. An undoubted success was the launch of the orbital observatories "Roentgen" (on the "Kvant" module of the space station "Mir") and "Granat".

The most spectacular result of the "Roentgen" observatory was the discovery of hard X-rays from the Supernova 1987 A in the Large Magellanic Cloud. These X-rays were caused by radioactive decay of ^{56}Co synthesized during the stellar explosion, and the emission of gamma-ray photons and their subsequent Comptonization in the expanding envelope. The emergence of the hard emission was predicted by the computations carried out in Sunyaev's department. Among the most important results at the "Granat" observatory were detailed maps of the central region of the Galaxy, broadband spectra of accreting black holes and neutron stars, and the discovery of tens of new X-ray sources, including the first microquasar in the Galaxy.

On October 17, 2002, the "Proton" launcher successfully lifted the International Gamma-Ray Astrophysics Laboratory "INTEGRAL" off to a high-apogee orbit. R A Sunyaev is Russia's scientific leader of this project. Russian scientists will receive 25% of the entire observing time in this laboratory.

R A Sunyaev has won a number of prestigious prizes and awards in astrophysics and cosmology, including the Bruno Rossi Prize of the American Astronomical Society (AAS, 1989), the Gold Medal of the Royal Astronomical Society (1995), the Sir Massey Award and Gold Medal of the Royal Society of London and COSPAR(1998), the Catherine Bruce Gold Medal of the Astronomical Society of the Pacific (2000), the Dannie Heineman Prize of the American Institute of Physics and the AAS (2003) and the Cosmology Prize and the Gold Medal of the Peter Gruber Foundation and the International Astronomical Union (2003). In 2000 R A Sunyaev received the State Prize of Russia for observations of black holes and neutron stars using the orbital observatory "Granat" and in 2002 — Aleksandr Friedmann Prize for Gravitation and Cosmology of the Russian Academy of Sciences.

In 1984 R A Sunyaev was elected corresponding member of the Academy of Sciences of the USSR and in 1992 full member of the Russian Academy of Sciences. He is a member of the Academy of Europe, a foreign associate of the National Academy of Sciences of the USA, an honorary foreign associate of the American Academy of Arts and Sciences, and a foreign fellow of the Royal Astronomical

Society; he is an honorary member of the Academies of Sciences of Tatarstan and Bashkortostan and of the American Astronomical Society, and honorary professor of Kazan State University and Ludwig-Maximillian University in Munich.

R A Sunyaev heads the Laboratory of Theoretical Astrophysics at the Space Research Institute of the Russian Academy of Sciences, he is a director of the Max Planck Institute for Astrophysics, and is also Editor-in-Chief of the journal *Pis'ma v Astronomicheskii Zhurnal* (*Astronomy Letters*). With characteristic energy and enthusiasm, R A Sunyaev continues his intense work. The theory of the boundary layer formed in the process of accretion onto neutron stars, the physics of quasars and microquasars, X-ray binaries as an indicator of the star formation rate in distant galaxies, CMB fluctuations — this is but an incomplete list of his current interests.

Friends, colleagues, and disciples heartily congratulate Rashid Alievich on his birthday and wish him new ideas, new discoveries, and that unforgettable feeling that one gets every time when a complex and entangled problem suddenly becomes simple and clear.

D A Varshalovich, A A Galeev, M R Gil'fanov,
S A Grebenev, V V Zheleznyakov, E P Mazets,
M N Pavlinskiĭ, A A Starobinskiĭ, O V Terekhov,
A M Cherepashchuk, E M Churazov, N I Shakura