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Vladimir Vasil'evich Zheleznyakov (on his seventieth birthday)

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January 28, 2001 was the 70th birthday of Vladimir Vasil'evich Zheleznyakov, full member of the Academy of Sciences, outstanding physicist and astrophysicist.

V V Zheleznyakov's work in astrophysics, theoretical radio astronomy, and cosmic plasma physics has made him famous in our country and abroad. He obtained results of major importance on generation and propagation of electromagnetic waves in astrophysical plasmas, in particular, on the theory of sporadic solar radio emission, optical and X-ray emission from pulsars, physical processes in plasma on magnetic white dwarfs and in cosmic gamma-ray burst sources.

V V Zheleznyakov proved the importance of cyclotron radiation mechanism for the formation of frequency spectra of radio emission from the Sun and magnetic Ap-stars, the optical radiation of magnetic white dwarfs, the radiation of pulsars and gamma-ray burst sources. While working on the cyclotron mechanism, V V Zheleznyakov pointed out the existence of depression of cyclotron radiation of electrons at gyrofrequency in dense plasma, the instability of non-equilibrium plasma in the region of anomalous Doppler effect, and synchrotron instability. He found that the relativistic dependence of electron mass on velocity has a significant effect on the growth rate of cyclotron instability in low-relativistic plasma. Important applications of this effect to electronics were found when cyclotron-resonance masers started to be designed in the Radiophysical Research Institute and the Institute of Applied Physics of the USSR Academy of Sciences. For his work on cyclotron radiation in astrophysics, V V Zheleznyakov won the A A Belopolsky Award from the USSR Academy of Sciences in 1984.

The thermal cyclotron mechanism of radiation developed by V V Zheleznyakov was successfully used in the theory of the slowly varying component of solar microwave emission, which is based on the joint effect of thermal bremsstrahlung and cyclotron mechanisms in nonuniform magnetic fields of solar active regions, and gives a consistent explanation of the observed properties of radio emission: the frequency spectra, the polarization and brightness distribution over the sources. This theory is widely used nowadays in data processing of radio observations of the Sun, in obtaining information on the distribution of temperature and magnetic fields in active regions of the solar corona and the upper chromosphere.

Concerning the research by V V Zheleznyakov on the plasma mechanism of radiation, we must note the first studies of Raman scattering (coalescence) of plasma waves in the solar corona resulting in their transformation to electromagnetic radiation at the doubled plasma frequency. This result made it possible to solve the main problem for mechanisms of this kind, namely, the conversion of plasma waves into electromagnetic waves under cosmic conditions. It became the basis for the theory of radio emission of sub-relativistic electron beams in the solar corona (types III and V of solar radio bursts). All subsequent research of this phenomenon in the field of solar radio astronomy was based on this theory. Moreover, the analysis of Raman scattering of plasma waves was one of the pioneering works in a sequence of studies of nonlinear decay interactions in plasma physics.

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While studying the propagation of electromagnetic waves under cosmic conditions, V V Zheleznyakov developed the theory of linear interaction (transformation) of waves in smoothly nonuniform weakly anisotropic media, including magnetoactive cosmic plasma and plasma in magnetized vacuum near neutron stars. This theory made it possible to solve the problem of the 'limiting polarization' of radiation escaping from magnetoactive plasma, and to find new types of linear interaction (for example, those in neutral current layers of the solar corona). In particular, the observed features of noise-storm polarization led V V Zheleznyakov to the conclusion that current sheets must exist in the active regions of the solar corona.

Studies of solar radio emission that are now being done in our country and abroad have to a large degree been stimulated by the work of V V Zheleznyakov and his team. One should note, for example, the discovery of cyclotron lines in the

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spectrum of solar radio emission; V V Zheleznyakov's team had previously pointed out the possibility of detecting these lines.

V V Zheleznyakov and his team analysed the efficiency of the cyclotron radiation mechanism under the conditions of the coronae of magnetic Ap stars. They showed that the microwave emission from the nearest stars of this class can be detected by modern radio astronomical facilities even if the density of coronal plasma is insufficient for observing its X-ray radiation.

In a series of papers on the theory of radio pulsars, V V Zheleznyakov studied the physical conditions and processes in the magnetospheres of neutron stars, and analysed in detail the synchrotron mechanism of optical and X-ray radiation of the Crab pulsar. As a result, he showed that the radiation source must be located near the light cylinder. This is a significant fact for models of short-period pulsars.

Since the early 1980s, the scientific interests of V V Zheleznyakov related to white dwarfs and neutron stars with superstrong magnetic fields. He showed that under such extreme conditions, the cyclotron radiation mechanism has some important features. In particular, resonance scattering at the first harmonic begins to play a dominant role in the formation of cyclotron radiation.

V V Zheleznyakov laid the basis of the theory of coronas of isolated white dwarfs. According to this theory, the coronas of such stars consist of hot plasma with an anisotropic temperature. The cyclotron spectral features formed under such conditions are a more sensitive indicator of the coronal plasma than its soft X-ray emission.

V V Zheleznyakov suggested and justified a model for a radiation source on a accreting neutron star, an X-ray pulsar. In this model, the X-ray radiation in the continuum and in cyclotron lines is formed in the dense isothermal plasma of the polar spot atmosphere on the surface of the neutron star. In this case, the observed lines in absorption are formed due to efficient cyclotron scattering and appear against a continuum which is attenuated as a result of Thomson scattering on free electrons. Prior to creating a model of the X-ray pulsar, V V Zheleznyakov analysed the propagation of X-ray radiation and cyclotron absorption in high magnetic fields where the polarization of normal waves is determined by the magnetized vacuum.

At the same time, V V Zheleznyakov began to study the physical processes in cosmic gamma-ray bursts. He proposed a mechanism of the formation of annihilation lines in the spectra of gamma-ray bursters which explained the intensities of annihilation lines measured during spectral observation of gamma-bursts by the Venera 11 – Venera 14 spacecrafts. Later on, in the 1990s, V V Zheleznyakov and his team developed the theory of radiation transfer at the cyclotron harmonics in plasmas on strongly magnetized neutron stars . The theory predicted that gamma-ray bursters having both the first and the second harmonics of gyrofrequency in their spectra must be related to neutron stars which lie quite close to the Earth (at a distance of no more than several kiloparsecs).

Based on calculations made in the late 1980s of the pressure force of cyclotron radiation in plasmas on degenerate stars, in the early 1990s V V Zheleznyakov proposed and justified a hypothesis for the existence of a new type of astrophysical object called as 'radiation-driven diskons'. Diskons are hot magnetic degenerate stars with plasma disks and envelopes. The latter are formed by plasma escaping from the surface of the star under the action of high radiation pressure at cyclotron frequencies and do not require accretion. Isolated magnetic white dwarfs that demonstrate strong depression in the ultra-violet spectra are the prime candidates for this type of objects.

V V Zheleznyakov's work on the physics of cosmic plasma and astrophysics has been summed up in his widely popular monographs *Radio-Frequency Radiation of the Sun and Planets* (Nauka, 1964; Pergamon Press, 1970), *Electromagnetic Waves in Cosmic Plasma* (Nauka, 1977), and *Radiation in Astrophysical Plasma* (Kluwer, 1996; Yanus-K, 1997). They have become handbooks for several generations of scientists.

V V Zheleznyakov and his team have also worked in the field of nonlinear electrodynamics of magnetized vacuum and inverted two-level systems. They pointed out the possible existence of solitons and shock waves in the magnetized vacuum around neutron stars. In studies of superradiance, they pointed out the possible existence of dissipative instability of polariton modes in inverted media, discovered a close connection between this type of instability and the effect of Dicke superradiance, and proposed a new interpretation of this effect. Based on this research, they found and studied cyclotron superradiance, a classical analogue of this phenomenon. These results stimulated the research into superradiant regimes in electronics, and the effect was finally discovered in experiments at the Institute of Applied Physics of the Russian Academy of Sciences (IPF RAN).

For more than 30 years, V V Zheleznyakov taught at the State University of Nizhny Novgorod (former Gorky). Many graduates of the Radiophysical Department still remember to the course 'The Cosmic Physics' that V V Zheleznyakov, Professor at the Chair of Radio Wave Propagation, started teaching in 1968 and continued to teach for many years, alongside a special course on radio astronomy that he delivered to students majoring in this field. He later moved to the Physics Department of the University; in 1991, he moved to yet another department of the same university, the Advanced School of General and Applied Physics, where he teaches a course in astrophysics.

Between 1992 and 1999, V V Zheleznyakov took part in the creation of the Russian Foundation for Basic Research and was the member of its board.

A remarkable creation by V V Zheleznyakov is the Department of Astrophysics and Cosmic Plasma Physics that he heads at the IPF: an excellent team of highly qualified scientists who come from three generations of his pupils. Research done at this department concerns various aspects of the theory of interaction of radiation with plasma and plasma-like media in the Earth's vicinity, the Solar System, and under extreme conditions in the vicinity of white dwarfs, neutron stars and black holes.

Vladimir Vasil'evich gives much of his time to the journal *Izvestiya Vuzov. Radiofizika*; in late 1998, he became its Editor-in-Chief. Largely due to his efforts, the journal has a good standing among Russian science periodicals.

Vladimir Vasil'evich's colleagues, students and friends send their warmest regards and wish him good health, prosperity, successful work and happiness for many years to come.

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