

## Yakov Borisovich Zel'dovich (on his seventieth birthday)

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March 8, 1984 is the seventieth birthday of Yakov Borisovich Zel'dovich. YAB—as he is known to his students, co-workers, colleagues—was born in Minsk. At the age of fifteen he graduated from a Leningrad secondary school and enrolled in the course for laboratory assistants at the “Mekhanobr” Institute. During a visit to the Leningrad Physico-Technical Institute Professor S. Z. Roginskii's attention was drawn to the serious questions asked by the young man. It was agreed that the young man without giving up his studies at the laboratory assistant courses would begin working in Professor Roginskii's laboratory. Soon after that the Head of the Department of Chemical Physics of the Leningrad Physico-Technical Institute N. N. Semenov scheduled a report by Zel'dovich at his seminar and decided to arrange his transfer to the LPTI. The transfer was arranged (via the labor exchange—a significant detail of those years!), and on May 15, 1931 Zel'dovich became a member of the Institute of Chemical Physics that grew out of the LPTI. There is a legend that “Mekhanobr” traded Zel'dovich to the LPTI for a vacuum pump.

The first papers of Yakov Borisovich, including some experimental ones, dealt with the processes of adsorption and catalysis. He investigated the effect of surface inhomogeneity on the process of adsorption. These ideas and results are still viable today, and he is regarded as an acknowledged authority in this field. Thus, in 1938 he pointed out the possibility of adsorption affecting the structure of the adsorbent. One can appropriately evaluate this work now when similar ideas are being developed in a wide range of phenomena including molecular biology.

In the early thirties N. N. Semenov involved Zel'dovich in extensive collective work on the oxidation of nitrogen in the process of combustion. From this he progressed in a natural manner to the general theory of combustion, detonation, and shock waves. The papers of Yakov Borisovich in this field are rightfully regarded as classic. We are unable even to enumerate the results obtained by him<sup>1)</sup> but will simply restrict ourselves to a statement: he created the modern theory of combustion and explosion. The group formed by him (of their number Yakov Borisovich with particular

<sup>1)</sup>We direct the reader to Usp. Fiz. Nauk for 1964 and 1974. The reader will be able to find a complete list of his papers in the two-volume edition of the selected papers of Ya. B. Zel'dovich: vol. 1 “Chemical Physics and Thermodynamics,” vol. 2 “Particles, Nuclei, the Universe” being published in 1984 by the publishing house “Nauka.”



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warmth singles out D. A. Frank-Kamenetskii) has developed into a large school containing many branches. Alongside the purely scientific significance of the results obtained in the field under discussion, they also had a tremendous significance for defense. From the early days of World War II Zel'dovich immersed himself entirely into defense research. It is well known, for instance, how significant was his own work and that of the group headed by him on the combustion of powder in the legendary “Katyushas”.

A characteristic of Yakov Borisovich is his impetuous entry into any new subject. Soon after the discovery of uranium fission (1939) he together with Yu. B. Khariton developed the theory of the chain reaction of this process. In a series of papers the authors drew fundamental conclusions—negative (on the impossibility of a chain reaction in natural uranium and of a self-maintaining reaction—in a homogeneous system “natural uranium + light water”) and positive ones: they clarified the role of delayed neutrons,

the enrichment of uranium by its light isotope, gave an estimate of the critical mass, and of the criterion for neutron multiplication in systems involving slowing down of neutrons. Anticipating future results we must also mention his paper (1956) on the storage of cold neutrons which gained for him the I. V. Kurchatov academic medal. In the light of the above it is evident why Zel'dovich was among the first ones involved by I. V. Kurchatov in the design of the first Soviet uranium reactor. Later he was among those who created atomic weapons. His experience, knowledge, and talent for research turned out to be very important and valuable for his country. And just how important and valuable can be seen from the high government awards which he received.

The 1950's saw the first papers of Zel'dovich on elementary particle physics. In 1952 he formulated the law of conservation of baryon number with reference to the strange particles discovered shortly before that; in 1953 he formulated the law of conservation of leptonic charge. A prominent place in his work is occupied by research on  $\beta$ -decay. We should particularly note the calculation of the  $\beta$ -decay of the pion and the deep idea expressed by him in this connection concerning the conservation of the weak vector current. This idea is an inseparable element of the modern theory of the electroweak interaction. Already in the 1950's he proposed the bold idea of isotopic spin of the leptons and proposed experiments to search for parity violation in atoms.

From the early 1960's Zel'dovich turned his attention to cosmology. Today there are few who could equal him in the influence he had on its development. Because of the work of Zel'dovich and his students Moscow became truly the capital of relativistic astrophysics. The largest optical and radio telescopes, the orbital x-ray observatories have in their present and future programs the discovery of and search for effects predicted by Zel'dovich. Among his work is the indication of the possibility of the formation of black holes of small mass, work on accretion (fall) of matter onto black holes and neutron stars. When the cosmic background microwave radiation was discovered, Zel'dovich was one of the first to understand what a powerful instrument it is for learning about the past history of the universe. He analyzed the problems of the dipole and quadrupole anisotropy, of the angular fluctuations of the cosmic background microwave radiation, of the nuclear fusion reactions in the hot universe, of the relic neutrinos and quarks. He solved the problem of the recombination of hydrogen in the universe, calculated the distortion of the spectrum of the cosmic background microwave radiation associated with the decay of unstable particles, the evaporation of mini-black-holes, the annihilation of matter and antimatter, the dissipation of potential and vortex motions. At the beginning of the 1970's Zel'dovich predicted the lowering of the brightness temperature of the cosmic background microwave radiation in directions towards clusters of galaxies with hot intergalactic gas. This effect is at present included in the observational program of the world's largest radio telescopes. In recent years Zel'dovich has been working on problems of the creation and the earliest stages of evolution of the universe. These problems require the synthesis of the general theory of relativity and quantum theory without which it is impossible to construct a

really complete cosmological theory.

The main problem towards the solution of which Zel'dovich has been making steady progress during the last 20 years is the question of the origin of the large-scale structure of the universe, and of the causes which lead to the appearance of the surprisingly varied universe of galaxies, clusters and superclusters of galaxies from the primordial practically homogeneous matter. The most important achievement in this field—the theory of the large-scale structure—was named by Zel'dovich the “pancake theory”. Today this theory—which has predicted the now observed giant vacant regions and the reticular structure of the universe—occupies the centre of attention of observers and theoreticians. The detailed working out of this theory utilizing the most powerful computers is at present being carried on in the leading universities of the world; all its predictions are being checked.

In 1983 Zel'dovich's achievements in astrophysics were acknowledged by the award to him of the Catherine Wolf Bruce gold medal—an award based on the “lifetime devoted to astronomy and the outstanding contribution to the development of this science” as formulated in the citation.

Zel'dovich's role in the development of physics is not limited to his papers, or the creation of new directions and scientific schools. He is the author of more than twenty monographs. The number of his pupils is not restricted to tens of physicists, who interact with him directly. The stimulating influence of his work is experienced by scientists from other specialties including mathematicians. Some of Zel'dovich's achievements are essentially mathematical discoveries and interconnect with the most modern investigations in that science. One has to mention the influence which Zel'dovich has exerted and is exerting on the teaching of higher mathematics, and the many young people in whom he has kindled the love for the exact sciences by his book “Higher Mathematics for Beginning Physicists and Technologists” which has gained very wide popularity.

Years have no power over Zel'dovich. He continues to work with youthful fervor and with productivity which elicits both amazement and admiration. Where does he find time to be abreast of literary, theatrical, and in the broadest sense cultural life? Neither his work-load nor the burden of his extensive fame and popularity have in any way altered his democratic character. The sharpness of a theoretician's mind is combined within him with inexhaustible wit which makes him a most interesting and lively conversationalist.

Zel'dovich's work has received high appraisal. He has been awarded the title of Hero of Socialist Labor on three occasions, he has been awarded the Lenin Prize, he has been given the State Prize of the USSR four times, he has been decorated with many orders and medals. He is a full member of the Academy of Sciences of the USSR, a member of the Royal Society of London, of the National Academy of the USA, of the Hungarian Academy of Sciences, of the Academia Leopoldina (GDR) and of a number of other academies, and has received honorary doctorates from famous universities. For twenty years Zel'dovich has served on the staff of the Institute of Applied Mathematics, and now he heads the theoretical division of the Institute of Physics Problems. At

the same time he is in charge of the division of relativistic astrophysics of the P. K. Shternberg State Astronomical Institute, and is a scientific consultant for the administration of the Institute for Space Research of the Academy of Sciences of the USSR, and a professor of the Physics Faculty of the Moscow State University. Professor S. Hawking on meeting Yakov Borisovich in Moscow said: "Now I know that you are a real person, and not a group of scientists like Bourbaki." Along all the different scientific directions enumerat-

ed above one and the same person is working strenuously and selflessly surrounded by co-workers and pupils. That person is Yakov Borisovich Zel'dovich.

On his seventieth birthday we wish him to remain for many, many years "unique in multiple aspects" and wish him good health and new creative accomplishments

Translated by G. M. Volkoff