INTIMATE REFLECTIONS ON A CAREER AND A LIFE

Selected Works of Yakov Borisovich Zel'dovich Vol. II: Particles, Nuclei and the Universe

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The sweep of Zel'dovich's career was breathtaking. From the early 1960s until his death in 1987, my colleagues and I knew him as arguably the world's most influential astrophysicist and cosmologist—and also as a creative genius in general relativity and in quantum field theory in curved spacetime. Others revered his contributions to chemical physics, fluid mechanics, the theory of detonations, elementary particle physics, nuclear physics and the design of nuclear weapons. When I introduced him to Stephen Hawking in 1973, Hawking said, "Now I know that you are a real person and not a group of scientists like Bourbaki." Zel'dovich's friend and competitor Andrei Sakharov characterized his breadth of genius as "probably unique." (He shared with Sakharov the invention, in the USSR, of the "Teller–Ulam" idea that underlies the hydrogen bomb, as well as the distinction of being the most medal-bedecked scientist in Soviet history.)

This second volume of Zel'dovich's *Selected Works* gives some sense of his achievements, breadth and power. In 1939 and 1940—right after the discovery of nuclear fission—we find him, with Yuli B. Khariton, developing the theory of nuclear chain reactions and laying theoretical foundations for nuclear reactors (papers 1,2 and 3). In 1952 and 1953 we see him, in the midst of secret hydrogen-bomb design work, still finding time to propose the laws of conservation of baryon number and lepton number, although he did not use those names (papers 9 and 10). In 1971 we find him arguing that a spinning black hole must spontaneously emit radiation (paper 34), thereby triggering Hawking's subsequent discovery that all black holes must radiate. In the early 1970s we see him, via a clever analysis of nonlinear effects during galaxy formation, correctly predicting that there must be "pancakes," cellular structures and voids in the universe's large-scale distribution of galaxies (papers 55 and 56).

Zel'dovich himself chose in 1983 which of his original research papers should appear in his *Selected Works*, and he appended to each paper a several-paragraph commentary spelling out his own retrospective view of its significance. By writing his commentaries in the passive voice or in the third person (referring to himself simply as "Ya. B.") he saves the reader from wincing at words of self-praise and frank admissions of error. It is these commentaries, as much as the original papers themselves, that make Zel'dovich's *Selected Works* valuable for research scientists and historians alike—and also for graduate students.

The most tragic event in Zel'dovich's career may have been his explosive break with most of the younger members of his astrophysics research group in 1978. (In my view, never before or since has there been any single astrophysics group with so much power as the one thereby destroyed.) Perhaps because of the bitter aftertaste of that explosion, Zel'dovich omitted from the Russian-language edition of his *Selected Works* major papers that he had coauthored with Igor D. Novikov. Happily, the editors of this English-language edition chose—after Zel'dovich's death—to insert the key Zel'dovich–Novikov papers; for example, the 1966 paper (30b) in which the two proposed the ultimately successful method of searching for black holes (using x rays from the massive dark companion of a normal star) and the 1965 paper (29b) in which, they and Andrei G. Doroshkevich triggered the speculation that "a black hole has no hair" (later proved true). It is sad that these added papers carry no commentary. Perhaps Zel'dovich would have preferred it that way.

In an autobiographical afterword at the end of this volume, Zel'dovich assesses somewhat harshly his own original contributions to astrophysics: "In significant measure my work . . . in astrophysics turned out to be promotional, popularizing and pedagogical. All of this is necessary and useful; however, it is to be judged on a different scale than obtaining original results." Elaborating on this theme in 1985 in his Moscow flat over a bottle of cognac, Zel'dovich produced for me a list of great astrophysical discoveries that he missed by being "too-narrow minded" (for example, that *all* black holes should radiate), a list more impressive than his remarkable actual discoveries. As sad as this self-assessment may have been, it can be seen as an essential corollary of one of the keys to Zel'dovich's achievements: His life was an intense, competitive battle for new ideas—a battle not so much against his colleagues (he took great joy in their discoveries as well as his own) but rather against his own ideal of what he himself *ought* to be achieving.

Zel'dovich is a major figure in Kip Thorne's recent book *Black Holes and Time Warps* (Norton, 1994). From 1968 onward Thorne was a frequent visitor to Zel'dovich's Moscow research group.

Science and Anti-Science

Gerald Holton
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The title of this book might suggest that it is exclusively devoted to the battle between science and the forces of darkness, but the author deserves