Biography of Abraham Zelmanov
(1913–1987)

A. Zelmanov in the 1940's

Abraham Leonidovich Zelmanov was born on May 15, 1913 in Poltava Gubernya of the Russian Empire. His father was a Judaic religious scientist, a specialist in comments on Torah and Kabbalah. In 1937 Zelmanov completed his education at the Mechanical Mathematical Department of Moscow University. After 1937 he was a research-student at the Sternberg Astronomical Institute in Moscow, where he presented his dissertation in 1944. In 1953 he was arrested for "cosmopolitism" in Stalin's campaign against Jews. However, as soon as Stalin died, Zelmanov was set free, after some months of imprisonment. For several decades Zelmanov and his paralyzed parents lived in a room in a flat shared with neighbours. He took everyday care of his parents, so they lived into old age. Only in the 1970's did he obtain a personal municipal flat. He was married three times. Zelmanov worked on the academic staff of the Sternberg Astronomical Institute all his life, until his death on the winter's day, 2nd of February, 1987.

He was very thin in physique, like an Indian yogi, rather shorter than average, and a very delicate man. From his appearance it was possible to think that his life and thoughts were rather ordinary or uninteresting. However, in acquaintance with him and his scientific discussions in friendly company one formed another opinion about him.

Those were discussions with a great scientist and humanist who reasoned in a very unorthodox way. Sometimes we, people who were with him, thought that we were not speaking with a contemporary scientist of the 20th century, but some famous philosopher from Classical Greece or the Middle Ages. So the themes of those discussions are eternal — the interior and evolution of the Universe, the place of a human being in the Universe, the nature of space and time.

Zelmanov liked to remark that he preferred to make mathematical "instruments" than to use them in practice. Perhaps thereby his main goal in science was the mathematical apparatus of physical observable quantities in the General Theory of Relativity known as the *theory of chronometric invariants*. In developing the apparatus he also created other mathematical methods, namely — *kinemetric invariants* and *monad formalism* (he also referred to monad formalism, the general covariant extension of chronometric invariants, as *orthometric invariants*). Being very demanding of himself, Zelmanov published only a dozen scientific publications during his life, so every publication is a concentrate of his fundamental scientific ideas.

Most of his time was spent in scientific work, but he sometimes gave lectures on the General Theory of Relativity and relativistic cosmology as a science for the geometrical structure of the Universe. Stephen Hawking, a young scientist in the 1960's, attended Zelmanov's seminars on cosmology at the Sternberg Astronomical Institute in Moscow. Zelmanov presented him as a "promising young cosmologist". Hawking read a brief report at one of those seminars. Zelmanov's seminar was visited by also John Wheeler, Kip Thorne, Roger Penrose, and other well-known scientists.

Because Zelmanov made scientific creation the main goal of his life, writing articles was a waste of time to him. However he never regretted time spent on long discussions in friendly company, where he set forth his philosophical concepts on the geometrical structure of the Universe and the process of human evolution. In those discussions he formulated his famous *Anthropic Principle* and the *Infinite Relativity Principle*. He formulated the Anthropic Principle in 1941–1944, many years before the other scientists such as Robert Dicke (1957)* or Brandon Carter (1973)†

*Dicke R. H. Gravitation without a principle of equivalence. *Reviews of Modern Physics*, 1957, vol. 29, issue 3, 363–376.

†Carter B. Large number coincidences and the anthropic principle in cosmology. In: *Confrontation of Cosmological Theories with Observational Data*. Proceedings of the Symposium (Krakow, Poland, September 10–12, 1973), Dordrecht, D. Reidel Publishing Co., 1974, 291–298.

turned their attention to this problem. Zelmanov, being very demanding of himself, never published it in the scientific journals, meanwhile remaining his formulation of the Anthropic Principle wide known amongst the research stuff and students of the Sternberg Astronomical Institute.

Zelmanov's Anthropic Principle is stated here in his own words, in two versions. The first version sets forth the idea that the law of human evolution is dependent upon fundamental physical constants:

> "Humanity exists at the present time and we observe world constants completely because the constants bear their specific numerical values at this time. When the world constants bore other values humanity did not exist. When the constants change to other values humanity will disappear. That is, humanity can exist only with the specific scale of the numerical values of the cosmological constants. Humanity is only an episode in the life of the Universe. At the present time cosmological conditions are such that humanity develops."

In the second form he argues that any observer depends on the Universe he observes in the same way that the Universe depends on him:

> "The Universe has the interior we observe, because we observe the Universe in this way. It is impossible to divorce the Universe from the observer. The observable Universe depends on the observer and the observer depends on the Universe. If the contemporary physical conditions in the Universe change then the observer is changed. And vice versa, if the observer is changed then he will observe the world in another way, so the Universe he observes will also change. If no observers exist then the observable Universe as well does not exist."

It is probable that by proceeding from his Anthropic Principle, in the years 1941–1944, Zelmanov solved the well-known problem of physical observable quantities in the General Theory of Relativity.

It should be noted that many researchers were working on the theory of observable quantities in the 1940's. For example, Landau and Lifshitz, in their famous *The Classical Theory of Fields*, introduced observable time and the observable three-dimensional interval, similar to those introduced by Zelmanov. But they limited themselves only to this particular case and did not arrive at general mathematical methods to define physical observable quantities in pseudo-Riemannian spaces. It was only Carlo Cattaneo, an Italian mathematician of the Institute of Mathematics, Pisa University, who developed his own approach to the problem, not far removed from Zelmanov's solution. Cattaneo pub-

lished his results on the theme in 1958 and later. Zelmanov knew those articles, and he highly appreciated Cattaneo's works. Cattaneo also knew of Zelmanov's works, and even cited the theory of chronometric invariants in his last publication.

In 1944 Zelmanov completed his mathematical apparatus for calculating physical observable quantities in four-dimensional pseudo-Riemannian space, in strict solution of that problem. He called the apparatus the *theory of chronometric invariants*.

Solving Einstein's equations with this mathematical apparatus, Zelmanov obtained the total system of all cosmological models (scenarios of the Universe's evolution) which could be possible as derived from the equations. Having this system a base, he developed a classification of all possible models of cosmology which could be theoretically conceivable in the space-time of the General Theory of Relativity. Now, we refer to it as the *Zelmanov classification*. In particular, he had arrived at the possibility that infinitude may be relative. Later, in the 1950's, he enunciated the *Infinite Relativity Principle*:

> "In homogeneous isotropic cosmological models spatial infinity of the Universe depends on our choice of that reference frame from which we observe the Universe (the observer's reference frame). If the three-dimensional space of the Universe, being observed in one reference frame, is infinite, it may be finite in another reference frame. The same is just as well true for the time during which the Universe evolves."

In other words, using purely mathematical methods of the General Theory of Relativity, Zelmanov showed that any observer forms his world-picture from a comparison between his observational results and some standards he has in his laboratory — the standards of different objects and their physical properties. So the "world" we see as a result of our observations depends directly on that set of physical standards we have, so the "visible world" depends directly on our considerations about some objects and phenomena.

The mathematical apparatus of physical observable quantities and those results it gave in relativistic cosmology were the first results of Zelmanov's application of his Anthropic Principle to the General Theory of Relativity. To obtain the results with general covariant methods (standard in General Relativity), where observation results do not depend on the observer's reference properties, would be impossible.

The fact is that Zelmanov published his scientific ideas in only a dozen of very compressed scientific articles with formulae, without es-

sential comments. As a result for more than 60 years Zelmanov's work and the achievements remained known only a close circle of several of his pupils. His book *Chronometric Invariants*, containing his main fundamental studies on the General Theory of Relativity and relativistic cosmology, was written in 1944 and had survived only in manuscript until it has been published in 2006. It is impossible to find a more detailed and systematic description of the theory of chronometric invariants, than there. Even the book *Elements of the General Theory of Relativity*, which Vsevolod Agakov had composed from Zelmanov's lectures and articles, gives a very fragmented account of the mathematical methods that prevents a reader from learning it on his own. The same can be said about Zelmanov's original papers, each no more than a few pages in length. Anyway *Chronometric Invariants* is the best for depth of detail. Sometimes Zelmanov himself said that to use the mathematical methods of chronometric invariants in its full power would be possible only after studying his book of 1944.

Now everyone may read it. I hope that Zelmanov's classical works, in particular the chronometric invariants, the Zelmanov classification, his Anthropic Principle and the Infinite Relativity Principle, will become more widely known and appreciated. May his memory live for ever!

Dmitri Rabounski

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