
Ya B Zeldovich – Personal Reminiscences of a Pupil

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My first meeting with Zeldovich took place in 1978 when I requested him to be my guide for my pre-MSc course work at Moscow State University. To my great delight Zeldovich agreed, and to test my skills gave me a project in general relativity, a subject which I had only just started to learn. I soon realized that Zeldovich was an excellent teacher and could explain in very simple language exceedingly complex physical ideas. This was a great boon to students: despite his extremely busy scientific schedule, Zeldovich always found time to teach courses at Moscow University. So it was that I was initiated into the intricate and beautiful field of cosmology via a 22-lecture course taught by Zeldovich – each lecture being of roughly 2-hour duration with a ten minute break in between. Particularly impressionable for us youngsters was the fact that while teaching a mathematically rigorous course, Zeldovich always took great pains to explain even the most difficult ideas using simple physical arguments and intuition. Zeldovich did this even at regular seminars. If one of the talks excited him, Zeldovich would bound up to the podium when it ended and provide an impromptu summary. His great breadth of interests allowed Zeldovich to summarize talks on virtually any subject and I have seen him apply this skill to topics ranging from stellar physics to particle physics and quantum gravity. I should add that these short summaries were invaluable to us students, since they were frequently more lucid and transparent than the original seminar!

Zeldovich continuously modified and expanded his course material taking care to ensure that significantly new developments in the field were covered. Indeed, on attending the very same cosmology course 4 years later, I was pleasantly surprised at finding that almost a quarter of its content was new. Participants at his lectures consisted not only of students, but even professors, several of whom stayed back after class to discuss new science ideas with Zeldovich. A remarkable quality of Zeldovich was his willingness to acknowledge, often in public, the mistakes he had made, and what could be learned from them. Thus he admitted in class how he had misunderstood the data regarding the cosmic microwave background in the early 1960's and, to his great regret, had initially advocated the cold big bang model instead of the hot one (the latter had been predicted by another great Russian cosmologist George Gamow in the 1940's.)

Zeldovich strove to explain complicated ideas simply through numerous entertaining articles and textbooks [1, 2] including his excellent monograph 'Higher Mathematics for Beginners'



which presented serious mathematical ideas in a form which was accessible to a high school student [3]. He once wrote “the so-called ‘strict’ proofs and definitions are far more complicated than the intuitive approach to derivatives and integrals. As a result, the mathematical ideas necessary for an understanding of physics reach school-pupils too late. It is like serving the salt and pepper not for lunch, but later – for afternoon tea”. In this Zeldovich was following an old physics tradition epitomized by Landau in Russia and Feynman in the west, of bringing the excitement of science closer to students and ‘ordinary’ people.

Zeldovich’s manner of conducting exams was also quite unusual! When, towards the end of his cosmology course the time came for exams, I realised that there was no formal time table for a written test, as was usually the case¹. Instead Zeldovich asked me to meet him outside his office a few days later. When I did, Zeldovich scribbled two problems and asked me to solve them, after which he walked away. Although I had gone through his course material diligently I could not, even after trying hard, figure out how either of these problems could be solved, and so feeling quite dejected I walked back to my hostel a few miles away. This was summer 1979. By winter, with the heavy snows of Moscow having set in, I managed to crack one of the problems and, feeling rather elated, went back to Zeldovich. Zeldovich subjected me to a strenuous viva-voce after which he declared that I had passed with an ‘A’ and, even more significantly, that my solution to his problem was new and original and could be published as a paper. Zeldovich thought highly of the prospects of Indian science and encouraged me to publish my results in an Indian journal. Thus my first paper was published in *Pramana* in 1980, considerably before I completed my MSc.

Although most people found Zeldovich to be very inspiring, some of his colleagues found his intellectual brilliance rather intimidating. Indeed Zeldovich did not ‘suffer fools lightly’ and I have seen him demolish in less than a few minutes many a senior scientist propounding a silly idea. (At the same time Zeldovich was much more tolerant of students. I occasionally blundered in his presence only to see him smile and explain, with much patience and goodwill, just where I had gone wrong.) Zeldovich set very high standards both for himself and the group of students and collaborators who made up his school or *gharana*. As a result, he taught and nurtured a whole generation of talented Russian scientists many of whom developed, in the course of his tutelage, diametrically complementary styles ranging from the highly intuitive to the rigorously mathematical. According to Andrei Sakharov, “Zeldovich’s effect on his pupils was remarkable; he often discovered in them a capacity for scientific creativity which without him would

¹ Although Zeldovich’s class had been full, only one other student apart from me decided to take the cosmology exam. The reason, as I came to know later, was Zeldovich’s rather high standard which saw most students failing routinely, the first time around.



not have been realized or could have been realized only in part and with great difficulty.” In this he was following the tradition of the other great Russian *ustaad*, Landau, who like Zeldovich, fostered and left behind a great scientific legacy in the form of a *gharana of physics* which was almost unique in scientific method and style. An informative and entertaining account of Zeldovich with numerous anecdotal stories is provided by his colleagues and pupils in the book *Reminiscences* [4].

Zeldovich was not only an inspiring teacher, he was also a very refined human being. I experienced Zeldovich’s empathy on several occasions. Some years after commencing work on my PhD I was shocked to hear that Zeldovich’s wife had suddenly died of a serious illness. Together with some friends I went to pay my respects and offer condolences. Even before I could utter a word, Zeldovich turned to me and offered his own profuse condolences on the assassination of Indira Gandhi who had lost her life to extremists the very same day that Zeldovich’s wife lost hers to illness. In his eyes I could see how deeply he felt, and I was profoundly moved that he could place the historical anguish of a nation on the same footing as his own very deep and personal loss.

Although very fond of travel, Zeldovich faced numerous travel restrictions due to his early involvement with the Soviet defence program. In 1982, perhaps because of my political innocence and youthful enthusiasm, I was very keen that Zeldovich visit India, and before embarking home for summer holidays I asked him what I could do to ensure his visit. Looking at me wistfully Zeldovich remarked, “they (the soviet authorities) will reply to your government’s invitation saying Zeldovich is ill and unable to travel – don’t believe them! Look at me (Zeldovich flexed his muscles) I am perfectly fit and can travel tomorrow!”. Indeed Zeldovich’s visit to India never did materialise but the following year I was to bear witness to the very bizarre policies of the Soviet government with regard to foreign travel by its eminent scientists. Zeldovich and Starobinsky had both been invited to travel to a famous meeting on general relativity (GR10) scheduled in Padova, Italy. Indeed, Zeldovich had been invited to organise a special session on the Early Universe² while Starobinsky had consented to give a plenary talk on Inflation, which was then a very hot topic. I too was planning to go since my paper (written jointly with Starobinsky and another of his pupils Lev Kofman) had been accepted for presentation. I was very excited by the prospect of travelling to Italy from Moscow (3 days journey by train which passed through several countries) and the day before leaving I met Starobinsky who took me to Zeldovich with the remark “Yakov Borisovich here is Varun, the

² The Early Universe had emerged as an important new field in the 1980’s whose promising directions included: Inflation, cosmological consequences of grand unified theories including baryogenesis and leptogenesis, particle physics candidates for dark matter, quantum-cosmology and the wave-function of the universe, etc.



only member of our delegation who is sure of travelling to Italy"! I was taken aback to learn that, with only four days remaining for the meeting, neither Zeldovich nor Starobinsky had yet received official sanction for their visit.

I was broken hearted when, on reaching Padova 4 days later, I learned that neither of my gurus had been allowed to travel, and that the organisers were in a quandary as to how to salvage the early universe session. What was even more disheartening was the fact that while neither Zeldovich nor Starobinsky had been allowed to make the journey to Italy (and showcase Soviet science), the official Soviet delegation was nevertheless replete with scientists, of rather mediocre quality but with deep party connections, who despite their ideological leanings were not ashamed to thoroughly enjoy 'capitalist hospitality'.

Zeldovich was finally allowed to travel outside of the Soviet block in 1982 when, at the age of 68, he delivered an invited lecture 'Remarks on the Structure of the Universe' to the International Astronomical Union in Patras, Greece. When asked by Jerry Ostriker, an eminent American astrophysicist, when he was last out of the Soviet Union, Zeldovich unhesitatingly answered "sixty eight years ago", i.e., in a previous life!

Viewed in retrospect, and with the demise of the Soviet Union, it appears quite incomprehensible as to why so many of its leading scientists could not travel abroad and enjoy an invigorating science discussion with their contemporaries both in the east and the west. In Zeldovich's case this was all the more surprising since his work had gained widespread international recognition and Zeldovich was a foreign member both of the Royal Society of London and of the US National Academy of Sciences. Nevertheless, if the mountain cannot come to Muhammed then Muhammed must go to the mountain, and so the best minds from Europe and the US travelled to the Soviet Union to meet with Zeldovich and interact with the other eminent scientists belonging to the 'Moscow school'. So it was that I got the opportunity of listening to inspiring lectures by Stephen Hawking and Subrahmanyan Chandrasekhar at special seminars organised by Zeldovich at Moscow's Sternberg Astronomical Institute.

I should add that, despite his remarkable talents, Zeldovich never pushed ideas simply because they were his own. I was a witness to this when, on one occasion, after a seminar had formally ended, Zeldovich called us back into the auditorium saying there was a 'small idea' which he wanted to discuss. The idea turned out to be that of cosmic strings which, Zeldovich showed, could seed galaxy formation in the universe. This was in 1980 and Zeldovich had just published a paper in the *Monthly Notices of the Royal Astronomical Society* describing his scenario. However, this was also the period when the inflationary scenario was propounded. Zeldovich was fascinated by inflation, and even though he was not its discoverer, he championed this



model enthusiastically [2]. When, during 1981–1982, it became clear that the rapidly expanding inflationary universe could quantum-mechanically generate the perturbations required to seed galaxies, Zeldovich saw the logical beauty of this approach and abandoned, in the process, his own string-based galaxy formation scenario. Perhaps because of this, topological defects never did gain popularity in the Soviet Union, while interest in them thrived for more than two decades in the west (partly due to the influence of the talented Ukrainian emigré Alex Vilenkin).

Although Zeldovich did work hard, he was hardly a nerd and thoroughly enjoyed both entertainment and sport (he had boxed in his youth, written and directed a play, and loved to swim and ski). He was also very well versed in literature and frequently quoted from writers and poets while lecturing on physics³. His sense of humour was also legendary and he used it abundantly in class, which made his lectures far from boring!

I hope I have been able, within the short span of this article, to communicate to readers of *Resonance* what a remarkable man Yakov Borisovich Zeldovich really was. His deep dedication to science combined with great originality and a contagious enthusiasm made him one of the most influential theoretical physicists of the last century. I would like to end by quoting from Andrei Sakharov who was a long time colleague and friend of Zeldovich [5]: “Now, when Yakov Borisovich Zeldovich has departed from us, we, his friends and colleagues in science, understand how much he himself did, and how much he gave to those who had the chance to share his life and work”.

³ Perhaps Zeldovich had imbibed his love of prose and poetry from his mother, who had been a translator of literature from French into Russian. In this I felt a certain affinity with Zeldovich since my father too had been a litterateur and, during the 1960's, had translated several Russian classics into Hindi including works by Tolstoy.

Suggested Reading

- [1] Ya B Zeldovich and I D Novikov, *Relativistic Astrophysics, Vol.1: Stars and Relativity*. Mineola, Dover Publications, New York, 1996; *Relativistic Astrophysics, Vol.2: The Structure and Evolution of the Universe*, University of Chicago Press, Chicago, IL, 1971.
- [2] Ya B Zeldovich, *My Universe, Selected Reviews*, Harwood Academic, 1992.
- [3] Ya B Zeldovich, *Higher Mathematics for Beginners*, Nauka Publishing House, Moscow, 1970;
Ya B Zeldovich and A D Myskis, *Elements of Applied Mathematics*, Mir Publishers, Moscow, 1976;
Ya B Zeldovich and I M Yaglom, *Higher Mathematics for Beginning Physicists and Engineers*, Prentice Hall, 1988.
- [4] Zeldovich: *Reminiscences*, R A Sunyaev [Edited] Chapman & Hall, CRC 2004.
- [5] A Sakharov, A man of universal interests, *Nature*, London, Vol.331, 671, 1988.

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