Igor Stanislavovich Astapovich (1908–1976), Investigator of Meteoric Phenomena

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On the occasion of the 90th anniversary of his birth, a survey of the life and scientific work of Professor I.S. Astapovich is presented.

In one of his *Historical Miniatures*, Eberhard Hilscher says about the founder of the atomic theory, Ernest Rutherford, that his inspiration and perseverance determined his work. Of course, the investigation of meteoric phenomena, which was pursued by my scientific mentor, Igor Stanislavovich Astapovich, had far less significance than the work of the founders of contemporary physics, but, beyond any doubt, his work was also characterized by inspiration and perseverance.

Having dedicated myself to documenting reminiscences of I.S. Astapovich, I came to understand the full complexity of the task I had set myself.

A rather short biography of I.S. Astapovich was published in the journal *Earth and Universe* (1978, no. 2) on the occasion of the 70th anniversary of his birth. This paper was written by V.V. Fedynskii, corresponding member of the Academy of Sciences of the USSR. However, this article cannot, not even to a small degree, represent all aspects of Astapovich's many-sided character, vitality, and liveliness. Currently, there are almost no more people alive who spent their youth with Astapovich. As a consequence, many recollections of these days have been lost for ever. Nevertheless, there is a way to proceed into the past, even into times before I was born, to work again with my teacher and oldest friend. He was a scientist, a meteor researcher. This says all about his life—everything about him must necessarily be contained in scientific publications.

I.S. Astapovich was born on January 11, 1908, into the family of a lecturer in a Teacher Seminary in the town of Volchansk, in the Kharkov Region. That year was to become of great importance to meteor astronomy, as, on June 30, a unique event—known as the Tunguska phenomenon—occurred, which Astapovich would later study.

Astapovich's father, Stanislav Viktorovich (1864–1931), taught physics and mathematics. His mother, Elizaveta Pavlovna (1864–1943), had a diploma of house teacher. His maternal grandfather, P.I. Gorskii-Platonov, was an extraordinary professor of the Moscow Spiritual Academy. He was a specialist of archaeology and ancient languages. The mother's cousin was the well-known arctic explorer V.A. Rusanov. As to the lineage of Astapovich's father, they were of Polish birth, being related to the Counts of Tyshkevich.

The family's library, where the future scientist grew up, included books of C. Flammarion, F. Arago, F.A. Bredikhin, and K.D. Pokrovskii. Even in his later works, Astapovich referred to these books, even when Pokrovskii was designated as a "traitor of his country." Pokrovskii was rehabilitated only in July 1993 on the present author's initiative.

During 1924–1926, Astapovich studied at the school of the city of Nikolaev, with passes in joinery and mechanical workshop practice before he rose to a rank of engineer. This was before he was carried away by astronomy. A dominating role in this was played by the *Russian Amateur Society for Nature* (*RASN*).

In the year that Astapovich was born, another event took place in Russia, which subsequently affected the fate of the future enthusiast of sciences. In that year, S.V. Muratov, M.Y. Moshonkin, I.O. Seletskii, and A.A. Kondiain initiated the idea of the establishment of the *Russian Amateur Society for Nature*. A group of more than 20 young people from the *Russian Astronomical Society* joined them. They had worked at the *Russian Urania* Observatory on the Mars Field in St. Petersburg. They organized the *Bureau of Astronomical Observations*.

Figure 1 – Igor Stanislavovich Astapovich with his wife, Alexandra Konstantinovna Terentjeva.

In the journal *Studies of the World* (in Russian, *Mirovedenie*), the Society published an excellent research program, including meteor observations. More than 50 observers contributed to the work of the meteor department. Among them were D.O. Svyatskii, E.J. Öpik, and A.V. Solovjev. Later V.A. Maltsev, who came from Odessa, became the secretary of the astronomical divisions of the *RASN*. V.V. Fedynskii came from Mirgorod and was at the head of a group of observers of the *Moscow Society of Amateur Astronomers* since 1926. Both these scientists became friends and co-authors of Astapovich.

The first publications of meteor observations by I.S. Astapovich date back to 1923. Since 1925, he conducted systematic observations. A series of observations of the Nikolaev period comprises data on 1594 meteors. On August 20, 1925, I.S. Astapovich and S.S. Trikotskii observed a fireball of magnitude −12 and recorded the drift of the train over 18 minutes. Acoustical and electric sound phenomena were noted as well. Later on, these phenomena were widely studied by many investigators of meteoric phenomena. The basic observations of this fireball allowed the calculation of several of its characteristics. After having determined the trajectory and geocentric orbit, its velocity was found to be 74 km/s—at that time, the observer was only a 17-year old graduate pupil...

In 1926, Astapovich entered the Faculty of Physics and Mathematics of Moscow University. In 1928, he played an active role at the 11th Congress of the *RASN*, which was held in Nizhnii Novgorod. This congress was less uplifting than the 1st Congress in Moscow in 1921. Soviet power had placed such informal organizations under strict control, and circles and societies of local historians and even amateur astronomers were dissolved. Already in 1923, the *RASN* was obliged to present lists of its members. In 1930, the society was banned. (The Odessa branch of the *RASN* continued to existed until the beginning of the war).

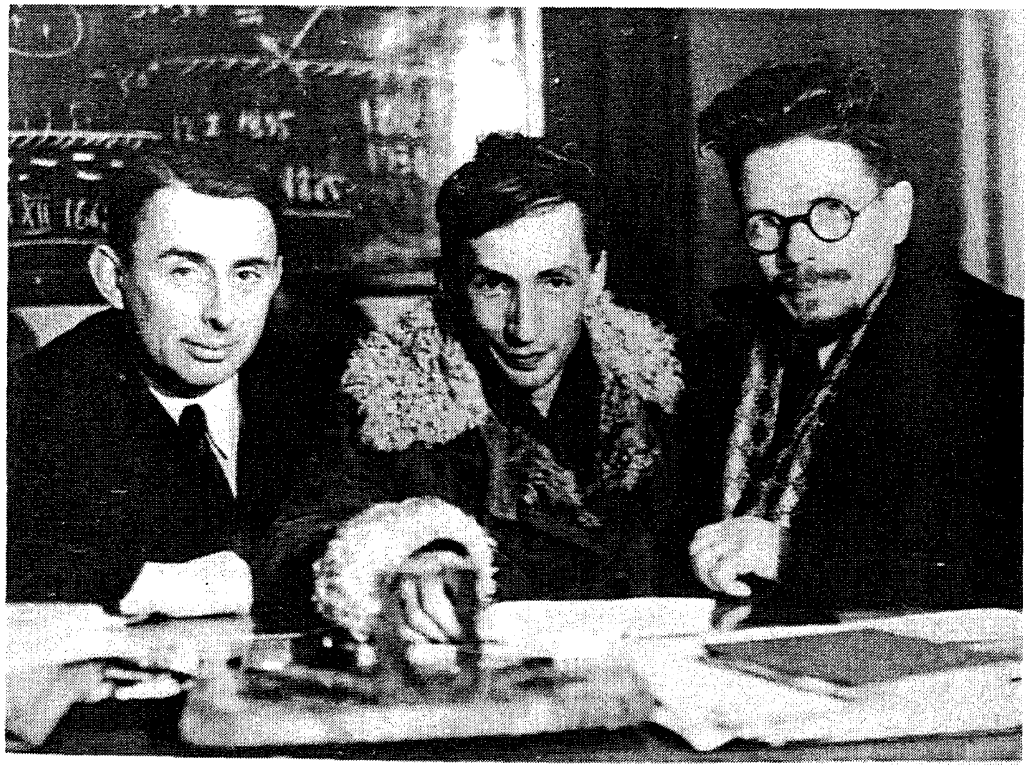

Figure 2 – In 1949, in P.K. Sternberg State Astronomical Institute (from left to right): V.V. Fedynskii, A.M. Bakharev, and I.S. Astapovich.

Many leading researchers were sent to places "not so remote": D.O. Svyatskii, for instance, was in exile in Alma-Ata, subsequently he was transferred to Aktiubinsk, where he soon died.

The well known investigator of meteorites, E.L. Krinov, was saved from arrest by participating in a prolonged expedition to the impact site of the Tunguska object.

Following his family's move to Leningrad, Astapovich went to the Leningrad University in 1928. Here, he became an active participant of the astronomical division of the *RASN*. He issued the brochure *The Task of the Amateurs in Meteor Astronomy*.

Upon request of D.O. Svyatskii, Astapovich determined the orbit of the Belozersk meteorite of 1662. He also presented the report at the General Assembly of the *RASN* on October 23, 1929. Since 1928, he worked at the Institute of Applied Geophysics, at the same time being a collaborator of the Mineralogical Museum of the USSR Academy of Sciences in Leningrad.

Astapovich completed his studies at the university in 1930, when he received a degree in astronomy. In 1930 and 1931, he became a PhD student at the Pulkovo Observatory.

Until 1932, he took part in expeditions to Eastern Siberia, organized by the Central Research Geological Prospecting Institute. He discovered a deposit of magnetite, opened new prospecting areas, and organized the Cabinet of Geophysics of the East-Siberian Geological Prospecting Management in Irkutsk.

Astronomy was not forgotten during these diverse occupations, however. Astapovich paid great attention to the study of archives of the geophysical observations of the Tunguska phenomenon. He was one of the first to assume a cometary origin for the event.

Figure 3 – I.S. Astapovich in the Caucasus, in the Kislovodsk district, during an expedition for the Leonids in 1965.

In 1933, Astapovich was appointed Director of the newly built Stalinabad Astronomical Observatory. It was created especially for the investigation of meteoric phenomena and afterwards turned into the Institute of Astrophysics of the Tadjik Academy of Science.

In Stalinabad, Astapovich continued observations of telescopic meteors, which he began in Leningrad, and of meteor trains, which he began in Nikolaev. Here, Astapovich also started spectroscopic observations of meteors which were successfully developed later (cf. *Earth and Universe*, 1986, no. 6).

In 1933, Astapovich became seriously ill with malaria and left his position for treatment. The next year, he became a senior researcher of the State Astronomical Institute of Moscow University. In 1935, the degree of candidate of physics-mathematical sciences has been conferred upon him without the defense of the dissertation. He was elected member of Commission 22 (Meteors and Interplanetary Dust) of the International Astronomical Union. Together with V.V. Fedynskii, he organized the Commission on Comets and Meteors of the Astronomical Council of the USSR Academy of Sciences. Astapovich became its head and prepared the first All-Union Conference on investigations of comets and meteors in 1935, 1937 and 1939.

In 1937, Astapovich became an associate professor at the Department of Cometary Astronomy of the Moscow University. He was the first to establish a separate course on meteor astronomy. In 1937, he gave such a course at the Faculty of Mathematics and Mechanics of the Moscow University, and, later, at the universities of Saratov, Ashkhabad, Odessa, and Kiev.

In the 30's, I.S. Astapovich began to develop his conception of the meteor phenomenon, which he described in the book *Meteor Phenomena in the Earth's Atmosphere*, published in 1958. This book, often called the "Meteor Almagest," remains one of the most frequently cited works in this field of science. In the book, aside from miscellaneous factual material, he presented ways to further develop meteor investigations. In particular, the theory of radiation, physiological possibilities of visual observations, various methods of meteors observation, celestial mechanics and astrophysical problems, and peculiarities of meteoric phenomena are mentioned and discussed.

Up to the present day, specialized scientists involved in meteor investigations make models of meteor phenomena based on the achievements of various branches of physics, for example, gas dynamics, results of which can be extrapolated for the phenomenon as a whole.

Astapovich's view on the meteor phenomenon, which he expressed in the 1930s, consists of the following. On the highest part of a meteor trajectory, several hundreds of kilometers above the surface, meteoroids collide with individual atmospheric atoms. An energy exchange takes place according to the laws of quantum mechanics. Further along the trajectory, the interaction with the air constituents increases, but the laws of aerodynamics are not applicable yet. The shape of the meteoroid can still change. Only when the free path length of molecules becomes comparable to the size of the body, an aerial pillow develops, causing aerodynamic heating, and the equations of gas dynamics become valid. At the lower part of the trajectory, the mass of the remaining meteoroid no longer changes. Processes like radiation, evaporation, and destruction of the meteoroid stop.

Some statements in his book *Meteor Phenomena in the Earth's Atmosphere* anticipate further investigations. As an example, I give only two of such statements.

> *"Given that in meteors hundreds of lines radiate simultaneously, the excitement of higher energy levels of atoms generally causes the maximum of the emission to shift to shorter wavelengths, giving rise to a Wien-like law. Therefore, meteors become whiter with increasing velocities and brightness. ." [p. 317]*
>
> *"The passing of the shock wave causes thermal ionization of the air, and the subsequent recombination of ions causes the luminescence of the ions, i.e. an after-glow of the air." [p. 336]*

Both statements were further developed in my book, *Spectra of Transient Atmospheric Light Phenomena: Meteors*, published in 1994.

Astapovich also described rare phenomena of meteor astronomy to let future investigators know about them. In *Meteor Phenomena in the Earth's Atmosphere*, for example, he described how "foggy slow meteors" [p. 569] confirm the theory of interaction of small comets with the Earth's atmosphere advanced by V.N. Lebedinets.

At the beginning of the Second World War, Astapovich joined the People's Guards and became a soldier in the Artillery Regiment of the 8th Krasnopresnensk Division of the 32nd Army. After demobilization in 1941, the Rector of the Moscow University, upon evacuating the university, directed him to Ashkhabad.

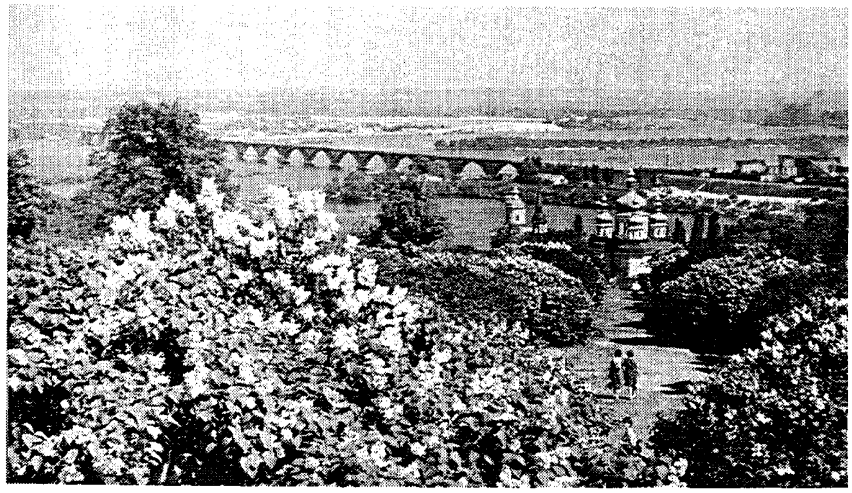

Figure 4 – I.S. Astapovich spent the last years of his life in Kiev. Shown are the botanical gardens on the slopes of the River Dnieper, where about 400 varieties of lilacs bloom.

In 1942, activity resumed at Moscow University, but Astapovich stayed in Turkmenistan, having accepted an invitation to work at the Ashkhabad Pedagogical Institute. From 1944, he worked in the Turkmen Affiliate of the USSR Academy of Sciences, where he organized the Astrophysical Laboratory in 1946.

In the period 1957–1958, the Astrophysical Observatory near Ashkhabad (more precisely, in the health resort Firiuza) was built under the guidance of Astapovich. All that time, he intensively made meteor observations. In 1124 observing hours during the period 1942–1945, he recorded 16 930 meteors. The complete archive of his observations contains data on more than 40 000 meteors. A major achievement. During the observations, Astapovich recorded a great number of details and peculiarities of each meteor.

I remember from a conversation with Krinov's wife that she wondered about the encyclopedic memory of Astapovich: "He knows, for example, the number of steps of the buildings of the Academy of Sciences in Moscow." Such a training of memory seemed unjustified to me, but, when I learned that Astapovich noted numerous details (contours, angular velocity, color, presence of wake, coordinates of the trajectory, etc.) of each meteor, it became obvious that, without an appropriate training, such detail would be impossible.

Already at the beginning of the last century, there were notes in the literature about an extremely faint elliptic luminescence in the anti-solar direction. Since July 1, 1942, Astapovich, concurrently with other investigations, began systematic observations of the *Gegenschein* (*Nature*, 1950, no. 1). This work was favored by the excellent observing conditions in the Turkmen wilderness. Astapovich selected comparison stars at the same height as the *Gegenschein*. The brightness of the luminescence was carefully noted. From his observations, he found that the intensity of the *Gegenschein* varied by 20–30%.

Simultaneous observations by I.S. Astapovich's sister, V.S. Astapovich, on the Karelian front made it obvious that an increase of the *Gegenschein* coincided with the appearance of powerful aurora. In total, 214 observations were obtained. Astapovich noticed the variability of the dimensions and shape of the *Gegenschein*. The position of the center of the brightest part was recorded with an accuracy of one degree. By making observations before and after midnight, it was possible to determine the parallax of the *Gegenschein*. At a base-line of 6400 km, the horizontal parallax of 3° corresponded to a distance from the Earth of 125 000 km. All information hinted to a gaseous model of the observed phenomenon. The width of the *Gegenschein* along the ecliptic was determined to be about 32 000 km, and its thickness to be about 14 000 *km*.

In the period of his work at the Ashkhabad Astrophysical Observatory, Igor Stanislavovich Astapovich did a lot for the development of young Turkmen science. Many Turkmen scientists were his pupils. He also befriended visitor scientists. A.P. Savrukhin, K.D. Gulmedov, and E.N. Kramer from Odessa were among his pupils. The student of the Gorkii University, Alexandra Konstantinovna Terentjeva, came to Ashkhabad during 1954–1955 to observe meteors. She eventually became his wife and friend, and with regard to his work, a co-author of many of his articles.

Astapovich took on an impressive number of public duties during all periods of his life. In 1945, he was elected Honorary Member of the Omsk branch of the *WAGO* (*All-Union Astronomy and Geophysics Society*). He occupied the post of Vice-President of the *Turkmen Geographical Society*. Astapovich was also as member of the board of the *Society of the Turkmen SSR on the Spread of Knowledge*, giving more than 1000 public lectures.

The catastrophic earthquake of 1948 which destroyed Ashkhabad deserves special mention in this overview. As Alexandra Terentjeva recalls, Igor Astapovich determined the periodicity of the occurrence of catastrophic earthquakes in the Ashkhabad district by using historical data and the destructions of the ancient constructions of the city, and predicted that "an earthquake will happen soon."

Figure 5 – Students and followers of I.S. Astapovich in Ashkhabad, in 1955. From left to right, we see I. Genkin, K. Lyubarskij, A. Suslov, A. Terentjeva, and Kh. Gulmedov.

He sent an article to this effect to an Ashkhabad journal, but the editor replied that he could not possibly accept it for publication, because he did not want to cause a panic. Astapovich did not insist, but simply replied with the following: "As a scientist, I am obliged to give an account of my conclusions, but you, as an editor, do what you believe is necessary." During the earthquake, the editor perished, but the article was extracted from the ruins, and it was found that the passages in it about the earthquake forecast were crossed out by red pencil.

During the period 1959–1961, I.S. Astapovich worked in Odessa, at the invitation of Professor V.P. Tsesevich. He continued observations of telescopic meteors and gave courses and lectures. His lectures were distinguished by their depth and the extensive description of material. Public lectures were accompanied by numerous illustrations.

As one of his former students, M. Chudnovskii, recalled, I.S. Astapovich gave intriguing tasks, for instance, to verify the accuracy of the description by Alexander Pushkin of the white nights of St. Petersburg:

> *"And not letting the darkness of night*
> *take over the golden skies,*
> *a new dawn is rushing to replace dusk,*
> *having given the night only half an hour."*

After a calculation, it was found that, at the latitude of St. Petersburg at this time of year, a night indeed lasts for half an hour.

In Odessa, I became a PhD student in meteor astronomy, with Igor Astapovich as adviser. My scientific mentor paid much attention to me, but, in 1961, he moved to Kiev, and communication was interrupted. Thereafter, I went to Kiev for consultation and advice. From his letters to me, it is clear that Igor Astapovich showed true paternal attention towards me. This was of particular value to me, because my father had died in 1938, when I was only two years old, and I grew up with and was educated by my grandmother, T.R. Zagradskaja, since I was five years old.

Igor Astapovich always tried to give me confidence to overcome all difficulties of life. To make my point, I shall give one citation from his letter to me dated May 8, 1965:

> *"We both are not the greatest among physicists, but people like us are necessary, too, otherwise the greatest would not know what to do! Indeed, according to Academician Krylov, a fleet cannot only exist of battleships, but must also contain slow coal boats which carry fuel for the battleships and without which these were useless! The old man understood that they are all necessary, the connecting links of a structure, of which there are hundreds, from battleships to cutters. It is the same in science and, therefore, I can by no means approve of your pessimistic conclusion: 'Is your work necessary at all?'— of course, it is! It is known that, for example, Carl Shapley achieved great success in astronomy, although never in his life he wrote a single integral. So, what does matter? The answer: dedication, with which you are already endowed! Thus you have a pledge for success, a pledge for that sooner or later you will achieve what you desire. Your aim is explicit: the spectrophotometry of meteors, a difficult task ..."*

In 1963, Astapovich successfully defended his doctoral dissertation. His monograph *Meteor Phenomena in the Earth's Atmosphere* was the basis for his dissertation. As Terentjeva recalls, one speaker during the defense, a specialist of rocket technique, said that, without this monograph, launching of artificial satellites would be impossible. Probably, this is a polemic exaggeration, but, at that time, the work of Astapovich were really a novel scientific approach to the calculation of the influence of atmosphere on the behavior of artificial objects traveling at great heights.

Together with A.K. Terentjeva and the collaborators of the Institute of Theoretical Astronomy of the Academy of Sciences of the USSR in Leningrad, E.I. Kazimirchak-Polonskaja and N.A. Belyaev, I.S. Astapovich successfully solved the celestial mechanical problem of the motion of the Leonid meteoroid stream. Based on the secular motion in longitude of the ascending node of the Leonids, they predicted the time of the maximum of the meteor shower in 1966 with an accuracy of two hours. And with fantastic accuracy (to half an hour), they did a numerical integration of the equations of motion, including planetary perturbations. The authors also gave a forecast of passages through the stream up to 2000.

The last period of the the scientist's life was set in Kiev. Here, he worked as a professor at the Kiev University, continuing his active scientific work.

During meetings in the flat of I.S. Astapovich, one might have seen around the table V.V. Fedynskii and E.L. Krinov from Moscow, A.M. Bakhareva from Dushanbe, V.N. Lebedinets from Obninsk, N.B. Divari from Odessa, A.P. Savrukhin from Ashkhabad, and many another scientists. As I have mentioned above, Astapovich was connected to Fedynskii from youth by true friendship that lasted his entire life time. According to Fedynskii's words, "this friendship was darkened by nothing."

Since January 2, 1976, Igor Stanislavovich Astapovich is no more. The phenomena of meteor astronomy which were described by him keep modern researchers busy. Well-known scientists from different states appreciated Astapovich's work. In this way, his ideas remain alive.

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