10. From Comet to Plasmoid to Mirror Matter

The most general question about the nature of the Tunguska event may be stated very simply – what was it? Unfortunately, there is no simple answer. First of all, one can ask: Was it a cosmic phenomenon indeed? Since no one saw the Tunguska space body (TSB) outside the atmosphere, the very term "Tunguska meteorite" is just a metaphor. So we have the hypothesis that the TSB was enormous ball lightning – formally not an absurd idea, but after a closer inspection erroneous. Ball lightning remains a scientific mystery, and to explain the Tunguska enigma by another enigmatic phenomenon is not to explain it at all. Besides, no one has ever recorded any manifestations of ball lightning that would even remotely have resembled the Tunguska event. So this hypothesis is not realistic. Still farther from reality are such terrestrial models of the Tunguska event as the explosion of marsh gas, the eruption of a volcano, a somewhat unusual earthquake, and so forth. The only contribution these models make is a negative one. Their advocates have meticulously and persistently picked holes in other theories, which was definitely of some use for the development of normal reasonable models of the Tunguska catastrophe.

But how many hypotheses have been offered to explain this event? To determine their exact number would hardly be possible, since even serious scientists, who could be brilliant specialists in their own fields of investigation, occasionally attempted to solve the "so-called Tunguska enigma" after reading a couple of newspaper articles on the subject – and putting forward their own solutions in the same newspapers. Probably, the whole number of Tunguska hypotheses reaches a hundred, or so. But only about a quarter of them may be called scientific hypotheses in the strict sense of this word – that is, built according to the standards of science and with due consideration of empirical data. Not so few, after all, especially as these 20–25 hypotheses, being, as a rule, mutually inconsistent, have had to explain the same set of empirical data.

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Also, the phrase "hypothesis to explain the Tunguska phenomenon" is somewhat vague. Researchers may agree between themselves about the nature of the TSB but disagree about the mechanism of its explosion. For example, a comet core could have entered Earth's atmosphere at a great speed and destroyed the taiga in the Great Hollow by its ballistic shock wave, but the core could also have exploded in the final stage of its flight due to thermal or chemical processes inside it. In this case the forest destruction would have been the result of joint action of both the ballistic and blast waves. So, even the hypothesis of the cometary nature of the TSB is in fact an array of several hypotheses. Nevertheless, if we pay attention only to the body's nature, temporarily setting aside the question of the mechanism of its explosion, the whole set of Tunguska hypotheses that have been put forward by now may be divided into the following three groups:

1. The TSB was one of the minor space bodies existing in the Solar System and known to astronomers (a meteorite or the core of a comet).
2. It was a *hypothetical* minor space body still not observed by astronomers, but probably existing in the Solar System or sometimes arriving here from interstellar space (a dense cloud of cosmic dust; a lump of "space snow" of extremely low density; a microscopic black hole; a "solar plasmoid"; an asteroid consisting of "mirror matter").
3. The TSB was an alien spacecraft.

And if we consider hypotheses about the mechanism of the TSB's explosion (or rather, about the cause of the forest destruction – since some of the proposed mechanisms cannot be called "explosions" in the proper sense of this word), they can be grouped as follows:

(1) The impact of a huge crater-forming meteorite. (This hypothesis has been convincingly refuted, but it did exist and was for a long time considered by meteor specialists as the only correct one.)
(2) The ballistic shock wave of a swiftly moving cosmic body that sharply decelerated in the air over the Southern swamp and collapsed into or ricocheted from the dense layers of the atmosphere.

(3) A thermal explosion.
(4) An explosion produced by the inner energy of the TSB (chemical or nuclear).
(5) A powerful electric discharge between the TSB and Earth's surface.

The majority of Tunguska researchers usually divide the question "What was it?" into two subquestions: "What kind of body was it?" and "How did it level so many trees in the taiga?" Traditionally, it is the area of the leveled forest that is considered the most important trace of the Tunguska phenomenon, whereas other traces (even "large" ones, such as the light burn of the vegetation and the local geomagnetic storm) are ranked as "auxiliary" traces. This is generally understandable: the area of the leveled forest was the first discovered trace of the event. It was found by Leonid Kulik in the 1920s and remained relatively unchanged until the epoch of the Independent Tunguska Exploratory Group (ITEG). At the same time, manifestations of the light burn of the vegetation that also impressed Kulik had disappeared almost completely by the late 1950s. As for the local geomagnetic storm, it was discovered somewhat "too late" to be considered as a trace of prime importance. So the great necessity of explaining the leveled forest and the lesser importance of explaining the light burn and the geomagnetic storm are psychologically understandable. Still easier to ignore, when developing Tunguska hypotheses, are "minor" traces of the Tunguska phenomenon such as the superfast restoration of the forest in the Great Hollow, anomalies of thermoluminescence, the paleomagnetic anomaly, and so on.

Incidentally, people trying to solve the enigma of the Tunguska "meteorite" have frequently forgotten that their "solutions" were nothing but conjectures. That's why there had appeared such funny newspaper headlines as "The Enigma of the Tunguska Meteorite Has Been Solved!" But to express even a plausible assumption about the nature of the Tunguska phenomenon is not the same as solving this enigma. Of course, any hypothesis must explain the facts associated with the Tunguska phenomenon, but what is definitely necessary is that the hypothesis is testable. And the best possible test for any hypothesis is its ability to predict some new empirical facts following from it *and not following from other Tunguska hypotheses*.

For such a big problem as the Tunguska event, a couple of successful predictions will hardly be sufficient, though. The history of the Tunguska problem has demonstrated this very convincingly. For example, Alexander Kazantsev predicted several facts that were in the 1940s regarded by meteor specialists as impossible and even absurd: the overground explosion of the TSB and the lack of any crater and meteoritic substance in the Great Hollow. These specialists believed that the Tunguska phenomenon was due to the impact of an ordinary crater-forming meteorite. According to their viewpoint, the TSB should have exploded when striking Earth's surface, forming a crater and leaving behind the remains of the meteorite. In fact there was neither – and the explosion itself did occur in the air. Thereby, the hypothesis of the crater-forming meteorite has been convincingly rejected, but the "spacecraft hypothesis" has not been proved. Why? Just because these three features (the overground explosion and the lack both of the crater and of the meteoritic substance) were for the spacecraft hypothesis necessary but not sufficient. They testified that the TSB was *not a crater-forming meteorite*, and only that. If, apart from crater-forming meteorites, only an alien spacecraft could have fallen to Earth, Kazantsev's hypothesis would have been proved. But this is evidently not the case. There exist in the cosmos other natural minor space bodies that could also collide with our planet.

Immediately, the meteor specialists rushed to create alternative hypotheses that could have explained the same facts, not going beyond the scope of the first group of suppositions – that is, that the TSB was another minor cosmic body existing in the Solar System and well known to astronomers. As we know, Fred Whipple's "dirty snowball" model of comet's core arrived in time. Such a body, generally speaking, could have exploded thermally or chemically, since it consisted of considerable amounts of watery ice and frozen gases.

With time it turned out that the "dirty snowball" had its own drawbacks in this respect. In the mid-1970s, Academician Georgy Petrov (1912–1987, one of the founding fathers of Soviet space technology, the creator of the thermal shield for Yury Gagarin's *Vostok* spacecraft, and the first director of the Institute of Space Studies) and Professor Vladimir Stulov at Moscow University repeatedly simulated the process of thermal explosions. They found that the icy core of a comet could not have exploded leaving no traces. By that time dozens of spacecraft had returned to Earth flying at great cosmic velocities, and several Soviet *Venera* space probes had landed on the surface of Venus, having penetrated through its dense atmosphere. Consequently, characteristic traits of the superfast atmospheric flight of material bodies were now understood much better than they had been in the early 1960s, when Professor Kirill Staniukovich and Dr. Valery Shalimov had devised their theory of the thermal explosion.

So what is needed for a flying body to explode in this way? In fact, only two things are necessary: heat must get to the body's interior at a faster rate than it leaves it and the flow of thermal energy must be powerful enough. Under these conditions a cosmic body will become overheated and explode while flying in the atmosphere and before hitting the ground. Ordinary iron meteorites, for example, are losing their speed and cooling down faster than they are heated, and therefore a thermal explosion is out of the question. In the so-called "zone of retardation" (at an altitude of about 15–20 km) their velocity is already practically zero, and they are simply falling down to Earth's surface under the influence of gravity. The Sikhote-Alin iron meteorite was unusually large and therefore it did not slow down but just broke into pieces due to the air resistance, and these pieces hit Earth at a sufficiently great speed to form dozens of craters. Petrov and Stulov's calculations show that only about 1% of the ballistic shock wave accompanying a cosmic body flying through the atmosphere is spent in heating its substance. Therefore no space body of normal density (even ice) could become overheated during its flight in the atmosphere. Rather, the 30 million Tunguska trees must have been leveled by the ballistic shock wave that separated from the TSB after it had collapsed due to the air resistance. And why not?

Just because the same calculations have demonstrated that the TSB could have completely collapsed and the ballistic shock wave could have done what it did only if the density of the TSB had been less than one-hundredth of the density of water. Such a body's mass must have been several hundred thousand tons, its diameter about 400 m, and the initial velocity some 40 km/s.

If Petrov and Stulov had been astronomers they would have realized they were wrong. Cosmic bodies with such a low density do not exist in the Solar System, or at least they are unknown to astronomers. The density of comet cores is, according to all existing models and observational data, about the density of water, which is a hundred times greater than the supposed density of the TSB. But Petrov and Stulov were specialists in celestial mechanics and hypersonics and did not worry too much about astronomical paradigms. Boldly they said: let's suppose that comet cores have just this super-low density. And they gave their model a name more beautiful than "dirty snowball." They called it the "cosmic snowflake." "Only this model," emphasized Petrov and Stulov, "could rationally explain all features of the Tunguska phenomenon."[1]

Astronomers were shocked. Objections rained down upon Academician Petrov and Professor Stulov. In particular, Staniukovich and Bronshten argued that even if, by a miracle, such a "cosmic snowflake" had originated in the Solar System, it would have been very quickly destroyed by the solar radiation, the solar wind, and the tidal effects of the Sun and large planets.[2] And in any case, it could not have passed several hundreds of kilometers through the terrestrial atmosphere and reached an altitude of less than 10 km. It would have dissipated much higher – at about 100 km above Earth.

The astronomers were definitely right: the very low mechanical strength of the "cosmic snowflake" would never have allowed it to reach the Great Hollow. And besides, astronomical data do rule out the possibility that comet cores could be low-density snowflakes. But Petrov and Stulov's main conclusion remains valid: a space body of normal density (consisting of ice or rock) would not have dispersed entirely in the air. Its fragments would have fallen onto Earth's surface, while a hypothetical body of super-low density would have dispersed completely at a great altitude – about 100 km. Now let's look at the real picture: there are no fragments of the TSB in the Great Hollow, but at the same time the TSB collapsed at an altitude not exceeding 8 km.

So what? This means, first of all, that the TSB was sufficiently dense and mechanically strong enough to fly through the whole terrestrial atmosphere. And second, the forest destruction in the taiga cannot be explained only by the action of a ballistic shock wave of a dissipating body. The body must have exploded and produced a blast wave as well – which is lacking in Petrov and Stulov's model of the Tunguska event. Their model is therefore incorrect.

But Petrov and Stulov have convincingly refuted the hypothesis of the thermal explosion of a comet core. Such a core would have left noticeable material traces on the ground. But these are not present. Should we therefore assume that the Tunguska explosion was nuclear, as Kazantsev and Zolotov had assumed? As a last resort, this hypothesis might just be considered.[3] But aren't there any "less exotic" options in the store of contemporary science and technology that could be used? Why not reanimate the old idea of Kirill Florensky's about the chemical explosion of a comet core – with due consideration given to the progress chemical explosives achieved during the years that have passed since this idea was suggested? In the 1970s the United States and the USSR developed effective new weapons – fuel–air explosives, also called high-impulse thermobaric weapons or vacuum bombs. Rumor is that the US military calls the vacuum bomb the Hellfire weapon, which is very apt because its explosive power fills the gap between nuclear and nonnuclear weapons.

How does this weapon work? Various industries have been damaged by vapor cloud explosion accidents, so military chemists hit upon the idea of using this principle for war. A bomb or warhead of a missile contains liquid fuel that is dispersed as an aerosol by the initial explosion. Then, this cloud of fine mist is ignited by additional charges, and the resultant fireball incinerates everything and everyone over an area of several hundred meters. The fireball heats the air to about 3,000°C, eating up the oxygen in the volume affected. When the hot gas rapidly cools the air pressure sharply drops, the inrush of air reaches great speed, and this destroys everything. Conditions necessary for the vapor cloud explosion are created with the help of special technical devices; but couldn't they occur naturally when the icy core of a comet was moving in the atmosphere?

Dr. Maxim Tsynbal, a chemist from Moscow, had a good understanding of such processes. Together with Dr. Vladimir Schnitke, a mathematician from St. Petersburg, he developed a model of the vapor cloud explosion of a comet core. In their theory, the core consisting of frozen gases (methane, acetylene, cyanogens, and others) is first broken up by the air resistance, forming a gaseous cloud that then detonates. This was not just another flimsy Tunguska quasi-hypothesis proposed for want of something to do and aiming rather at the self-advertisement of its authors than at solving the problem (such "hypotheses" have been legion). Tsynbal and Schnitke used figures and facts – first of all those having to do with the mechanical strength of the cometary substance. It is quite evident that the "cosmic snowflake" would not have reached the lower atmosphere, but what about a "normal" comet core whose density does not differ considerably from the density of water? Could it have reached the altitude of 6–8 km over Earth's surface, where the TSB exploded, moving at the velocity of several dozens of kilometers per second, a velocity needed for a "thermal explosion"? Petrov and Stulov did not consider this side of the question. They simply demonstrated that *if* the core had reached this altitude and exploded over the Southern swamp, then the mass of the substance falling on Earth would have been very considerable and easily detectable. But there is none, and therefore the core of the "Tunguska comet" had to have a very low density.

Tsynbal and Schnitke approached the problem from another direction, trying to find out if the icy comet core had any chance to penetrate the terrestrial atmosphere. The mechanical strength of ordinary watery ice is well known.[4] Calculations show that a monolithic icy body flying at a velocity of 10 km/s would have collapsed at an altitude of about 30 km. But a comet core could hardly be a monolithic body. In reality, its mechanical strength would have been much less and therefore it would have disintegrated higher.

Perhaps then, we should consider frozen gases in the composition of comet cores? Could they have helped the core of the "Tunguska comet" to overcome the air resistance and to reach its point of destruction? But the mechanical strength of frozen carbon dioxide exceeds by a factor of 2 that of watery ice. Even if we suppose that the core was monolithic and consisting entirely of this frozen gas, then moving at a speed of 10 km/s it would have collapsed at an altitude of some 20 km. And in any case, if the comet core did reach the point in which the TSB exploded it means that its speed did not exceed 2–3 km/s. Unexpectedly, Tsynbal and Schnitke confirmed Alexey Zolotov's conclusion that had been made on a very different factual basis – that is, from the structure of the area of the fallen trees. Their result did not even depend on the trajectory of the TSB flight through the atmosphere. No matter whether it moved in a flat or steep path, the speed of the comet core at the altitude of 6–8 km must have been low.

On the other hand, swiftly decelerating in the dense layers of the atmosphere, such a core could have evaporated almost completely and given rise to a vapor cloud. Its kinetic energy would have been quite sufficient for that. After this, the vapor cloud could have exploded due to a slight spark that could have originated in an electric discharge. Space bodies moving through Earth's atmosphere are electrified by friction with the atmosphere (just like amber – if rubbed with wool – but much stronger) and therefore such a spark could have occurred. If the mass of frozen gases in the comet core were, say, 10 million tons, this could have resulted in a 50-megaton explosion over the Southern swamp.

So, according to Tsynbal and Schnitke, the TSB did explode as a vacuum bomb, and its explosion leveled some 30 million trees in the taiga. As for the ballistic shock wave, it was weak. This is why the trees are lying strictly radially around the epicentral point. They have been leveled only by the blast wave, with no contribution from the ballistic shock wave (as had already been established by Alexey Zolotov). But how could the explosion of a moving vapor cloud having an enormous volume form a point-source epicenter? For a nuclear explosion – very short and having an enormous concentration of energy in the explosive substance – it would be possible, but hardly so for a vapor cloud one.

True, the hypothesis of Tsynbal and Schnitke does explain characteristics of the "second large trace" of the Tunguska phenomenon – that is, the thermal burn of leveled trees – better than the nuclear model. A nuclear explosion with a magnitude of 40–50 Mt of TNT occurring at a relatively low altitude would have been accompanied by such a powerful light flash that all the vegetation in the epicenter would most probably have been completely incinerated. In any case, the two larches that were found in 1958 at the edge of the Southern swamp and proved to be not only alive but devoid of burns never could have escaped such a fiery bath. But somehow they did escape it. . .

Temperature of the fiery ball of a thermonuclear explosion may reach, even if for a split second, some 10 million degrees. But the fiery ball of a vapor cloud explosion is much cooler – just about 3,000°C. It emits its energy mainly as infrared radiation, not as visible light. The infrared waves lie outside the visible spectrum at its red end, being sometimes called "black light" or "thermal rays." It was, therefore, the invisible infrared radiation that singed the vegetation in the Great Hollow and was perceived by local inhabitants as a skin burn.

Not all of the mass of the TSB would have evaporated at the moment of the main explosion over the Southern swamp, and the blast wave would have scattered its burning fragments throughout the Great Hollow. This would result in the patchiness of the after-catastrophe forest fire, well known to Tunguska researchers and putting them in a spot. Tsynbal and Schnitke have even proposed an acceptable explanation for the genetic mutations and anomalies of thermoluminescence discovered in this region. According to them, the chemical products of the Tunguska explosion rose to the ionosphere and, when going through the ozone layer, neutralized a large amount of ozone, forming there a "hole" open to radiation. Via this hole the high-energetic ultraviolet Sun radiation, usually absorbed by ozone, reached Earth's surface and affected the living organisms and local minerals.

Having studied Tunguska eyewitness accounts, the researchers concluded that the space body had flown from the south to the north, not from the east to the west. Somehow, the "eastern" set of eyewitness reports did not impress them. But yet, what about the axis of symmetry of the butterfly-like shape of the leveled forest area? It is a common opinion that this axis is the projection of the TSB trajectory at the final stage of its flight. . . And it goes from the east to the west, not from the south to the north. Here Tsynbal and Schnitke assumed that the flying TSB, heating due to the air resistance, evaporated very unevenly. Its shape changed, and the vapor jets, ejected from its surface, created a thrust. Consequently, the aerodynamic characteristics of the space body altered swiftly, and the body swerved unpredictably. So the body, flying generally from the south to the north, could have turned to the west when approaching the Great Hollow.

In fact, although the idea of "swerving" looks possible, the TSB could hardly have made such a complicated zigzag-like maneuver – turning after Kezhma to the southeast, then returning again on its path to the Great Hollow and overflying the Lena and Lower Tunguska rivers. The shape of the leveled forest area – the famous "butterflies" by Wilhelm Fast and John Anfinogenov – does not follow from this theory, either.

But its weakest point was that the comet core, which is surrounded by a cloud of gas and dust, the comet's coma, must have consisted of very pure ices – of water and frozen gases. Taking into consideration the enormous mass of the core (up to 10 million tons, according to Tsynbal and Schnitke), which had first to evaporate and then to explode, these ices had to be unnaturally pure. Supposing that the comet core had contained just 1% of silicate and metallic particles, there would have rested in Tunguska soil and peat 100,000 tons of hard cosmic substances. But as we know, in the Great Hollow lie just about *a ton* of such particles. Even if it is the real dispersed material of the TSB, and not simple fluctuations of the background fall of extraterrestrial matter, this figure utterly contradicts the hypothesis of Tsynbal and Schnitke. But recent astronomical investigations, supported by the data that were obtained by automatic space probes, do convincingly testify that the share of hard substances in cometary cores is fairly high – up to 50%. Therefore, the Great Hollow must have received up to 5 million tons of such substances. So where are they? Naturally enough, specialists in cometary astronomy have been very skeptical about the TSB model developed by Tsynbal and Schnitke.

Nonetheless, their work has contributed greatly to Tunguska studies. As a matter of fact, they have refuted the "classical" model of the thermal explosion of the swiftly moving comet core – demonstrating that under no conditions could such a core have reached the altitude of 6–8 km maintaining a high-enough velocity to have caused its thermal explosion.

In the 1980s the American astronomer Zdenek Sekanina also reasoned that the cometary hypothesis of the TSB is at variance with what we know about comets.[5] Being an astronomer and not a chemist, Sekanina did not attempt to develop a theory of the TSB vapor cloud explosion, but his calculations confirmed that the core of a comet would have disintegrated in the atmosphere at a much greater altitude than had in fact happened. Sekanina's additional argument against the TSB being a comet was its probable orbit in the Solar System. According to his calculations, it must have coincided fairly well with the orbits of asteroids from the so-called "Apollo group." As distinct from the majority of small bodies that revolve around the Sun between the orbits of Mars and Jupiter, these asteroids are moving in elongated orbits, traversing Earth's path in space. Not favoring the chemical model of the TSB explosion, Zdenek Sekanina came to a simple conclusion: since the TSB could not have been a comet core, it must have been a stony meteorite – that is, a fragment of an asteroid.

Well, let's suppose it was. How then could a piece of a stony asteroid have exploded in the air? As we know, a ballistic shock wave alone could not have leveled the Tunguska taiga, forming a butterfly-like figure. To form this the TSB must have exploded at the end of its journey through the atmosphere. However, it now seems that under certain specific conditions such an explosion of a stony cosmic body is possible – if, during its flight, it is swiftly fragmenting. A detailed theory of the fragmentation process was created in the late 1970s–early 1980s by Academician Samvel Grigoryan and Dr. Vitaly Bronshten.[6] Their theory was suitable both for a comet core and for an asteroid – substituting in the case of a comet the doubtful idea of the thermal explosion and in the case of an asteroid offering the mechanism for the explosion of an enormous stony meteorite.

Good. Now we have a theory explaining a very enigmatic aspect of the Tunguska explosion – the pattern of devastation it produced on the ground. Flying at a great velocity, a huge stony meteorite could have exploded in the air. And its strength characteristics would have allowed it, as distinct from a comet core, to reach an altitude of 6–8 km over the Great Hollow. But Vitaly Bronshten has asked the supporters of the stony meteorite hypothesis a simple question – where is the meteoritic substance? According to estimations, the overall mass of space dust at Tunguska does not exceed 1 ton at best. It is too little even for a comet core, but one could probably suppose that there exist in space comets with "very pure" icy cores. Although this hypothesis has not been proved as yet, it's not too fantastic. But for a stony meteorite with a mass of several hundred thousand tons at least, the lack of cosmic matter at the epicenter of the explosion seems inexplicable.

To put it bluntly, it is absurd. Had a stony meteorite exploded – due to thermal tensions or due to swift fragmentation – the Great Hollow would have been strewn with silicate dust, and the peat layer of 1908 would have contained lots of meteoritic matter. Not only dust, by the way. Calculations by Dr. Bronshten have proved that after such an explosion a great deal of large stony fragments – each weighing more than 10 kg – would have been present. These hard fragments would have fallen on Earth's surface for investigators to find and analyze. And where are these fragments at Tunguska? During recent decades very sophisticated techniques have been applied to find them, but this extensive search has gone unrewarded.

Bronshten was definitely right. It only remains to conclude with a touch of sadness that:

(1) The "snowflake" hypothesis by Petrov and Stulov does not work, first because there are no such "snowflakes" in the Solar System and also because such a snowflake would have disintegrated at an altitude of about 100 km, not at 6 km over Earth's surface.
(2) An icy comet core with a mass of one million tons could not have reached this point either – it would have broken apart at an altitude of about 25 km. To reach the necessary altitude at which the TSB exploded, this core would have needed a mass of 5 million tons at least. But in this case a question arises: Where is the "dusty" component of the cometary substance, whose share in comet cores, according to contemporary astronomical data, cannot be less than 50%?
(3) The same difficulty is met by Tsynbal's and Shcnitke's idea of the vapor cloud explosion of the evaporated comet core. Large amounts of the hard substance would have been present in the Great Hollow after this explosion and could have been easily found. Besides, Tsynbal and Schnitke believed that the main "explosive" in the Tunguska comet core was methane. But again, contemporary data indicate that there is only a small percentage of this gas in comets. For enough to be present to produce such a powerful explosion (with a magnitude of up to 50 Mt of TNT!), the overall mass of the comet core would have had to be several *dozen* million tons! And, again, where are millions of tons of cometary substance that would have fallen on the ground?
(4) And last but not least, the lack of appreciable quantities of silicate meteoritic matter in the Great Hollow does strongly contradict the hypothesis about a stony meteorite's explosion.

So, after decades of intense theoretical considerations and searches in the field, neither of the two main models of the

Tunguska phenomenon – cometary and asteroidal – can answer the most important (although far from the only essential) question: Where is the TSB substance?

What's to be done in this difficult situation?

Of course, coming to a temporary deadlock is not something unusual in studying complicated scientific problems, and the general strategy for such cases is obvious. We should look for new explanations of the phenomenon under investigation. But where and in which direction should these explanations be searched for? The spectrum of opportunities is rather broad; each researcher may find those fitting his or her own professional and personal inclinations. As often happens in science, the Tunguska investigators formed three different groups: conservatives, radicals, and anarchists. The conservatives paid their attention to the most obvious – and definitely important – question – whether or not all factors influencing a comet core or a stony meteorite flying through the atmosphere have been taken into proper account when analyzing this flight. Usually it was only aerodynamic forces that were considered – well studied and well described mathematically – but perhaps there is "something else" in the flight of meteorites?

The radicals behave more resolutely. If neither a comet core nor a stony meteorite can explain the Tunguska data, perhaps there exist in the Solar System (or sometimes flying through it) some cosmic bodies, still unknown to astronomers but having properties that could explain the Tunguska phenomenon?

And finally, the "anarchists." They lost heart and asked the ultimate question, that maybe there was no space body at all? Couldn't the Tunguska event be purely a terrestrial phenomenon? (The shade of Sergey Temnikov, who had participated in the Great Tunguska expedition of 1929–1930, after which he had sent a report to the authorities accusing Leonid Kulik of "inventing a fantastic meteorite" certainly went into raptures in this connection and agreed that there was no TSB.)

But let's look at the essential physical factors that could have been accidentally ignored by meteor specialists who were studying the flight and explosion of the TSB. One might have been the process of its electrification. Astronomers and meteor specialists did understand that this had to play *some* part in the interaction between the meteorite body and the air. It is thought, for example, that weak electrophonic sounds accompanying the flight of some large bolides could be explained by their electrification when traveling through the atmosphere. Perhaps this physical process could produce more powerful effects? Theoretically this is acceptable, but how can we measure the level of electrification of a piece of cosmic iron flying at a great altitude with an enormous velocity? We can't, so meteorite specialists have preferred not to include electrical effects in their theories and mathematical calculations.

The pioneer investigator of this question was Vladimir Solyanik – an engineer, not an astronomer. As far back as 1951 Solyanik read his paper at a meeting of the Commission on Comets and Meteors of the Astronomical Council of the USSR's Academy of Sciences, in which he tried to draw the scholarly community's attention to the missing factor of electrification.[7] Decades later, scientists became interested in his ideas, and he published his work in a collection of Tunguska papers.

Solyanik thought that iron meteorites could be shattered in the atmosphere not so much by the influence of the air resistance as by their electrification. They are too solid for aerodynamic forces to affect them. Say, for example, the Sikhote-Alin meteorite that fell in 1947 in the Soviet Far East had split during its flight into many large pieces, this disintegration starting at an altitude of 60 km. But the metal content of these pieces, which were collected by the expedition of the Committee on Meteorites, proved to be very strong and able to sustain much greater loads than the meteorite had been subjected to in the upper atmosphere. So why did it break up?

Solyanik pointed out an intriguing fact. When the Sikhote-Alin meteorite flew over a technician who was on a telephone pole repairing a telephone line he felt an electric shock. It seems, therefore, that the meteorite flying above the telephone line generated an electric field that induced an electric current in the line. Similar cases have been recorded when other large bolides have entered the atmosphere. If so, could such a field influence a meteorite itself?

Vladimir Solyanik has produced a simple but convincing theoretical description of the electric processes occurring when a piece of cosmic iron flies through the atmosphere. The molecules of air knock off electrons from the meteorite, which makes the meteorite lose its negative charge and acquire a positive charge. So the strength of the electric field around the moving meteorite swiftly increases to produce mechanical stresses in its substance. When the meteorite is approaching Earth's surface its positive charge induces a negative charge in the ground beneath the flying body, creating a zone of an electric field of increasing intensity. And as the electric charge of the flying meteorite rises, the altitude of its flight diminishes. Finally there arises between the meteorite and the ground something like a high-power electric ark, and the meteorite explodes.[8]

This is a good theoretical scheme – possibly fitting well some cases of bolide flights in the terrestrial atmosphere. But whether it has anything to do with the Tunguska phenomenon remains doubtful. First of all, according to Solyanik's computations, only an iron meteorite could acquire in its flight through the atmosphere an electric charge that would have produced such a powerful explosion. Stony meteorites could not do that – their physical makeup would not allow them to accumulate the necessary electrical charge. But had the TSB been an iron meteorite, the eyewitnesses would have seen a well-defined black tail consisting of small particles of meteoritic iron. Nobody reported seeing such a black tail. And once again, the same old question arises: Where is the meteoritic substance? Solyanik attempted to evade the issue by supposing that the TSB did not disintegrate completely over the Southern swamp, but that its main mass flew farther west and fell at a distance from the epicenter. This idea is interesting but hardly corresponds well with the enormous magnitude of the Tunguska explosion. Besides, *some* fragments of the iron meteorite would have been scattered near the epicenter as well, not only where the main mass of the TSB would have fallen. In 1951 one could assume that these fragments simply had not been found as yet; but since then this territory has been searched *very* thoroughly and no meteoritic iron has been found. Also the "electric explosion" would have lasted, according to Solyanik's calculations, not less than two seconds, while the TSB was still flying in a shallow trajectory with a great speed. But in this case, the leveled forest would not have been lain so radially. So, we must admit that Solyanik's electrical hypothesis (as well as its later variant developed by the rocket engineer Alexander Nevsky)[9] cannot explain even the most obvious empirical facts relating to the Tunguska catastrophe.

Then perhaps we should search for such an explanation in a more radical direction? Let's suppose that the Solar System contains "exotic" space bodies whose properties could help explain the Tunguska explosion? Generally speaking, even Petrov and Stulov's "cosmic snowflake" was an "exotic object" disguised as a comet core. That's why astronomers could not accept it as a possible solution of the Tunguska problem. Still more exotic is the "solar plasmoid" theory proposed by Alexey Dmitriev and Victor Zhuravlev. As Vitaly Bronshten noted with good reason, "If such bodies had existed, astronomers would have observed them. Diligent comet hunters would have discovered hundreds of such plasmoids per year. Nothing of this sort has ever happened."[10]

Well, it goes without saying that while both the "cosmic snowflake" and the "solar plasmoid" have been invented specially to explain the Tunguska phenomenon, they have never been seen and they lack interest for space scientists. But physicists have developed a lot of theories involving peculiar objects that may or may not exist in the cosmos. Take, for example, the ever-popular "black holes." In relativistic astrophysics, a black hole is a body (or rather a region of space) whose mass is so great that no material objects, not even photons, can escape its gravitational pull. Physicists showed that when a sufficiently massive star runs out of its nuclear fuel, it should collapse into a black hole. There is also observational evidence that some galaxies may contain gigantic black holes in their centers. Theoretically, as Stephen Hawking has calculated, there could also exist *microscopic* black holes that have survived from the early epoch of our universe.

So, in 1973, two scholars at the University of Texas in Austin, Albert Jackson and Michael Ryan, published in *Nature* a paper in which they suggested that the TSB might just have been one of these microscopic black holes – negligibly small but having a mass of one quadrillion (one followed by 15 zeros) tons. Such a super-dense body would have penetrated Earth and traveled right through, escaping from the Atlantic ocean somewhere in its northern part.[11] The idea got polite interest among physicists, who for some time discussed the question whether or not such microscopic black holes could exist. As for astronomers and specialists in the Tunguska problem, they did not take the idea seriously. If a small black hole made such a mess and leveled 30 million trees when entering Earth, then its exit from the ocean would have been accompanied by similar perturbations, including, most probably, a powerful tsunami that would have devastated the Atlantic coast of Canada and the United States. Happily enough, this did not take place, and no jumps of the atmospheric pressure had even been recorded. Thus, the hypothesis about the "Tunguska black hole" may serve as another good illustration of Vitaly Bronshten's words about abstract mathematical constructions – fairly scientific but having nothing to do with the Tunguska problem.

But here is an interesting paradox: a still more abstract physical theory proved to be able to make more concrete predictions concerning possible Tunguska traces. I mean the hypothesis explaining the Tunguska phenomenon as a collision of Earth with an asteroid consisting of the so-called "mirror matter." This idea was put forward in 2001 by the Australian physicist Robert Foot. So, what does this strange combination of words – mirror matter – mean?

It was in 1956 that American physicists Tsung-Dao Lee and Chen-Ning Young discovered that electrons and neutrinos arising when a neutron decays are always "left-handed." An observer toward whom these elementary particles flew would see them rotating clockwise. The scientists were awarded a Nobel Prize for their discovery, but the physical research community got upset – why such asymmetry? No physical law prescribes this specific order of things. There is good reason to believe that "right-handed" particles can also exist, and these were later called "mirror particles." But where should they be searched for?

It had already been established that, apart from ordinary elementary particles – the electron, proton, neutron, and others – there also exist antiparticles: positron, antiproton, antineutron, antineutrino, and so on. These had been predicted in the 1920s by the famous British physicist Paul Dirac from a different line of reasoning, and the first antiparticle (positron) was discovered experimentally in the 1930s. So, the Soviet physicist Lev Landau (that very man who explained to Alexander Kazantsev the physical principles of atomic explosion) had supposed that the hypothetical mirror particles and the well-known antiparticles are the same thing. Physicists agreed, and the physical world became symmetrical again. However, this situation did not last long. In 1964 the young American physicists James Cronin and Val Fitch, two future Nobel laureates, proved experimentally that Landau's hypothesis was wrong, and the asymmetry in the decay of subatomic particles still existed.

So physicists had to look for different candidates for the title of "mirror particles." And such candidates were found – or rather theoretically predicted – two years later by Soviet physicists Isaak Pomeranchuk, Lev Okun, and Igor Kobzarev. Their hypothetical mirror particles differed from antiparticles in that they could interact with ordinary subatomic particles only by gravitation. If a neutron and an antineutron collide they are annihilated, whereas colliding neutron and "mirror neutron" particles will simply "ignore" each other. But between themselves mirror particles interact absolutely normally and therefore there can exist cosmic bodies and systems consisting of mirror matter – mirror galaxies, stars, and planets. What is more, even in our galaxy there may exist double stars, one component of which consists of normal matter and the other of mirror matter – at least theoretical physics makes this possible.

As sometimes happens in science, the idea proposed by Pomeranchuk and his colleagues was discussed in the science community and then forgotten for 20 years. Its renaissance occurred in the 1980s and especially in the 1990s, when astronomers and cosmologists concluded that so-called "dark matter" (or "hidden mass") must be present to explain the gravitational dynamics of the universe. Astrophysicists have found that more than 95% of matter existing in our universe should constitute the invisible hidden mass, which is detected only by its gravitational influence on stars and galaxies. The origin of this mass remains unknown, but the hypothetical "mirror matter" is a very good candidate for this position. It fits well the two main characteristics of dark matter. First, it cannot be seen – because mirror photons emitted by mirror matter do not interact with normal matter. At the same time, mirror matter does interact with normal matter gravitationally, that is, through the omnipresent force of attraction between any particles of matter in the universe.

Dr. Robert Foot, who supported the idea of dark and mirror matter, disagreed, however, that the normal world and the mirror world would be almost completely separated from each other. He supposed that apart from the gravitational interaction between them, there could exist one more type of interaction – directly between photons and mirror photons.[12] If there is no such interaction, then even large asteroids consisting of mirror matter may pass through the atmosphere of our planet and even through the planet itself, not disturbing anything and remaining therefore unnoticed. But the situation changes considerably if photons and mirror photons do interact.

In this case, upon entry of a mirror space body into the atmosphere a drag force arises that swiftly heats the body. A large chunk of mirror ice on course to hit Earth with a cosmic velocity would melt at an altitude some 5–10 km, which corresponds well with the altitude of the Tunguska explosion. While it is melting and being dispersed in the air, the atmospheric drag force would sharply increase and the body would explode, releasing its kinetic energy into the atmosphere.[13]

So, if the TSB was indeed a mirror asteroid, the absence of the ordinary meteoritic substance in the Great Hollow becomes understandable. In addition, some fragments of mirror substance can still be expected, if it was not *too* volatile. Who knows, perhaps these fragments are still awaiting someone to discover them on the site. According to such physicists as Robert Foot and Zurab Silagadze, they could be found there. True, the task of digging them out may become much too difficult. As it follows from the theory, even if the mirror matter can interact with normal matter this interaction is very, very weak.

Needless to say that the "mirror hypothesis" of the TSB nature is not so much an astronomical conception as a purely physical one, emerging from a "frontier area" of physical science. Astronomers, especially meteorite specialists, have been accustomed to less-sophisticated theories and therefore they feel instinctive doubts about such considerations. For example, when Robert Foot attempted to explain some peculiarities of craters that had been photographed by the space probe *NEAR Shoemaker* on the surface of asteroid Eros in 2000 as resulting from collisions with mirror asteroids, astronomers just shrugged their shoulders. Thus, it should hardly be expected that the mirror model of the Tunguska phenomenon will soon take the leading place in this field of investigations – even though it's rather promising. But at present this model looks too far-reaching – "too cosmic."

An opposite approach to the Tunguska phenomenon – that is, attempts to declare it a purely terrestrial event – is evoking in the general public (if not among the specialists) much greater interest, or at least is understood better than the above microphysical theories. Really, why should all these researchers cudgel their brains over all that kind of rot, trying to associate enigmatic traces in the taiga with unknown parameters of a fantastic cosmic body? What if there was no cosmic body at all? What if it was just an unusual earthquake, or something like that?

The most active – and the most well-known – partisan of the purely "terrestrial" approach to the Tunguska problem is Dr. Andrey Olkhovatov, who in 1997 published in Russia a book with a provocative title: *The Myth About the Tunguska Meteorite. The Tunguska Event of 1908 as a Mundane Phenomenon*. As its author openheartedly informs the readers, "The idea about the Tunguska phenomenon as a product of tectonic processes came to my mind in the late 1980s, when I happened to read a couple of popular science books about earthquakes. Although I had never studied the Tunguska problem before, I was astonished by the similarity between Tunguska eyewitness accounts and those of witnesses of some earthquakes."[14]

Many papers by Olkhovatov have been published in various Russian and foreign periodicals. So, what data is Olkhovatov considering? Generally, these are the same well-known facts discovered by Tunguska investigators: no material substance of the TSB has been found; optical atmospheric anomalies had started several days *before* the TSB fall; neither the meteorite fall nor that of a comet core can explain the thermoluminescence and the paleomagnetic anomaly, the post-catastrophic accelerated growth of trees, genetic mutations at Tunguska, and so on.[15]

And what was Olkhovatov's conclusion from these facts? Very simple, even if not very logical: there was no TSB at all. So what was there instead? Judging from the literature, both advocates and opponents of Olkhovatov's viewpoint believe that it was an ordinary earthquake that caused the Tunguska phenomenon. This, though, was not his hypothesis, which is more exotic. According to Olkhovatov, there occurred at Tunguska the so-called "natural non-local explosion" (NNLE) – a new, previously unknown type of seismic activity "which is something other than an earthquake, even if rather similar to it."[16] That is, we are dealing here with an underground variety of exotic cosmic body that has never been observed by geophysicists and seismologists – neither before nor after the Tunguska explosion. Olkhovatov did quote in his works the descriptions of luminous formations sometimes appearing in the atmosphere before earthquakes or accompanying these. But in fact, these phenomena are essentially different. Neither their scales nor consequences are even comparable.

By the way, Olkhovatov refrains from describing the mechanism of NNLE in any detail, leaving it an enigma on its own. And it is so easy to explain one enigma via another one. But has an NNLE ever been recorded releasing the energy of 50 Mt of TNT? Olkhovatov's reference to the so-called Sasov explosion that took place in the Ryazan region of Russia on the night of April 12, 1991, has nothing to do with the case. Its magnitude was about 300 tons of TNT, that is, 100,000 times weaker than the Tunguska explosion; nonetheless, Olkhovatov calls it "mini-Tunguska." Why not call it "micro"? Yes, earthquakes are from time to time accompanied by strange light phenomena, but this does not mean that all strange light phenomena are generated by earthquakes or a fantastic NNLE. Incidentally, according to Olkhovatov, poltergeist is also an NNLE[17] as well as ball lightning. Then perhaps we should attribute the whole Tunguska phenomenon to a gigantic poltergeist? That would have been a truly original hypothesis!

Unfortunately the "purely mundane" origins of the Tunguska event are enthusiastically received and supported by those readers who have a poor grasp of the data collected during the century of Tunguska investigations. (When, some years ago, Andrey Olkhovatov described his hypothesis on his website, the web server was overloaded by people wishing to "know the final solution of the Tunguska enigma.") As for the specialists in the Tunguska problem, they find themselves in an unenviable position. Discussions with absurd statements could last infinitely – and lead nowhere. For example, Vitaly Bronshten, in his very substantial book *The Tunguska Meteorite*, somewhat perplexedly informed his readers: "But there had been a TSB, indeed!" This hardly convinced Olkhovatov's supporters.

To be truthful, Andrey Olkhovatov's contribution to the problem of the Tunguska meteorite closely resembles a sudden intervention of a passerby into a discussion group of geophysicists about the shape of our planet. The specialists are debating which dimensions of the globe should be considered as sufficiently precise and which is the polar radius of Earth, whereas a new participant appears and states aloud: "What are you quarreling about? Earth is flat and standing on three whales! This is the model that gives the best fit to all data collected by now!"

At the same time, Olkhovatov does notice very well those nuances and peculiarities of the Tunguska phenomenon that cannot be explained by its cometary and meteoritic models. For instance, he proves convincingly that the "fiery ball" flying over the Great Hollow could explode only due to its internal energy and not due to its energy of motion (confirming thereby Alexey Zolotov's and Maxim Tsynbal's conclusions – if they required any additional confirmation) and demonstrates the complicated character of the TSB's flight path... Well, and...? It is self-evident that the Tunguska phenomenon is full of various enigmas, but to explain them away with the help of a mythical NNLE eruption does not mean to work out the Tunguska problem. Rather, it means to muddle matters.

Now, why are the majority of "exotic" Tunguska hypotheses, both mundane and cosmic, inadequate? Why, after all, cannot an extraordinary event be explained by an extraordinary hypothesis? Well, perhaps it can be and even should be. But these hypotheses are either ignoring well-established facts or cannot generate any predictions through which it would become possible to verify them. Sometimes it is even both of these. Of course, ignoring facts is blameworthy, but it is only rarely that necessary attention is paid to the inability of a hypothesis to be testable via verifiable predictions. However, this self-test is the most important component of the whole scientific method of cognition. It is far from sufficient to say that, for example, the cometary hypothesis cannot explain some traits of the Tunguska event, whereas some "super-NNLE" can. The scientist still has to prove that it is *only* the "super-NNLE" that can account for this event.

That is why attempts by "conservative" advocates of the cometary-meteoritic TSB models to build advanced schemes of the Tunguska event, involving a comet core or a stony asteroid, should not be rejected out of hand. Recently, a group of Tunguska researchers from St. Petersburg – Dr. Henrik Nikolsky and Edward Schultz at the Institute of Physics of St. Petersburg University, and Professor Yury Medvedev at the Institute of Applied Astronomy – attempted to calculate a trajectory for the Tunguska comet that would best fit all the empirical facts. They suggested that the TSB was a fragment of Comet Encke, which had been discovered in 1786 and is revolving around the Sun with a period of just 3 years and 4 months (the shortest known cometary period of revolution). In December 1907, when approaching its perihelion (that is, the point in its orbit where it is nearest to the Sun), this comet broke up into several large pieces. One of these pieces, the St. Petersburg scientists believe, approached Earth, touched its upper atmosphere, and decelerated, after which it was caught by the gravitational field of our planet and became its temporary satellite. This was a cosmic body some 400 m across and with a mass of about 30 million tons. It made its first revolution around Earth in an orbit with an apogee – the maximal distance from the planet – of 60,000 km (six times closer than the Moon) and a perigee – its minimal distance – just 40 km distant. This was over Antarctica. Naturally, at such a low perigee the cosmic body would have been slowed down by air resistance, and so its altitude decreased with every orbit. Also, flying through increasingly denser layers of the atmosphere, the body's substance began to burn up. The Tunguska comet made three complete revolutions around Earth, losing half of its mass and producing atmospheric anomalies that, as we know, had started as early as June 27, 1908. When over Europe, the comet disturbed the geomagnetic field, the perturbations of which were recorded by Professor Weber in Kiel, Germany. By its fourth revolution around Earth, the TSB's speed was already less than that needed to keep it in orbit, and its altitude on its fourth incomplete circuit was just 100 km. Moving toward Tunguska along the 101st eastern meridian, somewhere before Kezhma, the TSB broke apart into several fragments.[18]

Each of these fragments was burning up and intensively evaporating, the whole volume of the explosive cloud reaching 200 km^3. And when the speed of the TSB fragments diminished to a couple of kilometers per second, the cloud detonated, its explosion lasting about five seconds. The blast wave hit the taiga, leveling trees. Two seconds later, scorching gases fell upon Earth's surface, burning the trees, bushes, and moss in the Great Hollow. Lesser vapor clouds, formed by other TSB fragments that followed the first one with intervals of several seconds, exploded as well, additionally devastating the taiga. Chemical products of these explosions were ejected into the upper atmosphere, where they brought about optical anomalies and the local geomagnetic storm. As for the lumps of cometary ice that had survived the explosions, these fell to the Southern swamp and melted there.[19]

One cannot but notice a close similarity between this hypothesis and the hypothesis proposed by Maxim Tsynbal and Vladimir Schnitke that was described above. The idea of the vapor cloud explosions has been taken from there (with due references, of course). Naturally, all its shortcomings have remained intact; but the hypothesis of the "orbital comet" goes far beyond the limits of the former hypothesis. Its essential advantage is the authors' desire to take into account as many Tunguska traces as possible. They have even paid attention to an unusual atmospheric glow that had been observed in Antarctica, near the Erebus volcano, just a few hours before the Tunguska event, by Professor T. W. Edgeworth David, the scientific chief of the Anglo-Australian Antarctic expedition of 1908.[20] According to the Russian researchers, this glow was associated with the Tunguska comet flying past Mt. Erebus, in the lowest part of its orbit. But the key advantage of their scheme is that they propose fairly rational explanations for a whole group of phenomena accompanying the Tunguska event – not just for a couple of them.

First, this scheme proposes an explanation for probably the most enigmatic precursor of the Tunguska phenomenon, the Weber effect – strange perturbations of the geomagnetic field recorded by Professor Weber in Kiel, Germany. As the St. Petersburg scientists state, it was generated by the orbital motion of the TSB. Second, we can now trust the reports of those eyewitnesses from Kezhma, some of which saw a flying body to the east from the village and the others to the west. These were the separate fragments of Comet Encke. The accounts of the Evenks about several powerful explosions and a strong quake *before* the first explosion – which, as we know, awoke Chuchancha and Chekaren, who were peacefully sleeping in their chum – also become better understandable. Nikolsky and his coauthors believe that this quake was produced by the fall of a "huge icy fragment of the TSB" into the Southern swamp. It is suggested that the local geomagnetic storm could have been due to an ejection of chemical products from the explosions of vapor cloud in the ionosphere. These products, weighing tens of millions of tons, made a "hole" in the ionosphere and disturbed ionospheric electric currents, which affected the geomagnetic field. But what is especially important, the anomalous atmospheric phenomena that took place both before and after the Tunguska explosion do also obtain a natural explanation. Before the explosion they were due to the loss of cometary substance during the TSB's orbits and afterward due to the ejection of the explosion products into the upper atmosphere.

As for genetic mutations and anomalies of thermoluminescence, the researchers accepted the scheme developed by Tsynbal and Schnitke – a breakout of the high-energetic ultraviolet radiation through the ionospheric hole. Equally, they have agreed with Sokrat Golenetsky and Vitaly Stepanok that it was the "cometary fertilizer" (that part of the TSB substance that got into the soil – not in the upper atmosphere) that promoted the accelerated restoration of the forest at Tunguska.

A beautiful hypothesis indeed! A clever, well-developed, and flexible one. Calculations of possible capture of the TSB by the terrestrial gravitational field and its subsequent orbital maneuvers have been made at a high professional level. But once again – where is the TSB substance? "It dissolved in the Southern swamp." Such an explanation looks very strained. To dissolve leaving no trace the cometary ice must have been extremely pure. This contradicts the recent astronomical data. Besides, the Weber effect – the strange regular oscillations of the geomagnetic field – occurred on June 27, 28, and 29, 1908, exactly 24 hours apart. How could the "orbital comet," whose period of revolution never exceeded 10 hours, generate the Weber effect? And also, how could a fragment of the icy comet core, flying at an altitude of tens of thousands of kilometers, perturb the geomagnetic field so much as to be recorded in Kiel?

And last but not least, it is evident that products of a chemical explosion, even though very powerful but devoid of any radioactivity, could not give rise to a local geomagnetic storm lasting five hours. At best, a geomagnetic disturbance, brought about by the vapor cloud explosion of the TSB, would have lasted several minutes, until all electric charges in the fiery ball had been neutralized.

Nonetheless, despite all these defects, at present it is the hypothesis by Dr. Henrik Nikolsky and his colleagues that may be considered as the most advanced version of the cometary explanation of the Tunguska phenomenon. Perhaps, its further development will open way to new progress in Tunguska investigations.

Thus, in previous chapters we have described 10 traces that remained after the Tunguska event – from the radially leveled forest and light burn of the Tunguska vegetation to genetic mutations and indications of radioactivity. We also considered eyewitness reports – which should certainly be taken into account when searching for the correct solution of this problem. In this chapter we have considered 10 hypotheses, whose authors are trying to explain these traces and to find out the nature of the Tunguska phenomenon – from a comet and a stony meteorite to the "natural non-local explosion" and an asteroid consisting of "mirror matter." Each of these hypotheses meets with considerable difficulties when trying to account for all peculiarities of this phenomenon, and therefore science does not possess as yet the correct theory.

Does this mean that the efforts of scientists who, during many decades, were putting forward and developing Tunguska hypotheses were in vain? Far from it. In a preceding chapter we saw that from the 1960s the scientific community, having made sure that it was impossible to take the "Tunguska fortress" by storm, went over to a more systematic siege. Specialists in various scientific disciplines have built around this fortress, so to say, a system of trenches helping them to work out their theories and to check if they correspond to known Tunguska facts. And this siege has borne some fruit. A map of the fortress, with its 10 "bastions" – traces of the Tunguska phenomenon – is now available. A circle of the "science army" around these bastions gradually becomes tighter, preparing for the final assault. Hypotheses and theoretical models of the Tunguska phenomenon may be compared with siege guns: success of the future assault depends, first of all, on their quality and caliber. The experience of this long siege has shown that a great many of these siege guns are, alas, ineffective against the walls of the Tunguska fortress, though some of them may still be useful.

So, which of the "siege-guns" have been sent to a melting furnace or at least withdrawn from service? First of all are the fringe hypotheses that suggest there was no cosmic body over Tunguska and that the phenomenon is explainable in terms of ball lightning, an explosion of marsh gas, an unusual hurricane, or an unusual earthquake. Eyewitness reports may not be that exact, but the very fact that they exist does convincingly testify that there was a cosmic body flying in the atmosphere for about 1,000 km. Also, the thoroughly investigated area of leveled forest and that of the light burn prove that the body exploded in the air over the Great Hollow at an altitude of 6–8 km. The iron meteorite hypothesis has also been refuted: no one reported a dense tail of iron particles behind the flying TSB and no pieces of meteorite have been found at Tunguska.

As for hypotheses explaining the Tunguska catastrophe by the arrival from space of such exotic objects as a black hole, solar plasmoid, or cosmic snowflake, these have remained just "initial conjectures" and have not become scientific hypotheses in the strict sense of this term. These conjectures either contradict well-established empirical facts or cannot generate any verifiable predictions. Regarding Alexander Kazantsev's spaceship hypothesis, which played a very important part in the history of the Tunguska problem, its progress has practically stopped. Having predicted some important facts: the overground character of the Tunguska explosion, the lack of meteoritic substance in the Great Hollow, traces of radioactivity and genetic mutations, this hypothesis ceased to evolve and lost – perhaps temporarily – its "predicting potential." But what, after all, may it predict if we have no idea of the searched-for object – an extraterrestrial spaceship?

On the other hand, the starship hypothesis does explain more easily and convincingly than a comet or a stony meteorite such aspects of the Tunguska event as the local geomagnetic storm, the rare earth anomaly in Tunguska soil (which can have no relation to small cosmic bodies), the anomaly of thermoluminescence, and especially possible maneuvers of the TSB in its flight to the Great Hollow. To return this hypothesis to the leading place in Tunguska studies that it had several decades ago, its supporters would have to look for material remnants of the TSB. But for the time being, it is a comet and a stony asteroid that are generally considered the chief candidates in the Tunguska mystery, even though each of these has its own serious drawbacks. But many scientists are certain that to solve this problem means to choose between these two hypotheses.

This choice has turned out to be more difficult than could have been imagined several decades ago. Somehow, the properties of either of these small cosmic bodies fall short of explaining all well-established facts relating to the Tunguska phenomenon. A comet core could not have penetrated the atmosphere so deeply, whereas a stony asteroid would have left a large amount of rocky substances in the Great Hollow. One can imagine a "cometary fertilizer" accelerating the growth of the taiga vegetation, but hardly a fertilizer consisting of meteoritic rock. On the other hand, a "radioactive meteorite" (not composed of pure uranium-235, as Alexander Kazantsev had assumed, but at least containing some radioactive elements that might have been responsible for the radiation effects discovered at Tunguska) looks somewhat more acceptable than a "radioactive comet core."

But as a whole, it seems that the real TSB must have possessed altogether the properties of a stony asteroid and those of a comet core. It had to be at least as strong mechanically as a stony asteroid to attain the altitude of 6–8 km before it disintegrated. It also had to contain still less hard substances than a normal comet core has. And finally, there must have been in the TSB something that made possible its detonation over the Southern swamp.

Very contradictory requirements, one has to admit! Perhaps, a mirror asteroid could have contained all the necessary traits, but as said above, for meteor specialists this hypothesis seems too alien. Nevertheless, however strange it may sound, the exotic mirror model is rational, theoretically substantiated (physicists are persistently looking for mirror matter), and verifiable, at least in principle.

Albert Einstein has wonderfully described the main properties of a truly good scientific theory: it must possess, on the one hand, "external confirmation" and, on the other hand, "inner perfection." In other words, a theory is good when it accounts for all well-established facts associated with it and when it does that from a minimal number of initial suppositions.[21] Of all 10 Tunguska hypotheses that we have considered, it is probably the "orbital comet" by Henrik Nikolsky and his colleagues that possesses the best external confirmation – even despite all its weak points. At least, its authors are trying to cover all facts accumulated in the Tunguska file. But it lacks inner perfection. The complexity of the scheme, developed by the St. Petersburg scientists, rather hints at gravitational maneuvers of an extraterrestrial spaceship than at a simple comet. As for the best inner perfection, this is found in the mirror asteroid model, though its external confirmation leaves much to be desired. Such a sharp contradiction between the two perhaps brightest contemporary hypotheses about the nature of the TSB seems to suggest that their chances of becoming the last word in the long controversy are not good.

Certainly, one can understand the broad audience that is inclined to believe every new idea about the nature of the Tunguska phenomenon – independent of the level of its justification. The infinite vacillations of meteor specialists between a stony asteroid and an icy comet core can hardly evoke enthusiasm. A 100 years of the history of the Tunguska problem – and 80 years of active investigations – is a sufficiently long period for the nonspecialists to become irritated with the progress made.

There is sad truth in this irritation. But who could have expected 80 years ago that the Tunguska problem would turn out so difficult, and especially so multidisciplinary? To find a correct explanation for every Tunguska trace is a challenging task, but still more challenging is combining these explanations into a unified picture. A biologist studying genetic mutations in Tunguska pines and a physicist investigating the local geomagnetic storm that started soon after the explosion are speaking very different scientific languages, and it is difficult for them to understand each other. As a rule, the biologist has a very general idea of the ionosphere, as the physicist has of the molecule of DNA, so how can they find a common ground for investigating the Tunguska phenomenon – or even for discussing it?

And such difficulties are constantly emerging before Tunguska researchers. So, perhaps the scientists besieging the Tunguska fortress have huddled into their "disciplinary trenches" somewhat too early? Yes, it is safe in these trenches, and one can build there highly professional schemes of the enigmatic event that occurred at Tunguska a century ago; but communications between different trenches are bad and attempts to summon up the existing scientific forces regularly fail. Luckily, there is a way out of this situation. We should retreat a little, have a better look at the besieged fortress, and try to build its model demonstrating the Tunguska phenomenon as it was. Then the real picture of the phenomenon would emerge not obscured by theoretical veils. This is what we will try to do in the next chapter.

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15. Ibid., pp. 6–7.
16. Ibid., p. 6.
17. Ibid., p. 32.
18. The authors do however admit that the Tunguska space body could have been a group of separate bodies from the very beginning, before entering the terrestrial atmosphere.
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