

# Ball lightning and unidentified flying objects (UFOs)

## Abstract

Descriptions of observations of large luminous objects (UFOs) are given. Particularly valuable is information about these objects obtained by pilots who saw them at close range. These objects are capable of flying at airplane speeds and emitting cone-shaped beams of light. Sometimes these rays break off before reaching the ground. When the beam hits a hard surface, it crumbles into “sparkles”. If there is close contact with a UFO, the aircraft’s electronic equipment fails. Sometimes these objects “land” on the ground and take off, moving faster than the speed of sound. Objects remain invisible on the radar screen operating in the decimeter range. A hypothesis of the UFO device has been proposed. It is believed that UFO is an ensemble of ball lightning located in a common shell. The reason for the generation of cone beams of light is the synchrotron radiation of relativistic electrons that are part of the nuclei of ball lightning. Objects are capable of moving at supersonic speeds due to the emission of charged micro-clusters of water from their surface.

**Keywords:** Unidentified flying objects; Pilot’s observations; Ball lightning

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## Introduction

For many years, since ancient times, large luminous objects, called “unidentified flying objects” (UFOs), have been observed in the atmosphere. Scientific analysis of messages has shown that in the overwhelming majority of cases these are optical effects associated with the scattering and refraction of solar rays, the observation of planets and “space debris” - the remains of rockets and satellites illuminated by the sun.<sup>1,2</sup> However, among these objects there remains a proportion of one to ten percent that cannot be classified as an “optical illusion” (Figure 1).



**Figure 1** A luminous object near the ship “Kaiba Shiharo”, observed in 1962 near the coast of Brazil.<sup>3</sup>

In most cases, unidentified objects are observed from a great distance, which makes it impossible to determine their true size and notice the details of their structure and behavior. However, there are also cases of observing these “strange” objects from close range, when they “sat” on the ground and left traces on it. Witnesses, amazed at the

sight of these objects, often mistook them for alien spaceships and even, according to them, talked with the aliens. Due to the peculiarities of the human psyche, it is often difficult to obtain reliable information about the properties of these objects from eyewitness accounts.

## UFO sightings

Let’s start with the first report of a UFO sighting in Russia: “On August 15, 1663, between 10 and 12 pm local time, a strong noise was heard, and a huge flaming object with a diameter of at least 40 meters appeared from the north from the clear sky. This object, moving in a southerly direction, began to slide over the surface of Lake Robozero. Two fiery rays emanated from the front of the object, and bluish smoke emitted from the sides... The total time the strange body remained above the lake was about an hour and a half. At the time of the appearance of this body, peasants were riding on the lake in a boat. They tried to approach it, but it was unbearably hot near the body. The light from the body was so bright that the bottom of the lake located at a depth of 8 meters and the fish spreading to the sides from the fire could be seen. Where the fire scorched the water during its movement, a brown, rust-like film appeared on its surface. This film was later blown away by the wind”.<sup>3,4</sup>

And here is a message about the appearance of a UFO over the city of Petrozavodsk: “On September 20, 1997, at about four o’clock in the morning, a huge “Star” suddenly flashed brightly in the dark sky. Spread out over Petrozavodsk in the form of a jellyfish, it hung above it, showering the city with many thin ray jets that gave the impression of torrential rain. After some time, the radiant glow ended, the “jellyfish” turned into a bright semicircle and resumed its movement towards Lake Onega. This phenomenon was been observed for 10-12 minutes”.<sup>4</sup> The “Petrozavodsk phenomenon” is an example of the difficulty of isolating a truly unusual phenomenon from the effects associated with rocket launches. The analysis showed that on September 20, 1977, at 4 o’clock in the morning, a rocket was launched from the Plesetsk Cosmodrome, which launched the artificial Earth satellite “Cosmos-955” into orbit. At 4:05 a.m. the rocket emerged from the earth’s shadow and found itself illuminated by the sun. The separation of the second stage occurred, and the scattering of combustion products and fuel residues began. They took the form of a large gas and dust cloud, which in the rays of the sun was identified as a “jellyfish” with curved rays.<sup>2</sup>

In recent years, a fairly large amount of observations of unidentified objects has accumulated, made by pilots - educated people with a stable psyche, who saw these objects next to them. In 1985, the "Trud" newspaper published a note about the meeting of pilots with a UFO on September 7, 1984:<sup>4,6</sup> TU-134A aircraft (flight 8352 Tbilisi-Rostov-Tallinn). Crew: ship commander Igor Alekseyevich Cherkashin, co-pilot Gennady Ivanovich Lazurin, navigator Egor Mikhailovich Ognev, flight mechanic Gennady Mikhailovich Kozlov. "Four o'clock in the morning. The flight altitude was 10,600 meters, 120 km remained to Minsk. The co-pilot noticed an unblinking large star at the top right. As it turned out later, it was not a star, but a yellow speck the size of a nickel (2.5 cm), elongated at the edges. "What is this," he asked himself, "the refraction of light in the atmosphere or something else?" A thin beam of light emerged from the speck and fell vertically down to the ground. Then the beam of light opened, turning into a bright cone of light. From that moment on, everyone saw what was happening on the right side. A second cone appeared, wider but paler than the first. Then – the third, wide and very light. Everyone noted that the object hovered at an altitude of 15-20 km. On the ground, illuminated by a cone-shaped beam, everything was clearly visible – houses, roads... Then the beam of the "searchlight" rose from the ground and was directed at the plane. At that moment, the pilots saw a dazzling white dot surrounded by concentric colored circles. Suddenly the white dot flashed and a green cloud appeared in its place. "He turned on the engines and ran away," said Lazurin. And it seemed to Cherkashin that the object began to approach with great speed, crossing the plane's course at an acute angle. He shouted to the navigator: "Report it to the ground!" But after the first words of Ognev's message, the object stopped. "It stopped moving away," the co-pilot decided. The Minsk air traffic controller took note of the crew's message and said that he saw nothing either on the radar screen or in the sky. And the green "cloud" suddenly fell down, overshooting the altitude at which the plane was flying. Then it rose vertically, darted to the right, then to the left. Then – down again, up and, finally, it was fixed exactly opposite the plane. It flew next to it, as if tethered, at an altitude of 10,600 meters at a speed of 800 km/hour. Inside the cloud, "lights began to play – they flashed and went out, like garlands on a New Year's tree." Then fiery zagzags crawled horizontally. The navigator conscientiously reported everything to the ground. From the ground, the air traffic controller replied: "I'm seeing flashes on the horizon. Where do you see your cloud?" The navigator explained. "Coincident," said the dispatcher. The cloud continued to change. A "tail" grew out of it, similar to a tornado – wide at the top, thin near the ground. It turned out to be a "comma". Then the "tail" began to rise towards the horizon, and the cloud turned from elliptical to quadrangular. Now they were escorted by a sharp-nosed "cloud plane" – without wings, with a beveled tail. It glowed with yellow and green lights. Where the real plane had a nozzle, the escort had a dense core... Together with the "cloud plane" they passed Riga and Vilnius. Air traffic controllers in these cities consistently recorded a strange tandem. Flying over Lake Chudnovskoe and Lake Pskovskoe, Cherkashin's crew was able to estimate the size of the "cloud plane." These two lakes, oblong in shape, are separated by a small land bridge. The TU-134A was moving one hundred and twenty kilometers away from them, and the "cloud plane" was on the right, closer to the city of Tartu. From the place where it seemed that a dense core could be discerned, the beam again advanced. A spot of light fell on a cloud and crawled along the ground. The object provided information about itself. Now, one could estimate that its length was equal to Lake Pskovskoe. The tandem flew all the way to the city of Tallinn. After landing, the Tallinn air traffic controller told them about other unusual details. It turns out that more than one TU-134A

was visible on the screen of the surveillance radar station at Tallinn Airport. Following its mark, two more crawled across the screen, although there were no more planes in the air. In addition, these two marks were constantly visible. And the light spot from the plane either disappeared or reappeared. "I could understand," said the controller, "if you were "flickering" on the landing locator screen. But this never happens on the radar screen, it's impossible."

The note, published in the "Trud" newspaper, opened up the possibility of a wide discussion of cases of sightings of unidentified flying objects (UFOs), which had previously been considered "indecent." It turned out that these strange objects are often observed by pilots.

In June 1948, test pilot A. Apraksin, flying a jet aircraft at an altitude of 9300 m in the area of Lake Baskunchak, saw an unidentified flying object. Light rays emanated from it, which had a limited length. The pilot reported to the command post and received confirmation that the object was being detected by ground-based locators.<sup>4</sup> In 1990, during a night flight of an AN-30 aircraft at an altitude of 6000 meters, the pilots noticed a bright formation the size of the moon to their right. The UFO began to approach, becoming larger and brighter. The crew asked the ground controller to check if there was an image of this formation on the ground radar. At the same time, the same request was made by an Aeroflot TU-154 aircraft, flying above the AN-30 on a collision course. The dispatcher replied that there was nothing unusual on his locator. Meanwhile, a beam emerged from the unusual formation, which with enormous power pierced the clouds all the way to the ground: a wooded area began to be visible below. This picture was also noticed by the crew of the oncoming plane. After this, the UFO switched to the course of the AN-30 and walked with it in tandem for an hour, being at a distance of 10 km. A UFO periodically appeared for a few moments on the screen of the aircraft radar in the form of thunderstorm flare, and then disappeared.<sup>4</sup> On August 7, 1967, fighter pilot Lev Vyatkin was sitting in the cockpit of an interceptor fighter standing on the runway of a military airfield in Crimea. It was 6.30 am, the sun had not yet risen, there was not a cloud in the sky. Suddenly, at a distance of about 2 km and an altitude of about 300 meters, a large luminous ball about 80 meters in size appeared. It was clearly visible against the background of a clear light blue sky and had the color of a burning match. Inside it, a dark blue core was visible, which seemed massive and solid. The ball did not float in the air, but flew, moving against the wind at a speed of 60-70 km/h. The trajectory of its flight outlined the silhouette of a green mountain, and it was noticeable how the trail of hot air left by the ball swayed. The flight was silent. There was no signal from the object on the airfield locator. The flight of the ball lasted 3 minutes. It had stopped, a thin beam erupted from its center and rested vertically on the ground. Then the object quickly, with incredible speed, passed upward and immediately disappeared. 5 days later, on August 12, during a night flight, Lev Vyatkin encountered another incomprehensible phenomenon. He saw to the left and above him a large bright object in the form of a luminous oval. Avoiding a collision with it, he shifted the plane into a right turn. After a few seconds, the object began to slowly fade away. Having completed a full right turn, the plane returned to its starting point. The pilot decided to make a left turn. But as soon as he set the desired roll, speed and added turbine speed, a white light appeared from somewhere above and immediately ahead – a slightly inclined beam. It was approaching quickly and, if the pilot had not turned the bank in time, it would have landed directly in the cockpit. But the beam still hit the left wing. Having touched the wing, the white beam instantly crumbled into small sparkles, reminiscent of a flickering scattering of fading holiday fireworks. The plane shook violently. "What is this

thing? The beam seems to be solid,” the pilot thought, turning his head as the flickering pillar went far down. Soon all this disappeared without a trace. From his own experience, a person knows that there are no “solid” rays. But it was a great relief for Lev Vyatkin to read the message about how the chief of police of the city of Voronezh V.I. Selyavkin, walking along a country road at night, came under a bright and powerful beam of light, which crushed him to the ground with its weight. Then the beam went to the side and disappeared. This UFO’s phenomenon is repeatedly mentioned in other sources of information. At the same time, another feature was noticed, no less strange: the beam emanating from the UFO has the ability to “extend”, like a tripod or “probe,” ending abruptly at the end.<sup>4</sup>

On April 2, 1990, in the city of Lipetsk, an oblong oval object appeared above the airfield and hovered over the runway. It was illuminated by an airfield searchlight. In response, it released a hard beam that did not reach the ground, as if it had been cut off. The regiment commander ordered the duty pair to be lifted into the air, to carry out an inspection and try to land the object. It moved slowly and silently hung in the sky. But as soon as the command to “take off” was given, the UFO sharply took to the left, then to the right, and went up at high speed.<sup>4</sup> On April 6, 1990, MIG-21 fighter aircraft conducted night firing. A target appeared on the aircraft locator screen. As soon as the pilot began to aim the reticle at the target, the locator screen lit up with a bright light, and the reticle spread towards the illumination. The pilot saw the object not only on the radar screen, but also visually. The object sharply approached the plane and began to approach. When there were less than two kilometers left before approaching, the lentil-like object began a sharp turn to the right of the aircraft and, soaring upward, disappeared. All electronic equipment of the aircraft was disabled.<sup>4</sup> On March 21, 1990, a UFO flight was observed in the area of the city of Pereslavl-Zalessky. Here are the reports of military personnel who observed this event: 1) An object resembled a flying saucer with a diameter of 150-200 meters with two very bright lights at the edges. Between the two bright lights there was a less intense glow, reminiscent of portholes. After removing the object, a medium-intensity red glow remained. The movement of the object depended on the flickering of bright side lights: the more often they blinked, the higher the speed of the UFO, and vice versa, when hovering, the object almost completely extinguished the lights. 2) The contours of the object were impossible to distinguish, but two lights were clearly visible, flashing with a certain frequency. The UFO flew like a snake. 3) Apparently, the object was rotating in a horizontal area, since the light source either merged or doubled. The frequency of the UFO lights was 2-3 seconds. The trajectory of its movement is a “snake” horizontally and vertically. 4) Around 22 o’clock the flickering of the object disappeared for 5 minutes. Then a sharp light flashed. The entire cloud was illuminated, after which the object appeared again.<sup>4</sup>

### Cases of UFO sightings at close range

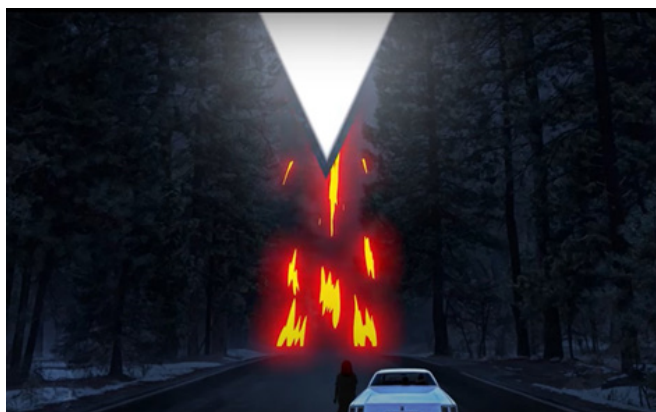
This is an interesting report by K. Morozov about a close-range observation of a UFO, accompanying the plane. It also sheds light on the creation of hallucinations by ball lightning. The Il-14 plane made a night flight on the Voronezh-Moscow route. While inspecting the engines through the window, Morozov noticed a glowing red ball that was catching up with the plane on the right along the course. He immediately reported this to the commander. The commander instructed him to watch the ball. The ball approached the plane, came close to it, passed between the stabilizer and the left plane and disappeared from view. After some time, Morozov saw that a ball the size of the disk of the moon was again approaching the plane. The disk quickly approached the right wing and suddenly, flashing, turned into a huge round luminous object with a diameter of about fifty meters.

Gradually the ball began to align with the plane of the plane. It flashed a second time and glowed yellow. After a few seconds, the reddish backlight turned on. By this moment, the UFO was completely level with the plane, and a powerful spotlight hit Morozov’s eyes. Later he noticed that there were two light pillars – on the left and on the right. The “uninvited fellow traveler” pressed closer and closer to the plane. Because of the bright light, Morozov recoiled from the window for a few seconds, and when he approached it again, he saw that the ball had changed position and was no longer directed towards the plane with a plane, but sideways, with an edge, and was a flattened object. Gradually its glow stopped, and Morozov could see it. The object was completely transparent and greenish. It consisted of two separate planes, enclosed one within the other. Between them there were like spacers 60-70 centimeters long, only a little darker in color. Taking a closer look, Morozov saw another dome, placed in the very middle. A golden light seemed to emanate from it. He also saw many rods of different diameters connecting the upper and lower parts of this internal volume. But suddenly this volume began to be filled with some kind of whitish gas, similar to smoke, which came from below. On the left side there were two arcs consisting of diamond-shaped cells. This volume flashed and glowed. And suddenly Morozov saw a man. He was wearing clothes that resembled a clergyman’s cassock and almost completely covered him. His straight hair was combed back and he wore no headdress. When the object moved ahead of the aircraft, its glow disappeared. Then it took a little to the right above the plane and, flashing a bluish light, went forward. And again it was the reddish ball that Morozov saw at the very beginning. This picture was observed by the entire crew of the plane.<sup>4</sup>

In September 1979, an employee of the State Automobile Inspectorate, foreman Vyacheslav Plotnikov, was driving a car GAZ-24 along a street in the Zheleznodorozhny district of the city of Voronezh. He stopped a hundred meters from the railway crossing. Getting out of the car, he turned off the engine, but left the sidelights on. Suddenly there was a loud bang, similar to that produced by an airplane crossing the sonic barrier, and the sidelights went out. Turning towards this sound, he saw a bright glow emanating from a source located 500 meters above the ground. The light was very bright; it emanated in a sharply defined cone from an object that was illuminated by it from below. The object was shaped like a dark lentil, measuring 100-120 m in length and 5 meters in height. The top of the object was also illuminated. At first the object hung motionless. A few seconds later, it sharply went down and landed in a field 400-500 meters from the observer. Plotnikov got scared, got into the car and tried to start the engine. But the starter did not work, the dashboard was not illuminated. Against the dark background of the earth’s surface, the object was barely visible. Suddenly, a chain of lights flashed along the perimeter of its body, illuminated from within by a bluish light. The lights were shaped like portholes. There were about ten of them, each about 1-1.5 times the size of a lunar disk. The upper light source also glowed, but the lower one went out. After a few seconds, two bright beams, reminiscent of spotlights, flashed along the edges of the object. They quickly rummaged around the sky, then across the field, and one of them illuminated the car. After that, both beams went out. The object remained on the ground for about an hour without making any sounds. Then it took off and hovered at an altitude of 500 meters. At the same time, the lower light source burned brightly. Suddenly there was a loud bang, and the object sharply, almost instantly, flew up at an angle of 70 degrees and turned into a small star. Immediately after this, the dashboard in the car lit up. Turning the ignition key, Plotnikov started the engine.<sup>4</sup> The pilot, walking home after the flight, saw on the highway a ball with a diameter of much more than 10 meters, standing on three supports. He decided to come closer to

the ball, but felt an invisible obstacle standing in his way. The air resistance was so strong that it was impossible to take a single step. The force field lasted a long time. After standing for 15 minutes, the pilot decided to return to the airfield. On the road he met a man who also saw this ball. During a conversation with him, the ball flew away.<sup>4</sup>

At 9 o'clock in the evening on December 29, 1980, a car was driving along a single-lane road passing through a pine forest. There were two women in it – Betty Cash (51 years old) and Vickie Landum (57 years old), as well as Vicky's grandson Colby Cash (7 years old). The event occurred on State Farm Road 1485 15 miles from Dayton Texas, a suburb of Huston, Texas, USA. The passengers saw a light above the treetops that appeared and then disappeared. After a few minutes, the light became very strong and they saw a bright diamond-shaped object hovering over the road. Betty slammed on the brakes and stopped the car near the object. As she braked, her palm pressed against the dashboard and left a dent in it: the plastic panel had become soft from the heat emitted by the object. All three got out of the car. A huge "ship" hovered above the earth (Figure 2).



**Figure 2** An unidentified flying object observed on December 29, 1980 near the city of Dayton (USA) (reconstruction).<sup>7</sup>

Flames emitted from its lower part and heat emanated. It made loud noises that hurt their ears. The bright light of the object hurt their eyes. The grandmother and grandson returned to the car, while Betty remained outside and even walked closer to the object. She stood like that for 5 minutes. But the heat became stronger, she felt that her body was "burning" inside, and decided to return to the car. But the car door handle became hot and it was impossible to touch it with a bare hand. Pulling her coat sleeve over her hand, she turned the door handle and got into the car. Everyone in the car was terribly scared. Betty had the idea to turn the car around and drive away. But the road was narrow, there was a lot of mud on it from the recent rain, and she abandoned this idea. But suddenly she discovered that the car would not start, as if the "ship" had short-circuited the ignition. The car stood near the "ship" for about 20 minutes. The object began to rise. Once above the trees, it bent down and slowly flew south toward Galveston Bay. When the "ship" flew away, Betty was able to start the car. Suddenly the radio started working. It was turned on, but was silent for 20 minutes while the car was next to the "ship". Betty drove Vicki and Colby home and went to bed. But this was only the beginning of their torment. They all had the same symptoms: thirst, headache, stomach pain, nausea and diarrhea. Their vision deteriorated, their hair began to fall out, and skin became inflamed, like a sunburn. Vicki Landrel developed cataracts in one eye. Betty Cash, who was outside the longest, was hit the hardest. The next day, blisters appeared on her skin and she was admitted to the hospital. Two days later, her daughter visited her in the hospital. She did not recognize her mother: her face was swollen and there were blisters on her skin. Fearing ridicule, Betty did not tell the

hospital about the reasons that caused her illness. However, after some time, she told the doctors what happened to them. Doctors determined that this was due to radiation damage. Betty Cash was later diagnosed with breast cancer. She was hospitalized for years and died in 1998, 18 years after the incident. Vicki Landrum died in 2007 at the age of 83.<sup>7</sup>

### Properties of UFOs found based on observations

Based on observations, it is possible to compile a list of the properties of luminous formations appearing in the atmosphere. These are objects ranging in size from 40 to 200 meters, located at altitudes from 0 to 15,000 meters and living from ten minutes to two hours. Most often they have the shape of a ball with a diameter of 40 m to 500 m, and sometimes they look like a disk measuring 100 m × 5 m. Sometimes they take the form of a cylinder, a carriage, have a "tail" and can change their shape. Such an object can move up and down. It can accompany an aircraft flying at a speed of 22 m/s for a long time, staying nearby or following it at a distance of up to 10 km. They can descend to the ground and stay on it for some time. After that, they fly up at speeds of up to 1000 m/s. They disappear, "melting" into the air. These objects emit light. Sometimes luminous points are located along the line and can be mistaken for portholes. The color of an object can change quickly, sometimes the glow is constant, and sometimes it pulsates. They emit conical beams of light that are powerful enough to "pierce" clouds. The beam directed at the observer looks like a white dot surrounded by concentric colored circles. These beams "extend" from objects, much like a tripod extends. Sometimes these rays break off before reaching the ground. When the beam hits a hard surface, it crumbles into "sparkles". There is a "force field" around the ball on the ground that prevents one from approaching it. Being near this object, causes anxiety and fear in people; the electronic equipment of cars and airplanes temporarily breaks down, after deleting the object, its operation is restored. These objects are detected differently by radars operating in the meter, decimeter, centimeter and millimeter wavelength ranges. An object may be invisible to a locator operating in the decimeter range, but visible on the screen of a meter range locator. It often appears as a flickering thunderstorm mark.

The diamond-shaped "ship" hovering over the road on December 29, 1980, demonstrated properties typical of an unidentified flying object.<sup>7</sup> As in the observation of Vyacheslav Plotnikov in 1979,<sup>4</sup> its presence blocked the car's ignition system. The "fire" that flared up in the space between the object and the ground was the glow of electrical discharges. The object's powerful radio frequency radiation caused the car's body to heat up and caused a severe burning sensation in Betty Cash's internal organs. A new property of the object's action was radiation damage to people who were near it. This is the second case of such an action of "large ball lightning" described in the literature. The first occurred in 1886 in Venezuela.<sup>8</sup> The energy core of ball lightning (and UFO) contains relativistic electrons; they serve as a source of synchrotron radiation in the form of conical beams.<sup>9-11</sup> When fast electrons collide with air molecules, powerful X-ray and gamma radiation can be generated.

Let's discuss whether there is anything in common between ball lightning and unidentified flying objects or whether they are objects of a fundamentally different nature. Both ball lightning and these objects are most often spherical in shape, but can also be ellipsoids, cylinders and disks. They emit light in different colors and can change color quickly. They can move in different directions and fall to the ground, leaving holes in it. Both are sources of high-frequency radio emission. Both of them can push people away from them (create a "protective" screen). Ball lightning and UFOs interfere with the operation of radio equipment and affect the human psyche.

However, the so-called “ufologists” draw a clear line between these objects, excluding ball lightning from the UFO class. One of the reasons for drawing this “line” is the difference in the sizes of ball lightning and unidentified flying objects: the former are small, and the latter are large. The reason for this division lies in the fact that some “ufologists” consider unidentified flying objects to be spaceships of galactic aliens. The aliens and the flight equipment must somehow be placed in the ship, which, naturally, must be large. The so-called “contactees” (people who “communicated” with these aliens) talk about conversations with “ufonauts” - humanoid creatures two meters tall, dressed in sparkling clothes that tightly fit their figures.<sup>4</sup> At the same time, two-meter figures often emerge from a one-meter-sized ship.<sup>12</sup> At the same time, there are reports in the literature about ball lightning measuring 100 m.<sup>13</sup> Thus, it turns out that the division of two groups of objects based on the principle of different sizes has no basis. The second criterion is the lifetime of the object. The “average” ball lightning “lives” for 20 seconds, and the “average” unidentified flying object lasts several hours. But here the line between them is also fuzzy. Ball lightning is known to have been observed for several minutes<sup>14,15</sup> and even for more than one hour (ball lightning pulling a train<sup>16,17</sup>). Moreover, if we plot the dependence of the lifetime of ball lightning on its diameter and extrapolate it to a region of about 100 m in size, it turns out that such ball lightning can “live” for several hours.<sup>18</sup> Therefore, it is quite acceptable to assume that there is no difference between the two groups of objects and the UFOs are large ball lightning.

### Place of formation and structure of UFO

An idea of the structure of unidentified flying objects and the place of their formation can be obtained based on descriptions of the observation of ball lightning inside clouds. “On August 6, 1976, the AN-12 plane flew along the Aktyubinsk-Chita route. The flight took place at an altitude of 6000 m at a speed of 600 km/h. Not far from the city of Novosibirsk, the pilots got caught in a thundercloud and began to gain altitude to escape the thunderstorm. But the cloud was powerful, and at an altitude of 8000 meters they still could not get out of it. The plane was thrown from side to side, sounds began to be heard from outside, reminiscent of the roar of a nearby cannonade. In front of the porthole, fiery yellow balls with a diameter of 30-40 centimeters stood and flew past. The balls burst with a terrible roar, scattering sheaves of sparks. This lasted 20 minutes, then the thunderstorm was left behind”.<sup>19</sup> “We flew along the Black Sea coast. About halfway through the journey, thunderclouds appeared, illuminated by flashes of lightning. The plane was flying in the clouds at an altitude of 500-600 meters. Multi-colored balls the size of a soccer ball began to appear to the right of the plane. The balls were bright white inside, and on the edges they were multi-colored, like a rainbow. They appeared and disappeared instantly – now in one place, now in another, now very close, now in the distance”.<sup>19</sup> “One day I had to make an emergency landing near the Chinese border. There was cloudiness of 10 points, thunderstorms, lightning, and downpour. The upper edge of the clouds lay at an altitude of 10,500-11,000 meters. There were continuous cumulonimbus clouds, similar to large waves in the ocean – with smooth humpback dips. When the plane entered the ridge of the cloud, it vibrated, shook, and was thrown upward like a piece of wood. I directed the plane down between two waves. The clouds were torn by linear lightning. I went down with almost no fuel. But then I saw something unusual: a lot of ball lightning the size of a large apple was floating inside the thundercloud. This happened at an altitude of 4500 to 6000 meters. For some reason it seemed to me, that it was brighter in the cloud than outside”.<sup>19</sup>

These rare observations from an airplane inside a thundercloud indicate that there may be a large number of ball lightnings inside the cloud. It is natural to assume that inside the cloud there is also a large amount of water, from which the shell of “large” ball lightning can form. Let us assume that the radius of this shell is 5 m and there are 20 ball lightnings inside it, each of which has a charge  $Q_{bl} = 0.1$  C. Let the internal radius of the shell of ball lightning be equal to  $R_{bl} = 0.1$  m. The electric field strength on the surface of such ball lightning is equal to  $E_{bl} = Q_{bl}/4\pi\epsilon_0 R_{bl}^2 = 9 \cdot 10^{10}$  V/m, which is greater than the value  $E_{min} = 2 \cdot 10^9$  V/m found from the Langevin condition.<sup>20</sup> Therefore, all dipoles of water molecules in the shell will be oriented along the electric field vector. Charge carriers  $Q_{bl}$  stretch the shell of ball lightning with the force:

$$F_{Ob} = Q_{bl}^2/8\pi\epsilon_0 R_{bl}^2. \quad (1)$$

A shell of polarized water molecules compresses the shell with a force:

$$F_{sb} = \sigma a_b \cdot 4\pi R_{bl}^2 \text{ grad } E_{bl} = 2 \sigma a_b Q_{bl}/\epsilon_0 R_{bl}. \quad (2)$$

Here  $\sigma = 1$  C/m<sup>2</sup> is the charge density of water dipoles on the surface of the shell. At  $F_{Ob} = F_{sb}$ , the shell thickness is  $a_b = Q_{bl}/16\pi\sigma R_{bl}$ . At  $Q_{bl} = 0.1$  C and  $R_{bl} = 0.1$  m  $a_b = 2$  cm. Let us assume that in addition to the force of Coulomb repulsion of charges, pressure due to the movement of charge carriers of the core of ball lightning acts on the shell. To compensate for this pressure, we increase the thickness of the shell to  $a_{ba} = 5$  cm. The volume of the shell is  $V_{be} = (4\pi/3) \cdot [(R_{bl} + a_{ba})^3 - R_{bl}^3] = 9.943 \cdot 10^{-3}$  m<sup>3</sup>, and the mass is 9.943 kg. The mass of 20 ball lightnings is  $M_{bl} = 199$  kg. Now let's determine the parameters of the shell of a flying object with a radius  $R_{nl} = 5$  m, inside which there are placed twenty ball lightnings with a total charge  $Q_{nl} = 2$  C. The electric field strength on the surface of this object is  $E_{nl} = Q_{nl}/4\pi\epsilon_0 R_{nl}^2 = 7.2 \cdot 10^8$  V/m. The value of  $E_{nl}$  is of the order of magnitude  $E_{min} = 2 \cdot 10^9$  V/m, therefore we can assume that the surface charge density of the dipoles is equal to  $\sigma = 1$  C/m<sup>2</sup>. Equating the force of charge repulsion to the compression force of the polarized shell, we find the thickness of the shell of the object under consideration  $a_{nl} = Q_{nl}/16\pi\sigma R_{nl} = 1.19$  cm. The volume of the shell of the flying object is equal to:

$$V_{nl} = 4\pi R_{nl}^2 \cdot a_{nl} = 3.74 \text{ m}^3, \text{ and the shell's mass is } M_{nl} = 3740 \text{ kg.}$$

The total mass of an unidentified flying object consisting of 20 ball lightning and a shell with a radius of 5 m is equal to  $M_{\Sigma} = M_{bl} + M_{nl} = 3936$  kg, and its weight is equal to  $P_{\Sigma} = 38612$  N. This object can fly in the air if the strength of the electric field acting on its charge  $Q_{nl} = 2$  C will be no less than  $E_{cl} = P_{\Sigma}/Q_{nl} = 1.93 \cdot 10^4$  V/m. Let us assume that the flying object is located under a cloud, the lower part of which has a charge  $Q_{cl} = 25$  C. In this case, the required value of  $E_{cl}$  is located at a distance from the cloud  $R_{cl} = (Q_{cl}/4\pi\epsilon_0 E_{cl})^{1/2} = 3.4 \cdot 10^3$  m.

### Explanation of the properties of UFOs

Thus, it can be assumed that the unidentified flying object is a hollow sphere with a radius of 5-10 meters with a shell of water. Let there be a certain number of ball lightnings with a size of 20-100 cm inside it. These ball lightnings, pushing away from each other, will be located on the inner wall of a large sphere. The volume of each ball lightning is filled with “dynamic electric capacitors” – structures consisting of electrons and protons rotating in closed orbits.<sup>9-11</sup> There are more protons in these structures than electrons, which is why every ball lightning, as well as an unidentified flying object, has an excess positive charge. The electrons orbit at sub-light speeds and emit synchrotron radiation in a narrow beam. This radiation can pass through the wall of the shell of ball lightning and a flying object. In

addition to the visible component of the electron emission spectrum, it contains ultraviolet radiation. It can ionize air caught in the beam area. Because of this, the conductivity of the air inside the beam will be greater than the conductivity of the rest of the air. A spherical flying object constantly loses charge. If a beam of light is directed toward the ground, then, due to the ionization of the air, a conducting channel may appear in it, connecting the ball to the ground. Charges flowing through this channel will create electron avalanches. The gas will begin to glow and the beam will become visible. Near the ground, where the air pressure becomes too high for avalanches to form, the airglow will stop and the beam will appear “cut off.” When a large flying object is located close to the ground, the charge flowing from it charges (positively) nearby objects. Repulsing them away from the main charge of the object creates the illusion of a “force barrier” that prevents one from approaching it. Radio wave radiation generated by an object affects electronic equipment. Since the emitter of radio waves in an object are the elements of its core, which have certain dimensions, the conditions for the object to reflect the radar signal will be different for different wavelengths of the probing radiation. In the observation,<sup>5</sup> a flying object was moving next to an airplane flying at a speed of  $v = 22$  m/s. The friction force of a ball with radius  $R = 25$  m is equal to  $F_{fr} = (C_x/2) \cdot \pi R^2 \cdot \rho_a v^2 = 5.89 \cdot 10^4$  N. (Here  $C_x = 0.3$  and  $\rho_a$  is an air density). If the friction force is compensated by the force of the electric field on the charge  $Q = 10$  C, then the strength of this field will be equal to  $E_{hor} = F_{fr}/Q = 5.89 \cdot 10^3$  V/m.

As we see, the movement of ball lightning at a speed less than the speed of sound can be explained if we assume that the process of air flowing around its shell occurs in the same way as that of an ordinary body. However, it is not possible to explain the movement of ball lightning and UFOs at supersonic speeds in the same way. It is known that they can move silently without creating shock waves. Let's try to understand the physical reason for this. Let's imagine that a body with a sharp profile is moving in the air. The gas flowing onto the tip is compressed, and from this place a compression wave propagates against the flow. It moves at the speed of sound. At some distance from the tip, it “warns” the flowing gas about the presence of an obstacle, and it, “reacting,” changes the direction of its movement and flows around the obstacle.<sup>21</sup> However, if the speed of the body exceeds the speed of sound, then this compression wave no longer has time to “warn” the oncoming flow and, having reached the tip, it instantly loses speed, and a shock wave cone is formed. Ball lightning and unidentified flying objects apparently have some kind of “warning” mechanism of their approach, which operates faster than the speed of sound. Let's consider various options for the operation of this mechanism. Let us remember that ball lightning has an electric charge that flows from it, in particular, in the direction against the oncoming flow. The ions that leak through the shell of ball lightning have the same charge sign as the charge of its nucleus, so they are repelled from the shell. Colliding with water droplets, they stick to them, resulting in the formation of clusters with an elementary electric charge  $e = 1.6 \cdot 10^{-19}$  C. Let us assume that the cluster contains  $n = 10$  water molecules. The mass of a water molecule is  $m_w = M_{gm}/N_{Av} = 18 \cdot 10^{-3}$  kg/ $6.022 \cdot 10^{23} = 2.989 \cdot 10^{-26}$  kg. Here  $M_{gm}$  is the mass of a gram molecule of water, and  $N_{Av}$  is Avogadro's number. The mass of a cluster of 10 water molecules is  $m_c = 2.989 \cdot 10^{-25}$  kg. Let us assume that the cluster has the shape of a sphere with radius  $R_c$ . Its volume  $V_c = 4\pi R_c^3/3 = m_c/\rho_w = 2.989 \cdot 10^{-29}$  m<sup>3</sup>, and its radius  $R_c = (3m_c/4\pi\rho_w)^{1/3} = 0.415 \cdot 10^{-9}$  m. Here  $\rho_w = 10^3$  kg/m<sup>3</sup> is the density of water. The cross section of the ball is  $\sigma_c = \pi R_c^2 = 5.4 \cdot 10^{-19}$  m<sup>2</sup>. In a strong electric field  $E$ , a charged cluster moves in the air at a speed:<sup>22</sup>

$$v_{dr} = (eE/m_c N_a \sigma_c)^{1/2} \quad (3)$$

Here  $N_a = 2.687 \cdot 10^{25}$  is the number of air molecules in one cubic meter. Substituting numerical values into formula (3), we obtain  $v_{dr} = 0.192 \cdot (E)^{1/2}$ . In the considered above UFO with a radius of 5 m, containing a charge of 2 C inside the shell, the electric field strength on the surface is  $E = 7.2 \cdot 10^8$  V/m. At this field strength, the speed of movement of a cluster consisting of ten water molecules is  $5.15 \cdot 10^3$  m/s. At the same field strength, a singly charged cluster of 100 water molecules moves at a speed of 757 m/s, and a cluster of 1000 molecules moves at a speed of 111 m/s. Thus, small-sized clusters are capable of moving towards the flow of incoming air at a speed greater than the speed of sound and can play the role of an agent warning of the approach of a flying body. In addition, there is another possibility of creating a harbinger of an approaching body. In a strong electric field near the surface of ball lightning, a glow discharge is ignited, the optical spectrum of which has an ultraviolet component. The light propagates towards the gas flow and creates positive and negative ions at a distance from the tip. Moving in the electric field of the main charge of ball lightning, these ions transmit momentum to the molecules of the oncoming flow and change the conditions of its movement. It is quite possible that this mechanism also operates in subsonic gas flows. This leads to an increase in the thickness of the boundary layer of gas flowing around ball lightning and, accordingly, to a decrease in the force of its friction with the air.

Gaidukov<sup>23</sup> searched for the reasons for the existence of low resistance when ball lightning moves in the air. He came to the conclusion that “both the flow of air molecules from external space and the flow of particles of matter from the ball lightning itself do not pass through the surface of ball lightning. There is only a quasi-stationary flow of electrons into the ball lightning. Electrons are formed by the interaction of air molecules with the substance of ball lightning on its surface. Because of this, the magnitude of the positive charge of ball lightning is constantly decreasing. The interaction of the flowing charge with the surrounding air leads to the fact that ball lightning behaves in a viscous air flow like an indeformable ball in a flow of an ideal incompressible fluid. As a result of this effect, large ball lightning is captured by the sources of the aircraft's engines and pursues it at a speed of 150-200 m/s, while maintaining its spherical shape and a constant distance from the tail. Near the surface of ball lightning, the air flow practically loses its viscous properties”.<sup>5,24</sup> As we see, ball lightning, which has a positive electric charge, is, in principle, capable of changing the conditions of air movement near its surface.

## Conclusion

This article completes the series of articles devoted to the description and explanation of the properties of ball lightning.<sup>17,25-30</sup> According to our model, ball lightning is an object with an uncompensated electric charge.<sup>9-11</sup> This approach to solving its problem makes it possible to explain a wide range of phenomena of different scales – from several microns to tens of meters. In the theory of ball lightning, the main problem is the need to explain how energy with a density  $\rho_E = 10^{10}$  J/m<sup>3</sup> can be contained inside a ball with a radius of 10 cm. If this is the kinetic energy of particles, then, according to the virial theorem, they must exert pressure on the wall of the vessel, in where they are located, equal to  $P_E = 3 \rho_E = 3 \cdot 10^4$  MPa =  $3 \cdot 10^5$  atm. This is a fantastically high pressure, which can hardly exist in such an “ephemeral” object as ball lightning is considered to be. Therefore, for a long time, it was natural to strive to somehow “bypass” the requirement of the virial theorem and find forces of a different nature that hold the matter of ball lightning in a limited volume of space. For example, Dijkhuis<sup>31</sup> believes that this force is the magnetic attraction of very

close electrons. Protons rotating around threads of electrons serve as an accumulator of kinetic energy. According to Callebaut,<sup>32</sup> the energy of ball lightning is stored in the form of a magnetic field generated by an eddy electric current. Bychkov<sup>33</sup> suggests that the energy keeper of ball lightning is hot steam and the chemical energy of oxidation of its substance. If we assume that ball lightning, in addition to the energy of the particles that form it, also has an electric charge, then the task of explaining its existence becomes even more difficult. If ball lightning with a radius  $R = 10$  cm has a charge  $Q = 10^{-2}$  C, the pressure force of the charges on the container wall will be  $P_Q = \frac{Q^2}{32\pi^2\epsilon_0 R^4} = 3.6 \cdot 10^3$  atm. A quarter of a century ago, a new task of explaining the mechanism for holding large charges in a limited volume of space came from micro-particles. In the experiments of Shoulders,<sup>34</sup> Matsumoto<sup>35</sup> and Mesyats,<sup>36</sup> compact clumps of like charges were observed that existed for quite a long time and had high energy density. To explain the structure of such objects, various models have been proposed, among which the most reasonable is the Sapogin's model.<sup>37</sup> According to this model, the spherical layer of like charges has a configuration that promotes the appearance of a hypothetical self-consistent electric field in it. The presence of this field leads to a non-uniform distribution of charges and the appearance of a gradient force that prevents Coulomb repulsion of charges. Our approach to determining the principles for creating systems that hold charges of the same sign together is close to the Sapogin's approach. However, unlike he, we are not considering a homogeneous configuration, but a heterogeneous one. The agent that creates the force that holds charges of the same sign in a limited area of space is a separate system – a shell of polarized molecules. The shell creates a mechanical force due to the same electric field that causes the charges to fly apart.

It can be considered that the desire to solve the problem of ball lightning has led to results that cover a wider area of natural phenomena. This actually led to the creation of a new field of physics, and we are at the very beginning of its exploration. It is difficult to predict the practical results that can be expected from solving specific problems in this new area. A possible application of the principles underlying ball lightning is the creation of new batteries of electrical energy and the development of new methods of aeronautics.

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## Conflicts of interest

None.

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