

Ball Lightning Penetration into Closed Rooms: 43 Eyewitness Accounts

A. I. GRIGOR'EV, I. D. GRIGOR'EVA, S. O. SHIRYAEVA

Department of Physics, Yaroslavl State University, Sovetskaya 14, Yaroslavl, 150000, Russia

Abstract 43 Eyewitness Reports on the ability of ball lightning to penetrate into rooms through window glass (very often leaving no holes) and to enter houses through radio and electric sockets are presented.

Introduction

Many mysterious and unexplained events are related to ball lightning (BL)—a largely unexplored geophysical phenomenon. Present science is not ready to provide a reasonable explanation for the formation, structure, shape and lasting existence of this physical object. Meanwhile, ball lightning appears to be a dangerous phenomenon of nature and close contact with it sometimes leads to unpleasant consequences for accidental witnesses. It is this danger that provides a ground for creating myths. A number of abilities attributed to ball lightning are pure fantasy. Others—like the ability to melt and vaporize wires and ruin radio equipment—can be explained within the framework of known physical laws. But among other mysterious BL properties its ability to penetrate through window glass leaving it unaffected and to leap out of radio and electric sockets are distinguished for their being unrealistic from a physical viewpoint. Nevertheless, many eye witnesses of different ages and education levels, from different cities and countries claim to have seen these processes with their own eyes. And the fact that their descriptions are similar suggests that they are telling the truth.

Since BL is an insufficiently explored geophysical phenomenon, collecting and analyzing information on its natural behavior remains the main source of information about BL, as it was centuries before. This is the main aim of the authors of this paper, who during several years have collected 5315 previously unknown descriptions of BL and prepared them for statistical analysis by computer. Some preliminary results of this research were published by Grigor'ev (1989, 1991). See also the collections of BL descriptions by Rayle (1966), McNally (1966), and Stakhanov (1985). Given in the present paper is the evidence of extremely exotic properties of BL reported by independent observers, which cannot yet be reasonably explained within the framework of contemporary science, but understanding them may provide a clue to the mystery of the origin and structure of BL.

Window Glass Penetration by Ball Lightning Without Damage

Any science is based on facts. Facts in BL studies are the reports by eye-witnesses who are often frightened by the unexpected and dangerous appearance and as a result are not always objective. Nevertheless, scientists do not have at their disposal anything better than BL descriptions. So let us refer to eye-witnesses and begin with the description given in one of the earliest scientific books on ball lightning written by W. Brandt (1923), who was the first to introduce BL properties into the category of those deserving scientific exploration.

1. June 22, 1914, Hanenklee.

Between 6:00 and 6:30 p.m. during a heavy rain, counselor Kulgatz was sitting at the table with two neighbors in a closed veranda, his left side to a glass wall. Another group of people sat at the next table. The eyewitness saw a fire ball 10–15 cm in diameter pass into the room through upper glass, flying slowly in the direction of the nearby table, above which it exploded producing sound as loud as a cannon report. No one suffered, but telephone and electric wires in the room were melted. There was no hole in the window glass through which the ball had passed."

And here is a description from the collection of the facts of BL observations in Germany (Rodewald 1954), not included in the book by Brandt, which was later frequently referred to. See for example, Silberg (1965) and, Powell (1969).

2. July 27, 1952, witnessed by T. W. Kohn of Hamburg meteorological observatory.

"A few seconds after a close discharge of lightning we saw outside behind a window a bright luminous ball the size of a fist moving downwards along a curved trajectory. This luminous ball passed inside the room through the glass of a closed window, moved one meter into the room, made a 90° turn, moved further into the room parallel to the wall and then disappeared with a sharp loud blast. The ball had a violet-and-blue color tinged with red. The observation lasted three seconds. The ball caused no damage either inside or outside the room. After the explosion there remained an odor typical to electric discharges."

A description taken from the monograph on ball lightning by S. Singer (1971) is equally interesting:

3. The year 1960.

KC-97 USAF tanker airplane was on a blind flight in the clouds at an altitude of 5400 m. There was weak precipitation with a temperature above 0° C. St. Elmo lights appeared at the binding of front windows. The pilot saw a yellow-white ball penetrate inside through the windscreen passing between him and the second pilot at a speed of a running man. The pilot waited tensely for an explosion to come. The ball flew along the passage, passing the navigator and the flight mechanic. In approximately three seconds the refueler reported by intercom from the rear compartment that a fire ball had rolled through the rear compartment and disappeared into the clouds moving along the right wing. The ball did not produce any sounds.

Among 5315 previously unknown descriptions of BL collected by the authors of the present paper there are 42 cases where BL penetrates through glass without damaging it. We now give some of them.

4. *July 1957, Biysk, a town in Altai territory, observer M. D. Treshetkina.*

"It was the middle of the day, around 3 p.m. It rained heavily and there was a thunderstorm. At the table beside the window sat my elder son, his face to the window; to his left on the bed sat my younger son. They were doing their homework. I was sitting on another bed, not near the table, but somewhat further away. Suddenly, during a strong discharge, a little ball that looked very much like a bright electric bulb of 100 W flew in through the window glass. It flew over the elder son's head 0.5 m from him, then lowered a little towards the furnace. The ball moved rather fast, but at the same time somewhat smoothly since we all distinctly saw a bright ball, not just a glaring line. The ball turned back from the furnace and, after flying a little backward, exploded near my feet (15 cm above the floor and 8–10 cm from my leg). I was barefoot but felt no heat. As for the sound, it was like someone had smashed an electric bulb. I observed the ball lightning not very long, 3–5 seconds. I stood up to check the glass. It was intact, but from the outside there remained a round dry area, while the rest was all wet with heavy rain."

5. *Summer 1948–1949, Sursk, a town in Penza Region, observer V. Rubtsova, born in 1906, a nurse.*

"In the hospital there was a small two-bed ward some 3 meters long. A woman patient lay on one bed, I sat on the opposite one. There was a large high window between the beds, a bedside table, a small passage. It was afternoon. A thunderstorm roared outdoors. Suddenly I heard the ringing of glass in the upper part of the window and immediately an orange fire ball approximately 22–23 cm in diameter appeared. Very even, without changing direction the ball flew from the window through the room, simply penetrated the wall above the door and disappeared. The hospital is a brick building, its walls very thick. I walked out of the ward but nothing was there and nobody saw anything. There was no explosion, the ball penetrated the wall quietly without a single spark. But when it entered through the window there was a strong sound of vibrating glass, it even seemed to me that the glass broke. But when I climbed the window-sill and examined the glass it was completely intact, without damage. It all occurred in 8–10 seconds."

The brightness of the ball lightning was like that of the full moon when it is red. Its speed was about 30–40 cm/s. It passed the observers at 1 m distance, they felt no heat.

6. *August 1969, village Kortkeross, Komi Autonomous Republic., observer N. K. Arkhimenko, born in 1938, a teacher:*

"During a thunderstorm, the woman who owned the apartment where we were hiding from rain suggested to turn the lights off, went to a socket and pulled out a plug, while I clicked the switch since I was sitting nearby. At this moment

from two places simultaneously—from the radio socket and from inside the switch—came strange hissing, not very strong sharp clicks (two, one after another), and two brightly-violet balls a little larger than billiard balls (6–7 cm) rapidly fell out from the socket and from the switch. The balls moved fast along the diagonals of the kitchen, touched one another producing one more clicking sound similar to a weak spark discharge, and leaped outside through the window glass. We all rushed to the window. The balls were already on the ground, in one or two seconds they disappeared. The glass on the windows was intact, but the socket and the switch were charred. The wires were undamaged—the safety device was in place."

The observation lasted 3–4 seconds inside the house and 1–1.5 seconds outside through the window. The balls themselves looked not uniform, but as if composed of a vast number of smaller balls, in fact dots, 1–1.5 mm in diameter, engaged in chaotic motion but remaining within the limits of the big ball.

7. The middle of August, 1986, Kholmsk, a town in Sakhalin Region., observer V. I. Polzikova, a kindergarten employee 30 years old.

"At about 3 p.m. a thunderstorm was about to begin, lightning flashed one after another, it started to rain. During the thunderstorm I closed all upper windows and stood in the kitchen watching the thunderstorm. Suddenly, simultaneously with a flash of lightning, through the closed upper part of the window a bright yellow ball of the size of a tennis ball (2–3 cm in diameter) flew in like a bullet. It collided with the wall between a switch and an electric meter and stopped, spinning around its axis. Small sparks sprinkled from its surface, and its swift motion was like that of a sunbeam reflection. Then came a not very loud sharp electric discharge. No traces remained on the wall near which the ball had rotated. It all took place during some 4–5 seconds. In about five minutes a woman neighbor with whom we shared the apartment came out of her room. Suddenly lightning flashed again, and once again an extremely bright white ball flew into the room, but this time not through the upper part of the window, but from the window sill level. This "unexpected guest" flew into the kitchen like a bumble-bee, turned sharply into the corridor, began to fling back and forth there illuminating everything around. In two or three seconds there was an electric discharge a little louder than the first one and the ball disappeared. The ball lightning moved a speed of approximately 5 m/s and had the brightness of an electric arc."

8. July 1978, village Lys, Kemerovo Region, observer H. I. Jakovleva, 48 years old.

"At 6:20 p.m. that day a mighty thunderstorm broke out, clouds hung very low above the earth, lightning struck one after another. My husband and I were eating supper at the table that stood right under a big window. My husband finished eating, stood up from a wooden stool to switch off the refrigerator. Suddenly I saw a very bright, round ball, 10–12 centimeters in diameter, fly through the window glass, and with a thunderous sound hit against the edge of the stool on which my husband sat, and fall into pieces. I was very frightened, my hus-

band said: 'My foot hurts, the toes.' We examined his foot but there were no injuries. The stool was also undamaged, no traces of burns or scratches. And then suddenly a second similar ball flew in from the window, struck with the same thunder against the edge of the stool and fell to pieces producing sparks like those from electric welding. The stool again remained intact."

The balls that flew in were light-yellow, their brightness reminiscent of a full moon. They moved at a speed of approximately 1 m/s and during collision broke into a number of fragments 40–50 cm from observers who felt no heat. About 10–12 seconds passed between the moments when the first and the second ball lightning appeared.

9. Moscow, observer I. G. Orekhova.

"It was a powerful thunderstorm with rain. Streak lightning discharges flashed one after another. Practically simultaneously with a flash of a very strong discharge a luminous orange ball began to puff out of an electric socket (as a soap-bubble out of a straw). Its shape constantly changed. When its size reached the size of a football, it separated from the socket and flew across the room toward the window. It passed through the glass without slowing down or changing shape, as if there was no glass at all. Later I found no hole in the glass. Outside, after flying several meters from the window, the ball loudly exploded."

10. September 1984, village Pyrja, Khanty-Mansiysk region, observer L. P. Doronin.

"During a very severe thunderstorm into the room right through the window glass slowly entered a glaring little ball 4–5 cm in diameter. It passed through the glass without changing its shape as though there was no glass at all. It struck against a metal ball decorating the bed, bounced back towards the window and left through the glass as slowly as it had entered. When the ball hit the bed there came a melodious sound similar to the sound of a tuning fork. It all lasted 5–7 seconds. The glass through which the ball passed twice bore no traces whatsoever."

11. July 1950, 8 p.m., Orsk, a town in Orenburg Region, observer H. A. Shachneva.

"After a short thunderstorm with heavy rain a big puddle was formed in the yard, and my son with his friends began running in it. But then a new thunderstorm was about to start and I called my son home. As soon as he came in I began to wash his feet in a basin that stood on the floor. It was then that I heard a cracking sound coming from the window. I raised my head and saw a fire ball 8–10 cm in diameter that flew through the window glass. The ball did not change as it passed through the window. It flew directly at us and blew up between me and my son (approximately 15 cm from me). The sound was like a shot of an air rifle. My son and I were not injured. I found no hole in the window glass."

12. The summer of 1956, Pskov, observer K. G. Ustinova.

"At noon, during a strong thunderstorm I was serving at the table. Just as I turned towards the window, I saw a fire arrow flying directly through the win-

dow glass. Rather, it looked like a stick 2–4 cm wide and 40 cm long. At a speed of 3–4 m/s this 'arrow' flew one meter from my father who was sitting on a bed besides the window, passed very close to me and, after skirting the Russian furnace, flew out through a closed door. How it could have passed through the door neither I, nor my father were able to see from where we were. But it did fly towards the door and vanished there in complete silence, probably flew away. The color of this 'arrow' was orange and it shone as a 75 W lamp. We felt no heat. It all lasted 1–2 seconds. My father was 81 at that time. There was no hole left in the glass. The 'arrow' flew as if there was no glass at all."

13. July 27, 1987, village Golosilovka, Ludinov district, Kaluga Region, observer V. N. Vojnova, an accountant, 66 years old.

"At about noon a light thunderstorm began. Through the double-glass window frame three meters from me a little fire spot entered the room, hung in the air and took the shape of a ball approximately 3 cm in diameter. Its brightness was like that of a 100 W yellow-light electric bulb. It did not move anywhere, just hung there, and later began to turn pale until it faded completely. It all lasted about 6 seconds. Nearby, approximately 70–80 centimeters away, there was a kapron blind and an electric meter, but the ball lightning caused no damage."

14. July 1938, Tukulinsk, a town in Omsk Region, observer M. G. Tukanov, born in 1899, a bore foreman.

"At noon there was a meeting in the office. 20 men or so gathered, all were sitting on chairs and benches along the walls. The doors and windows were tightly shut. Outdoors a thunderstorm was about to start, but there was still no rain. Suddenly, a bright-red fire ball approximately 15 cm in diameter entered through the glass in the window. Somewhere in the center of the hall about two meters above the floor it exploded with the sound of a rifle-shot. Sparks fell down cracking throughout the entire hall; the hall was filled with smoke, it smelled of burned straw. No one got hurt, there was no damage on the glass. It all lasted about 2 seconds."

15. June or July 1977, countryside, Dnepropetrovsk Region, observer T. A. Varfolomeeva, born in 1955.

"It was evening. There was a strong thunderstorm outside. We were living near the forest, and lightning was striking directly into the forest. We both were in a dormitory room. Suddenly, a ball lightning 1.5–2 cm in diameter flew in through a closed window 1.5–2 m from us. The lightning flew in with a loud cracking sound and hung still between us 1 m away. We did not move. Slowly, at the speed of approximately 20 cm/s, it moved towards the door and left through a keyhole. There it discharged--exploded loudly. We were afraid to touch the door, but someone opened the door, came in and nothing happened to him. In the next room a TV set got out of order, though it seemed to us that the lightning exploded right inside the keyhole. We found no damage on the window glass. It all lasted 25–30 sec."

16. *Village Sosnovka, Novokuznetsk Region, observer B. I Botnar, a fireman.*

"During a fire safety inspection in a boarding-school (an old one-story log building) I drew the tutor's attention to the lamps in the corridor that hung without bowl shades, that they might cause fire. She said that there was no electricity, probably because of a thunderstorm. Then, mechanically, I went and turned the switch. A 150 W lamp flashed brightly, and out of it flew a bright ball 1–2 cm in diameter and fell to the floor. A dark spot formed on the floor paint, but the paint did not start to burn. When I turned the bulb out and thoroughly examined it I found that its base was intact, its glass was intact, no hole whatsoever. There were those long nibs that support the tungsten filament, but no filament."

Damage Caused by Ball Lightning

Among 5315 descriptions of BL collected by the authors of the present paper, there are also 26 cases where eye witnesses report that BL left holes in glass.

17. *May 25, 1897, Bad Szliaes, a small town in Hungary (From Brandt, 1923).*

"During a thunderstorm a fire ball flew into a lobby of a hotel through an open window, flew past two executives at a distance of one meter or so and flew out through a closed window leaving a hole in the glass the size of a fist. Some 15 steps from the building the fire ball collided with a big silver poplar and exploded chipping off a chip 20 cm wide, 2 cm thick and about 10 meters long. The sound of the explosion was similar to a rifle shot. No one was hurt."

18. *Midsummer, 1944, Borovichi, a town in Novgorod Region, observer A. G. Redkinsky.*

"In the middle of the day three of us sat at the table in a little room eating dinner. There was a strong thunderstorm outdoors. Suddenly, after a strong discharge, an orange ball the size of a goose egg that shone as a 200 W lamp, flew through the window into the room. Rather slowly, with a cracking sound, it drifted above the table, rolled along a nickel-plated back of the bed, along the strings of a guitar that hung on the wall (the strings immediately started to sound), then again flew right in front of me (half a meter away) above the table and left through the window. It seemed to me that I felt slight heat coming from it. When we recovered from shock, we examined the window glass and found two perfectly round holes in it the size of the lightning. There were no drops of melted glass. We found nothing wrong with the back of the bed and the strings. There was a light smell of burning in the room. We were watching the ball lightning for approximately 20 seconds."

19. *August 1938, village Parny, Chastin District, Perm Region, observer M. N. Aristova, born in 1921.*

"August 11 was my birthday. In the afternoon (1–2 p.m.) a very strong thunderstorm began, lightning discharges made the windows shake. My father was in

the room, my mother was in the kitchen. I was standing before the mirror trying on my new dress. Suddenly, the whole sky lit up and a fire-yellow round ball with a blue tinge in the middle flew into the room through the window, crushing the glass. It was 8–10 centimeters in diameter, shone like a 100 W bulb, moved at a 2 m/s speed, crackled and produced smoke. It flew to me, touched the fingers of my right hand. It felt very hot, as if someone stuck a needle into my fingers. Then it flew toward the door that had a 10 x 10 cm hole below for a cat to pass. The ball passed out through the hole into the porch. In the porch there was a separator screwed onto a table, and above it 1.5 m from the floor a shelf nailed to the wall with jars of milk and sour cream on it. At that moment a terrible explosion shook the porch, all jars fell to the floor from the shelf. We were all very frightened, my father rushed to me crying 'Are you alive?'. I said 'I am,' but my hand was as if made of cotton. My mother started to rub my hand with liquid ammonia. Daddy went to the porch and when he returned he said that there was a smell of rotten apples. Our neighbors came hurrying in and said that they also saw how a 'fire ball' flew into our window. My hand recovered, but it took a long time before I was back to me senses, probably because I was so frightened. There remained a hole in the window glass the size of a plate, its edges blackened a little. It all lasted 3–5 seconds."

20. Summer of 1910, Odessa, observer-correspondent M. N. Erlichman, an engineer, the story told by his mother:

"Until 1910 my mother was a nurse in one of the hospitals. Once in the summer a powerful thunderstorm broke out, lightning flashed, the rain was heavy and intense. Mother stood at the terrace behind a glass door. Behind her there was another door that led to a machine room. Suddenly, mother saw a white ball tinged with blue, as large as a head of a newborn baby, and it moved directly at her. Mother threw herself aside, the ball drifted slowly past her, leaving neat round holes in the glass in both doors, and moved towards a working machine. There came a peculiar crackle, as if two electric wires came into contact, and the ball disappeared."

21. Summer 1978, Narva, Estonia, observer A. G. Artsivenko.

"Once I was repairing a TV set. I opened the back cover, turned the TV on and began searching for a defect by replacing tubes. I removed a big tube from the right side of the video amplifier (6 M or 6.5 M, I do not remember exactly). Suddenly my attention was caught by a buzzing medium-pitch sound. I started to search for the source of the sound and found it. There is a damper diode in a sweep unit and inside it bounced a small fire ball no more than 3 mm in diameter. Then it remained still for a moment, burned out a hole in the glass bulb of the diode and flew away into the window. I was very frightened—the TV was not mine, neither was the house, and playing with lightning does not do any good. The hole in the bulb was neat, round, no more than 2 mm in diameter. Melted contour of the hole was twisted outward, it was smooth, without sharp edges."

22. *Late September–early October 1960, Vladivostok, observer N. O. Vlasova.*

"I was living in a room in a cellar of a two-story house. It was a cold autumn day and it rained. I lit the stove, first by firewood, then I put in some coal. The fire grew stronger and it became warm. There was nothing on the stove. Suddenly, something red flashed in a slot between cooking-rings and a fire-red ball flew out into the room. I understood at once that it was ball lightning. The ball was not big, 7–8 cm in diameter. It started flying back and forth across the room that was 3 m wide. It was approaching me, but not fast. It was flying in the room from wall to wall at low speed. When approaching the wall, the ball did not touch it, but turned back some 15–20 cm from it. The ball itself looked fire red as if it was red hot. Then, the ball headed along the room to the window at the same low speed. Before my eyes, it flew outside through the glass absolutely quietly, without any noise or crackle, and as it was flying outdoors it was the same ball as before. I saw how it left through the glass, but did not notice any diminishing or lengthening while it was passing through the glass. However, a little hole remained in the glass, considerably smaller than the ball's diameter. The hole was of the size of a coin, with cindered edge, melted 0.5 cm outward."

23. *August 1943, railroad station "Povorino" (in Siberian direction from Stalingrad), observer N. V. Kurnos.*

"A train to Stalingrad was getting ready for departure. We lined up to get permission to board the train from the military commandant. It rained heavily, lightning flashed far away, thunder roared. We crowded into a small corridor. The outside door of the corridor was wide open, opposite it stood a big tree. Above the door there was glass. The door to the commandant's office was opened into the corridor. To the left, at the table sat the commandant and stamped our documents. Opposite the door was an open window. It was my turn, but I did not have time to enter the office. The Commandant took a telephone receiver, and suddenly a small dazzling fire ball flew in through the window and headed toward him. It touched the telephone receiver, rose to the ceiling and flew out into the corridor. There came the smell of ozone and we bent down. The ball flew over our heads outside, not through the door, but through the glass in which it melted out a neat round hole. The blazing ball struck the tree, broke into two halves and disappeared. It all lasted about a second. I was a military assistant doctor and as soon as I came to my senses, I rushed to the office where, pale and silent, lay the commandant. I thought he was dead, but then sensed a weak heart-beat, and soon he recovered consciousness."

These same forms of ball lightning do melt holes in glass. It also may be pointed out that ball lightning which leaves holes in glass more often explodes, causing considerable damage. And this suggests that the energy stored in this kind of ball lightning is greater than the kind which passes through glass without a trace. Nevertheless, a number of facts do not fit into this simple explanation.

24. *August 1965, Vladivostok, correspondent S. V. Kalinchenko.*

"There was a thunderstorm. I was sitting at home near an open furnace. Suddenly, a bright nearly white luminous ball as big as a ping pong ball emerged



Fig. 1. Photo of round glass pieces that fell out of window glass during thunderstorms

inside the furnace flame. It flew into the room, immediately turning dim orange and growing to the size of a fist. The ball flew past me at a distance of 10–20 cm. There were no unusual sensations or pain in the eyes. I tried to touch it with my hand, but the ball moved rather fast (like a walking man) and at the moment when I raised my hand it was already near the window 4–5 m away from me. More than 10 seconds passed since the ball appeared when grandmother entered the room. The air wave from the opening door literally pressed the ball lightning to the window glass (there were single-glass frames in the window). There came a sound resembling a hiss of a flying bullet or a click, and the lightning was already outside. It was caught by a gust of wind, headed upward and out of sight. There remained a hole in the glass through which an index-finger could hardly pass. The edges of the hole were sharp, not melted, its form slightly oval."

25. July 19, 1981, Tyumen, observer M. I. Sidorov, electric engineer.

"It was around 8 p.m. The thunderstorm was nearly over, there were practically no lightning flashes seen in the window. I was about to open the window to let in some fresh air when there came a sharp blast. My wife who stood near the sofa, her face to a glass balcony door, screamed with horror seeing how a luminous little snake flew fast through the glass into the room, immediately melted forming a bright glowing puddle on the floor that vanished right away. A piece of glass was knocked out from the balcony door glass that had the shape of a truncated cone with smaller base approximately 2 mm (inlet hole) and bigger base 6 mm (outlet hole)."

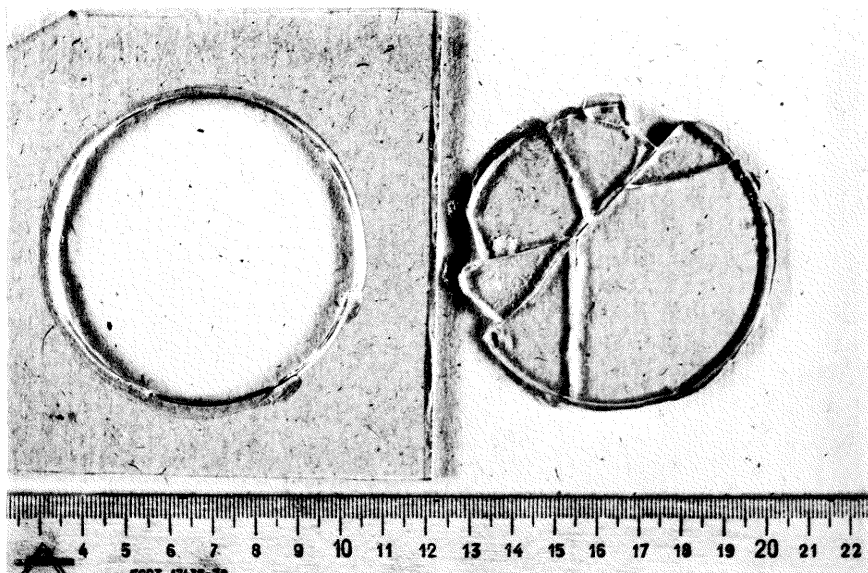


Fig. 2 Photo of window glass with a hole in it formed during a thunderstorm, and of the glass piece that fell out of this hole.

The last report is confirmed by material evidence: M. I. Sidorov has sent us at the University of Yaroslavl the damaged glass together with the knocked-out piece. It has sharp edges and shows no signs of melting. It is worth mentioning that here in Yaroslavl we receive reports on holes formed in window glass during thunderstorms rather often. Unfortunately, in the majority of cases eyewitnesses discover holes in the glass only after the thunderstorm is over and inform us only assuming that the holes were made by BL. Shown on Figure 1 are photographs of round glass pieces that fell out of window glass during thunderstorms sent to us by L. V. Nivina from Arkhangelsk and T. V. Novikov from Taganrog. In all cases the edges are very sharp and it is impossible even to speak of their melting. Shown on Figure 2 is a photograph of a window glass with a hole in it formed during a thunderstorm, and of the glass piece that fell out from this hole, sent by I. M. Barkovsky from Saratov. In the paper by Muller-Hillebrand (1965) a very similar photograph of a window glass with damage is given as an example of heat influence of ordinary lightning. But the same photograph from Muller-Hillebrand (1965) in the book by Iryanitov and Tikhy, (1980) about BL is given as an example of an effect of BL. For completeness sake it is worth mentioning that the damaging of window glass described by Muller-Hillebrand (1965) and interpreted differently by Iryanitov and Tikhytook (1980) place without witnesses, as in the cases illustrated by Figure 1 and Figure 2.

In (Egely, 1987) and (Kolosovskii, 1981) thermal mechanism of BL interaction with glass is proposed. According to Egely (1987), if the heating of glass by

BL is not very strong BL passes through the glass freely. If the heating is considerable, melting and vaporization of glass as well as its cracking due to arising thermal mechanical stresses result in hole formation. In fact, the idea of thermal origin of BL interaction with glass was first proposed and experimentally tested by Kolosovskii (1981).

26. *Summer 1977, Fiazino, Moscow Region.*

"Ball lightning looking like a hairy red ball approximately 5 cm is diameter approached from outside the outer glass of a double-glass window frame of a classroom situated on the second floor of a school building. In the classroom was a teacher and a group of children. A small round hole with luminous red contour was formed in the glass. Then the diameter of the hole enlarged reaching 3-4 cm, and the BL disappeared with a burst of light and loud sound. At the moment when the BL disappeared the teacher who was holding an epidiascope plugged into electric socket in his hands, experienced electric shock. The BL interacted with glass for approximately 5 seconds. As a result, the internal glass remained intact, while a round hole was formed in the external one."

It was this description that the research by Kolosovskii (1981) was based on. During examination of the damaged glass it was found that the edges of the hole were sharp, not melted as one might expect, and the glass at the edge of the hole did not have mechanical stresses. To find the mechanisms that can form such holes, experiments on glass heating by the radiation of a powerful gas laser were performed. It was established that during intense heating of glass the heated region melts and vaporizes. Then as the glass cools a ring-shaped crack forms around the melted region, and a disk containing the melted region falls out. The hole thus formed has sharp edges and does not have mechanical stresses as in BL description cited by Kolosovskii (1981).

It would thus appear that both types of glass damage in descriptions 17-25 can be explained within the framework of (Kolosovskii, 1981). In one case thermal mechanical stresses in the glass are small, the ring crack does not form and the ring does not fall out, the edges of the hole remaining melted. In the other case all proceeds according to the scenario described in (Kolosovskii, 1981), and the resulting hole has sharp edges. But there are two facts that make questionable the reality of such a simple explanation: 1) no one of the eyewitnesses has found a glass ring with melted internal edge and sharp external edge: it appears that there were no glass rings found at all; 2) it remains unclear how BL passes through glass without damaging it.

Interaction of BL with glass is not limited to the two described types: sometimes BL simply breaks the glass when passing through it.

27. *July 1956, village Tartyshovo, Bashkir Autonomous Republic, observer N. M. Jidina.*

"Heavy rain was falling outdoors, lightning flashed. My younger brother and I were home along. There was no electricity in the village. We had a "Roding"

radio set that operated when connected to a battery. Suddenly, lightning flashed and a fire ball of the size of a football flew in unexpectedly through the window. It was tinged with red and blue. We could look at it without blinking since it appeared transparent. There was a hole left in the glass 7 by 10 cm with round edges. This fire ball was flying under the ceiling slowly and silently as a soap bubble, producing blue sparking flashes approximately 1 cm long. There were a great number of these flashes flying around. It became stuffy in the room, and blue gas formed. After skirting a samovar covered by a knitted napkin that stood on the table, the ball approached the radio. After this the radio's power supply was burned out. Then, the ball flew outside, breaking the lower glass in the window."

Such a type of BL interaction with glass was also discussed by Egely (1987) and Kolosovskii (1981) within the framework of thermal mechanisms of BL acting on the glass, where the conclusion is made that such damage may occur during non-locally concentrated slow heating of glass. In this case the glass breaks or cracks appear

28. *1941–45, Leningrad, observer A. V. Lebedeva, an accountant, born in 1910.*

"Our apartment is on the fifth floor. Around 6–7 p.m. the family was sitting drinking tea. A thunderstorm began and I closed the window. I went away from the window and stood near the table. At that moment the lightning flashed very close behind the window, and a golden ball tinged with red of the size of an Antonov apple separated from the window. The ball flew slowly 10 cm above the head of a boy who was sitting at the table, right before the face of a girl, silently hit the side of cupboard that stood nearby, bounced back, flew close to an electric switch and 'broke' into sparks like a Bengal light. The window glass turned out to be cut as if by a diamond. There was a crack across the side of the cupboard from bottom to the top. The switch was not damaged. The ball emitted no heat. It all lasted about 30 seconds."

It turns out that BL may form right on the glass.

29. *The summer of 1941–42, Pereslavl Zalessky, observer V. S. Kirilyuk.*

"In the evening a thunderstorm was about to begin, but there still was no rain. Mother came home from work, lighted the Russian furnace and was cooking food. The kitchen in our village house was small, mother was in it near the furnace, and not far away near the window were my sister and I. On the window, somewhere on the glass, appeared something like a soap bubble, as big as a half of a man's palm (no more than 15 cm). As I remember, it was not exactly a ball, but had a slightly pulled-out shape. When inside the house, it 'vibrated' for a second, like a soap bubble before breaking away from a tube. Then it flew from the window along the kitchen past three of us towards the furnace. Maneuvering between us, changing shape, gleaming, it leaped into the furnace and we lost the sight of it in the fire. It might have 'escaped' through the chimney. There was no sound. It was flying not fast (~ 1 m/s) and was moving along a curved trajectory

carefully skirting us. It lasted 3–4 seconds. My sister and I ran outside to examine the window. In that spot there was a small slot between the glass and the frame, but too narrow even for a mosquito to pass through. There was no trace of a bum or anything like it on the frame. It may have seeped through the slot, but we did not see that. Its color was a pale yellow and pink."

Here is an example of BL interaction with glass that is even more puzzling.

30. June–July 1938, Orenburg Region, the Yulaly mine, observer A. S. Andreev.

"I came to the window. There was a strong rain. It was a wonderful sight: lightning was flashing, rain was as heavy as a waterfall. I stood with my face very close to the glass, my hands holding the window jambs. Suddenly a bright white ball 6 centimeters in diameter emerged outside in front of the glass. It moved right at me, and, when it struck the glass, it broke into little sparks. It all lasted only an instant. I was frightened. It turned dark in my eyes. The sound that came when the ball hit the glass was like a sharp clap. I cannot tell whether there was any trace of the strike left on the glass since I was too scared, and it was very long ago."

31. The summer of 1940, Sudzha, a town in Kursk Region, observer L. T. Fedorovich, an economist, born in 1920.

"During a thunderstorm, a yellow and orange ball about 15 cm in diameter with an undefined permanently vibrating contour crawled into the room through an open upper part of the window. It was not too bright to look at. Silently and slowly it rolled along the wall. It rolled over the door where I stood leaning on the door post to the other room, continued to move towards the window at the opposite side, and crawled outside, squeezing itself through a crack in the glass 1–2 mm wide. The ball flew 20–30 cm above my head. It did not emit any heat. There were no traces left on the wall. It all took place during 1–2 minutes."

32. February 3, 1981, Buzuluk, a town in Orenburg Region, observer Z. A. Samoylova, born in 1903.

"The weather was overcast, the sun could not be seen behind the clouds. There was wind, snow, the temperature was 0–1° C. About 4 p.m. I was sitting in my room, sewing. The sewing machine was on the sofa, and I was sitting on a small bench near the window. Suddenly, through the double-glass window, a fire ball as large as a football (25–27 cm in diameter) flew into the room. Inside the ball I could see a play of different colors: bright red, dark purple, and orange. It resembled the fire of burning wood in a big bonfire or of firewood in a Russian furnace. The ball illuminated the entire room, everything in it. The door to another room was open. Freely and silently, the ball flew across my room and moved rapidly to the next one. After flying 2 meters there, it stopped in the middle of the room. Its appearance changed, now it resembled a white cloud on a blue sky, or smoke, or white colored gas. Then, without moving, it dissolved in the air, disappeared, leaving the smell of burning sulfur. The entire event lasted

2–3 seconds. When I recovered my senses, I stood up, opened the balcony door, checked all electric devices—everything was all right. The smell in the room lasted for 2 hours.

33. July 1957, village Degutishky, Zarasai district, Latvia, observer N. V. Svetlova.

"During a strong thunderstorm my daughter-in-law and I were sitting at home reading. Suddenly there came a terrible clap of thunder and a fire ball, its size 6–7 cm, flew in through a closed window. When it was flying in the room there was a loud crackle. After making a circle in the room, the ball flew out through the same window.

34. June–July 1965, countryside, Kiev Region, observer A. I. Kulish, born in 1911.

"At noon a strong thunderstorm broke out. I was standing and smoking 1.5 meters from a closed window. There came a horrible clap of thunder and after some 15–20 seconds, a ball 13–15 cm in diameter flew in right through the closed window. It was light gray, not bright, like cigarette smoke. It flew slowly, constantly changing shape, as a soap bubble. Heading towards me, half a meter away, it suddenly exploded with a loud crackle, and turned into a spark that flew like a fire arrow into a socket. A cloud of smoke remained at the spot where the explosion occurred. I watched the ball for 3–4 seconds. After the explosion, I could not move for 10–15 seconds. Then I saw that the socket was burned and the wall was all black around it. It turned out later that the whole underground wire got burned. The entire wiring had to be rebuilt."

Emergence of Ball Lightning from an Electrical Socket

We have compiled statistical data on the conditions of BL formation obtained on the basis of 1138 descriptions where our correspondents were witnesses of the fact of BL birth. In 65% of the cases, BL appears to form on conductors (see descriptions 6, 9, 16, and 21).

35. July 1974, Ivanovo, observer E. A. Kniazeva.

"The thunderstorm began early in the morning. I stood up and closed the windows and the chimney. Just as I approached the bed to go back to sleep, a terrible thunder roared and out of the radio-socket above the bed, a spark burst out like lightning, followed by a fire ball the size of a walnut. It fell on the bed and started rolling over the mattress. I stood stone-still with horror, while the ball, after rolling a meter or so, stopped, made a strange rustling sound, and bunches of sparks 20 cm long suddenly began to spurt out of it. All of this reminded me of electric welding. It all vanished as suddenly as it appeared. Only a small hole remained in the bedsheet and in the mattress."

36. May 10, 1978, village Korotygino, Podolsk district, Moscow Region, observer T. V. Vasilyeva.

"About 10–11 a.m. a thunderstorm began. At the moment when I entered the room there came a very strong roar of thunder and the room turned bright with light. At the same instant a very bright, shining ball tinged with mauve, 16–18 cm in diameter, appeared on the light switch above the bed. The next moment the switch started to bum with yellow fire. Both fires touched the wallpaper. 'It's fire! All the village will burn!' I thought, and hit the flame as strongly as I could with the palm of my right hand, and grabbed the burning switch. The shining ball immediately fell into smaller balls that spread around the woolen blanket. It started to smell of burning wool. Both flames faded. With an effort I shook a piece of switch from my hand. Then thunder struck again, and once more a fire ball of the size of my fist appeared on the remaining part of the switch. This time the cord broke and the ball disappeared. Only then was I seized with horror. My hand was burned to the bone, the wound had a white bottom and black burned sides. The skin on the fingers was also burned and black as coal. This wound left a white scar across my palm. The first big ball lasted 2–3 seconds, while the small ones lasted 0.5 seconds. Only the pile was burned on the woolen blanket."

37. October 6, 1967, the Moscow "Vnukovo" airport building, observer N. A. Kitrossky, candidate of chemistry.

"During operation of a cleaning machine, a short-circuit occurred. At this moment from under the panel of a socket connected to the machine by a 5 m long cord, a dazzling yellow ball 10–15 cm in diameter flew out. The ball immediately headed horizontally towards a man who stood no less than 2 m from the socket. When the ball hit this man, he fell. His clothes caught on fire at the point of impact and completely burned out, leaving a hole 20 centimeters in diameter. The victim was carried to the medical room. The socket was almost completely burned, but the cord remained undamaged."

38. June–July 1953, village Troitskoe, Tulgan district, Orenburg Region, observer V. F. Prokhodtsev, a mechanic.

"At 4–5 p.m. the sky was quickly covered by a thunder cloud and lightning discharged approximately a kilometer from our house. I looked at the radio socket to be sure that the radio was unplugged, but it was plugged in. At that moment a light yellow fire ball came out of the socket with the plug in it, and started moving towards me. The ball emitted a bright light. I was sitting in the kitchen reading a book and was so frightened that I could not move. The ball changed direction and began to skirt a plant 1.5 m high and 1.5 m wide, and headed towards the window. The ball, the size of a chicken egg, moved slowly, and shone weakly. Suddenly, with a weak crackle and rustle, the ball broke into a multitude of sparks the size of a pea and spread all over the plant. To my surprise, I found no damage on the plant, when I examined it. It all lasted 5 seconds or so, and during this time, the ball flew 2.5–3 m."

39. May 28, 1977, village Novobureisky, Bureisk district, Amur Region, observer S. S. Rudnoy.

"Around 9 p.m. I was preparing to go to sleep. I turned out the lights and detached the TV antenna. Suddenly there came a loud sound like a shot. The room filled with a horrible blue white light. I lay still, afraid to move. A huge blue white ball hung at the socket, 40 cm or so in diameter. For about 5 seconds it remained unchanged, and then began to diminish. After it reached 10 cm in diameter, it remained this size for about 10 seconds, then disappeared. A green spot the size of a cigarette pack remained on the wall. It turned out that the wire leading to the socket was bare in two places. Approximately one fifth of the socket was broken away, and the antenna plug was burned off. My ears rang for two days after that shot."

The examples cited above lead to the conclusion that BL may form on electric conductors connected to radio or electric wires. However, eye witnesses report that BL may also form at compact metal objects not connected to radio or electric wires, where over voltage formation is very unlikely.

40. Early July, 1934, Zvanovo Region, observer I. N. Galkin.

"Around 6–8 p.m. a strong thunderstorm with hail broke out. I was standing beside my father and mother in the middle of the house. During a strong discharge of lightning, a bright light blue ball the size of a goose egg, covered by a multitude of small lighted needles, separated from a metal rod (1.3–1.4 m long) on which a kerosene lamp hung. After it separated, it flew in the air quietly and easily, like a toy balloon, lowering slowly to a bench near the wall. A still hot samovar was on the bench. When the ball lightning approached the upper part of the samovar, there came an explosion like rifle-shot, and the ball disappeared. From the point where we first saw it to the samovar the ball lightning traveled 3–4 m. All outside doors, furnace cover and chimney shutters were closed. On the upper cover of the samovar there were traces of melting."

This description also points to the fact that BL frequently discharges into metal objects, and is absorbed by a conductor (see descriptions 28, 34).

41. July 1976, Temirtau, a town in Karaganda Region, observer M. A. Mironova.

"The weather was cloudy, but there was no thunderstorm activity. Around 5 p.m. I heard hissing. At the same time a luminous ball that consisted of double dotted lines 2.5–3 mm thick flew through an open balcony door into the room at the height of 60–80 cm above the floor. Its color may be compared to a heated spiral of an electric stove. The ball (50–60 cm in diameter) started to spin while hanging approximately 50 cm away from the doorstep. The entire ball spun and hissed like a swarm of bees. We did not move. After spinning there for awhile, the ball began to move slowly, like a soap bubble in the air, towards the wall. It changed into a conical shape with the sharp end pointing to an electric socket. When it was only a meter from the socket, two continuous 'threads' protruded

from the cone's tip into the socket. This produced a loud noise. The entire ball was pulled into the socket. It is difficult to say how long this all lasted, perhaps about a minute. It is surprising, but the electric wiring was not damaged."

42. Late June-early July 1975, Barnaul, observer G. E. Gustenkova, born in 1942.

"I was working as an electrician at a high-voltage substation. Once during our shift there was a strong thunderstorm with rain. We were sitting in the machine hall where all equipment is situated. My table was near the window that was opened just a little, and the controller's table with a telephone and a radio was 12-15 meters from an empty wall. Suddenly a little snake 'crawled' into the room through the window. It flew in the air near my left ear, above the shoulder. It reminded me of a saw. The upper edge was smooth, the lower edge was saw shaped. It was approximately 0.5 m long and 1.5-2 cm wide. It was yellow blue, bright, and shined as a kerosene lamp. I could feel heat from it or smell it. The snake was not uniform in shape, but looked like it was woven of distinct 'threads'. It flew along a telephone wire to the controller's table and leaped into the telephone which made a noise and stopped working. We found out later that a coil was burned in it. The incident did not last long, a few seconds at least, but I had enough time to have a look at the 'little snake'. All equipment in the hall was grounded."

43. August 1950-51, the town of Syzran, observer A. I. Chekunov, a mechanical engineer:

"Around 11 a.m. a strong thunderstorm began and lasted 7 hours. I, my aunt, and my cousins were in a central room of a 'Finnish house'. My cousin and I were sitting at the table browsing through a book. Suddenly I heard a click behind my back that reminded me of 220 V wires short circuiting. A ball shining with red light, 5-6 cm in diameter, flew between me and my cousin, stopped for awhile near my other cousin who was sitting on my aunt's lap right near the window, and with a light ringing sound slipped into a closed window. There were no traces left, either on the frame, nor on the glass. Aunt, who sat with her face to the spot where the ball appeared, said that it came out of either a telephone or a radio socket (they were close to each other). The telephone and the radio turned off."

Conclusion

Presented in Table 1 are statistical data on the disappearance of BL in 746 cases in which the BL origin was on conductors.

We mention in conclusion that, according to cited descriptions of BL and the statistical data, BL may simultaneously possess two exotic properties to which the present paper is devoted: to originate on a conductor (or to be absorbed by a conductor), and to penetrate through glass without affecting it (see descriptions 6, 9, 16, 34).

TABLE I

Peculiarities of the disappearance of BL which were born on conductors (on 746 descriptions)

BL observation stopped when it	Percent
disappeared from sight	33
exploded	20
disappeared into the ground	10
disappeared into a conductor	9
crumbled into sparks	7
faded quietly	20
provoked explosion	1

REFERENCES

- Brandt, W. (1923). Der Kugelblitz: *Probleme der Kosmischen Physik. H.* Grand, Hamburg, 170 p.
- Charman, W. N. (1979). Ball lightning. *Phys. Rep.* Vol. 54, No. 4, 261–306.
- Egely, G. (1987). *Hungarian ball lightning observations*, preprint. Central Research Institute for Physics. Hungarian academy of sciences. KFKI-10/D. 152 p.
- Egely, G. (1989). Physical Problems and Physical Properties of Ball Lightning: Science of Ball Lightning. *World Scientific*. Singapore, 81–87.
- Grigor'ev, A. I., Grigor'eva, I. D., Shiryayeva, S. O. (1989). Statistical analysis of the ball lightning properties: Science of Ball Lightning. *World Scientific*, Singapore, 88–134.
- Grigor'ev, A. I., Grigor'eva, I. D., Shiryayeva, S. O. (1991). Ball lightning and St. Elmo's fire as form of thunder activity. *Journal of Scientific Exploration*, Vol. 5, No. 2, 163–190.
- Imyanitov, I. M., Tikhy, D. Ya. (1980). Beyond of the low of science. *Gidrometeoizdat*, Leningrad, 190 p. (in Russian).
- Kolosovskii, O. A. (1981). Investigation of traces of ball lightning on the window glass. *Sov. Phys. Tech. Phys.* Vol 26, No. 4, 510–511.
- McNally, J. R., Jr. (1966). *Preliminary Report on Ball Lightning*. Oak Ridge Nat. Lab., O.R.NL 3938
- Muller-Hillebrand, D. (1965) *Lightning Protection: Problems of Atmospheric and Space Electricity*. Elsevier ed., S. C. Corotniti, Amsterdam, 407–435.
- Powell, J. R., Finkelstein, D. (1969). Structure of ball lightning. *Advances in Geophysics*. Vol. 13, 141–189.
- Powell, J. R., Finkelstein, D. (1970). Ball lightning. *Amer. Sci.* Vol. 58, May–June, 262–280.
- Rayle, W. D. (1966). *Ball Lightning Characteristics*. Rept. N.A.S.A., T.N.O., 3188.
- Rodewald, M. (1954). Kugelblitzbeobachtungen. *Zeitschr. f. Meteorologie*. Bd. 8, H.1., 27–29.
- Silberg, P. A. (1965). A review of ball lightning: Problems of Atmospheric and Space Electricity. Elsevier, Amsterdam, 436–454.
- Singer, S. (1971). *The Nature of Ball Lightning*. Plenum Press, New York.
- Stakhanov, I. P. (1985). *On the Physical Nature of Ball Lightning*. Ed. Energoatomizdat, Moscow, 208 p (in Russian).