Optik 127 (2016) 5876–5881

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

How the ball lightning enters the room through the window panes

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ARTICLE INFO

Article history:
Received 17 February 2016
Accepted 13 April 2016

Keywords:
Ball lightning
Fire ball
Nonlinear optical medium

ABSTRACT

It is shown that Ball Lightning in a form of a self-confined light consisting of a thin spherical layer of a strongly compressed air where an intensive white light is circulating in all possible directions can penetrate into room through window panes. Only light penetrates through the pane. The compressed air cannot penetrate through the pane. But the air is located indoor in the room. The light compresses this air indoor in the same manner as it compressed the air outdoor. No plasma is connected with the natural Ball Lightning.

1. Introduction

Currently, it is well established that Ball Lightning (BL) can penetrate through window glass, sometimes destroying them, but in most cases leaving them intact. A damage, if any, is local in nature and is in that region, through which BL penetrated. In work [1], 43 cases of penetration BL indoors are described. It should be noted that a vast majority of BL theories cannot explain this BL property and therefore must be rejected. This applies to all theories where any particles: electrons, ions, clusters, plasmas and so on are used. It is known that the particles cannot penetrate through glass. Glass flasks and test tubes used in the chemistry, as well as glass cathode ray TV tubes through that cannot pass electron are a good confirmation of this.

We consider an object that can be characterized in modern terminology as an optical incoherent spherical space soliton (SSS) [2] that can penetrate in room through windowpane. SSS can be imagined as a thin spherical layer of the strongly compressed air where the conventional white light is circulating in all possible directions. The refractive index of the layer is greater than that of the surrounding space and the layer shows itself as a planar lightguide, the curvature of which is different from zero. The lightguide prevents radiation of light in free space. In turn, the circulating light compresses the air due to the electrostriction pressure. The energy of the light is significantly greater than the energy of the compressed gas. As a result, the behavior of the SSS obeys the laws of optics rather than laws of mechanics. This facts explains puzzling and intriguing behavior of Ball Lightnings in atmosphere.

In accordance with the Snell law, the light beam propagating in an inhomogeneous optical medium deflects in the direction of the gradient of the refractive index of the medium. In this case, SSS located in an inhomogeneous optical medium in a form of conventional terrestrial atmosphere moves along the gradient of the refractive index of the air.

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http://dx.doi.org/10.1016/j.ijleo.2016.04.056
0030-4026/

Unlike a child balloon where the air pressure within the balloon is greater than the outside pressure, the pressures within and outside SSS are identical. This provides the great deformability to SSS. If SSS is located in the air, the gradient of the refractive index of which is changed noticeably at the distance that is comparable with SSS size, SSS is subject to deformation.

SSS is the very sensitive device for determination of the air inhomogeneity. Indeed, the light makes about billion revolutions per second. If the displacement of SSS is equal to 1 nm per one revolution then SSS moves at 1 m per one second. That is why speeds of natural Ball Lightnings vary in a wide range.

The noticeable change of the gradient takes place near any obstacle. In this case, SSS heats up the obstacle due to the absorption of the light radiated by SSS. The obstacle heat up layers of surrounding air due to the heat conductivity. As a result, the refractive index in these layers decreases and the gradient is directed from the obstacle. Moving along the gradient, SSS bypasses the obstacle.

Usually, any holes and slots are located between two regions where the temperature of the air can be different. As a result, the gradient of the temperature and, therefore, the gradient of the refractive index takes place near the holes and slots. That is why SSS is not indifferent to the holes and slot. Any window can be considered as a hole confined by a windowpane. The homogeneity of the air is violated near a window in the same reason as that is violated near an open hole.

These obvious and simplest properties of SSS are sufficient to explain the abnormal behavior of natural Ball Lighting [3–13]. Below we will consider in detail a process of penetration of SSS through window panes. This process is not able to explain most of the known theories. That is why the last recent theory [14] is focused on the explanation of the process

2. Evidence of eyewitnesses

There is numerous evidence of eyewitnesses about Ball Lightning penetration through windowpanes [15,16]. We present several cases taken from these sources to show that this BL property is a reliable fact. The eyewitness saw a fire ball 10–15 cm in diameter that 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."

> "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 downward along a curved trajectory. This luminous ball passed into 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 for electric discharges."

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 the front windows. The pilot saw a yellow, white ball penetrates 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 regulars reported by intercom from the rear compartment that a fireball had rolled through the rear compartment and disappeared into the clouds moving along the right wing. The ball did not produce any sounds.

> "Suddenly, during a strong discharge, a little ball, that looked very much like a bright electric ball light 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 s. I stood up to check the glass. It was intact, but from the outside, there remained around the dry area, while the rest was all wet with heavy rain."

> "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 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 s. The glass, through which the ball passed twice, bore no traces whatsoever."

> "I heard a cracking sound coming from the window. I raised my head and saw a fireball 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."

> "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 s. Nearby, approximately 70–80 cm away, there was a kapron blind and an electric meter, but the ball lightning caused no damage."

"Suddenly, a bright-red fireball 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 s."

"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."

"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 m long. The sound of the explosion was similar to a rifle shot. No one was hurt."

"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 table and left through the window. It seemed to me that I felt slight heat coming from it. When we recovered from the 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 s."

"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 cm in diameter, shone like a 100 W bulb, moved with 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 10×10 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 my senses, probably because I was so frightened. There remained a hole in the window glass the size of a plate, it sedges blackened a little It all lasted 3–5 s."

"Once in the summer a powerful thunderstorm broke out, lightning flashed, the rain was heavy and intense. The mother stood on 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."

"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 speeds. 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."

"Aluminous little snake flew through the glass into the room, immediately 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)." "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 as 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 an electric socket in his hands, experienced electric shock. The BL interacted with glass for approximately 5 s. As a result, the internal glass remained intact, while a round hole was formed in the external one."

"Suddenly, lightning flashed and a fireball 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 fireball 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."

"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 the 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 the bottom to the top. The switch was not damaged. The ball emitted no heat. It all lasted about 30 s."

"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 s. 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."

"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 min."

"Suddenly, through the double-glass window, a fireball as large as 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 m 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 s. When I recovered my senses, I stood up, opened the balcony door, and checked all electric devices-everything was all right. The smell in the room lasted for 2 h."

"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 fireball, 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."

"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 a while, 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. 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. An aunt, who sat with her face in 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."

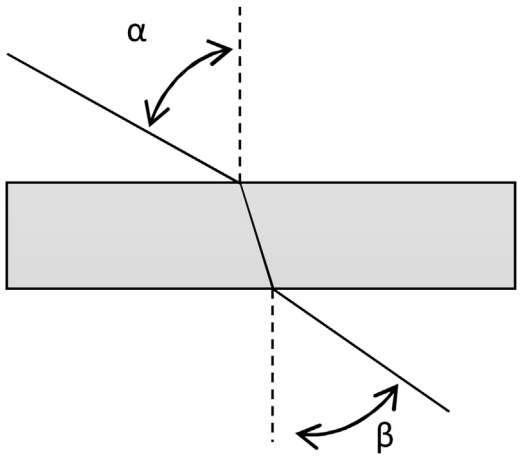

Fig. 1. Propagation of a light beam through a plane transparent plate.

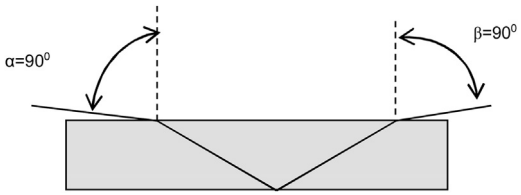

Fig. 2. Total inner reflection from bottom surface of a plane glass plate.

3. Explanation of penetration

BL detects window just as it detects a hole in the walls because distributions of the air density near the windows and slots are identical. In addition, in fact, in both cases, the gradient of the refractive index of the air should be directed to the room. If the room temperature is lower than outside, the heat penetrates into the room through the window glass. It is known that the heat propagates in a direction opposite the temperature gradient. This means that the temperature gradient directed from the inside to outside. The direction of the gradient of the air density is opposite to the direction of the gradient of the air temperature and, therefore, is directed into the room.

Penetration SSS through window glass in the room looks like as follows. If a light beam propagates through a flat glass plate (for example, window pane), the angle of incidence α is equal to angle of transmission β with which the beam exits the plate from the opposite side (see Fig. 1) on condition that refractive indexes of optical mediums before and after propagation through the plate are identical. It would seem that the light beam propagates in a straight line in the room after penetration through the windowpane and cannot get back into the SSS shell. This is true if the refractive indexes of the air on both sides of the plate are the same.

However, the refractive index of the compressed air in the shell SSS is greater than the refractive index of air on the opposite side of the plate where the normal air pressure takes place. In this case, $\alpha < \beta$. When SSS touches on the surface of the glass plate, we have $\alpha = 90^\circ$. In this case, angle β should be greater than 90°. It is impossible. There is the total internal reflection from the surface of the glass in the room as is shown in Fig. 2. Thus, there are two modes. In the first mode, the total internal reflection from the outer surface takes place. In the second mode, the light passes through glass.

When SSS touches the surface of the glass, there is a second mode because $\alpha = 90^\circ$. As is seen in Fig. 2, the light beam returns back into the first medium. However, the region where the incident beam enters the plate and the region where the reflected beam leaves the plate are different. A distance between these regions is comparable with the width of the plate. Seemingly, the reflected beam cannot return to SSS shell. Possibly, the similar situation takes place in nature, and SSS in this case does not penetrate through a glass plate. But many attempts are given to SSS. The situation presented in Fig. 3a is possible. In this case, SSS nearing the windowpane heats it due to light radiation and inevitable dissipative losses in the glass because its transparency is not absolute. As a result, SSS takes a form shown in Fig. 3a. In this case, the light can return into the SSS shell after the total internal reflection from the outer side of the glass.

A strong electromagnetic field occurs at the layer of the air near the surface of the glass in the room. Letter *P* in Fig. 3a shows a position of this layer. The thickness of this layer is comparable with the average wavelength of white light and is approximately equal to 1 μm. This field cannot excite the light wave propagating in a room due to the phenomenon of total internal reflection. At the same time, this field can compress the air in this layer due to the electrostriction effect. The refractive index of the compressed air is greater than that of uncompressed one. The next portion of the light that is

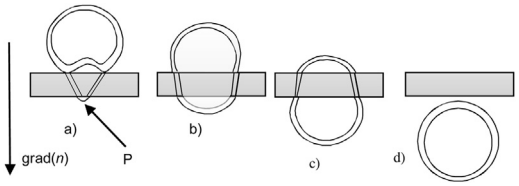

Fig. 3. Stages of penetration of the Ball Light shell through the window pane. (a) Initial stage of penetration when the region of the compressed air is produced on the back side of the window pane. (b) Intermediate stage when a small part of the Ball Light shell penetrates on the back side in the room. (c) Intermediate stage when a great part of the Ball Light shell penetrates on the back side in the room. (d) Ball Light penetrates in the room completely.

circulating in the SSS shell penetrates into the area of the compressed air. This leads to an increase of its volume, as shown in Fig. 3b. In this case, the light begins to propagate in the glass according to the first mode.

If air densities are different on opposite sides of the glass pane, SSS is moving in the direction where the density of the air is greater in accordance with the above-described effect. It seems that the SSS easily passes through the glass. In fact, only light passes through the glass. After that, it forms a layer of compressed air on the opposite side of the glass from the air in the room. A sequence of steps of SSS penetration through a glass pane is shown in Fig. 3.

As is seen, the light within SSS shell is circulating through both outer and internal sides of the windowpane. But the compressed air in the SSS shell located in the outer side of the window pane does not penetrate in the SSS shell located in the internal side of the glass. Light cannot be odorous. Therefore, any odors cannot penetrate through glass. An odor after SSS disappearance may refer to the smell that arose when SSS heated any objects inside the room.

Some evidence indicate that the SSS before it has entered the room, repeatedly bounces off the glass. This is explained by the fact that the glass is heated due to radiation. In this case, BL bounces off the glass as from a conventional opaque obstacle. There is evidence that if the glass is chipped off or there is a gap in the window, then the BL comes through this gap. In this case SSS changes its shape in the same manner as SSS penetrates through the usual hole. The number of reported cases, when BL penetrates through the crack in the window, is compared with a number of cases where BL penetrates directly through the glass. As the number of windows with defects is significantly smaller than a number of windows with conventional panes, we can conclude that the presence of defects increases a probability of BL penetration through a window. It is natural because the gradient of the air refractive index near the crack is significantly greater than that near the windowpane.

As for the heating of glass during the passage of BL, the result depends on many parameters such as the intensity of BL light, the losses in the pane, the presence of dirt on the pane, thickness of the pane, etc. Having analyzed the features of the resulting holes in the pane, we can conclude that the pane is heated rapidly enough, and the heating is localized in a circle, through which BL penetrates. Assuming that the rate of passage through the pane is constant, we can see that the maximum heating occurs at the circle whose diameter equals the BL diameter.

4. Conclusion

The main objection against our theory of Ball Lightning is connected with the assurance that the self-confined light is oxymoron like hot ice or dry water. No one has ever dared to admit that the conventional white light can confine itself in the conventional air atmosphere within a ball of several centimeters diameter. This looks like a ravings of a madman although up-to-date scientific knowledge is sufficient to characterize the self-confinement light in terms of scientific notions known since the end of 20 century.

In our opinion, the presented explanation of penetration of the self-confined light through the windowpane is a significant contribution in the judgment that the nature of Ball lightning is optical one and an availability of plasma is not required.

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