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ESSAY

The Challenge of Ball-Lightning: Evidence of a "Parallel Dimension"?

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Abstract--Ball-lightning, well described by Barry (1981), Singer (1971), and Stenhoff (1999), currently has no valid explanation. Attempted theories, based on present-day physics, fall into two categories: one in which energy is stored in the ball-lightning, and the other in which energy is fed into the ball-lightning as an electrical current or as microwaves. Some theories explain some of the facts, but no theory explains all of the facts. This suggests that we may need to introduce a new concept into our thinking. The concept of a "parallel dimension" seems promising.

Introduction

Ball-lightning is a scientific enigma. It is not a common phenomenon, but neither is it extremely rare. An average person is not likely to see one in his lifetime, yet it is likely that a friend or relative may have seen one. My mother saw one as young girl. She was in the family kitchen when a luminous ball came through an open window and moved slowly toward the kitchen table, where it made contact with a china plate. There was an explosion, the plate was shattered, and the ball vanished.

Luckily, that event did no serious damage or injury, but such is not always the case. A famous event occurred in St. Petersburg, in 1753, when the distinguished scientist Professor F. W. Richmann was carrying out an experiment to measure the atmospheric electric field during a storm. What happened has been summarized by Singer (1971:9]:

> Witnesses outside the laboratory saw lightning hit the metal rod on the roof which was connected to the measuring apparatus located in Richmann's laboratory. Inside, a ball of blue fire the size of a fist came from a metal rod on the apparatus straight to Richmann's forehead as he stood approximately one foot away. There was a shot as loud as a pistol shot when the globe hit Richmann . . . (Singer 1971:9 contains an engraving which may or may not be an accurate depiction of the event).

Stenhoff (1999:75) adds the following interesting information:

> The shoe belonging to the left foot was burst open. Uncovering the foot at that place they found a blue mark, by which it is concluded that the electrical force of the thunder, having forced itself into the head, made its way out again at the foot.

It appears that Richman was electrocuted by a current that entered at or near his forehead, and exited from one of his feet, but it is curious that the injury was localized to the foot.

The neurologist Oliver Sacks has described an almost identical case (Sacks 2007). A middle-aged man went to a payphone one afternoon (in 1994). There were no lightning events at the time, but there was "a little bit of rain" and thunder in the distance. He was about to leave the phone when a flash of light came out of the phone and hit him in the head. "Next thing I remember, I was flying backwards." Then "I saw my own body on the ground." For a few minutes, he had an out-of-body experience. He knew he had returned to his body when he found he was experiencing pain from burns on his face and his left foot. It appeared that "an electrical charge had entered and exited his body." One may surmise that the telephone, or wires feeding the telephone, had been struck by lightning, but Sacks does not provide information on that point. (Sacks' interest was in the curious fact that, after that event, the man developed an obsession for music.)

The Richmann case and the case described by Sachs are remarkably similar—in each case, the fatal or near-fatal event began with a localized electrical injury to the forehead and ended with another localized electrical injury to a foot. The fact that in each case there were two sharply localized electrical events raises the interesting possibility that each case may have involved more than one ball-lightning.

Fortunately, most ball-lightning events are less dangerous, although they can still be very dramatic. Singer describes the following case:

> On an oppressive day in Scotland in 1947 in which, however, there was no rain or thunder, a fireball was seen running along an outside electric wire. It struck a very large oak with a terrific explosion, shattering the tree to pieces. In the house nearby, the radio, telephone, and all fuses were burnt out; but the detonation did not break any windows or cause other damage. (Singer 1971:44)

Despite these and other impressive descriptions of ball-lightning events, some meteorologists doubted its existence even in the 20th century (Sturrock 2015:5). The reason was due in part to the rareness of the phenomenon, but perhaps in no small measure to the fact that scholars could offer no theoretical explanation.

The challenge to find an explanation became acute in the 20th Century when ball-lightnings would (fortunately only rarely) appear inside aircraft! The following is a description of such an event (Stenhoff 1999:113, Sturrock 2015:8).

> Professor Roger Jennison, then Professor of Physical Electronics and Director of the Electronics Laboratories at the University of Kent at Canterbury, England, was traveling in an Eastern Airlines all-metal aircraft over the East Coast of the United States during a thunderstorm on March 19, 1963, at 12:05 a.m., Eastern Standard Time. He was seated near the front of the passenger cabin. There was much turbulence. The aircraft was evidently struck by lightning (he saw a bright flash of light and heard a loud bang) and some seconds later a perfectly symmetrical glowing sphere of diameter 22 ± 2 cm emerged from the pilot's cabin and traveled at constant height and speed (75 cm above the floor at 1.5 ± 0.5 m/s relative to the aircraft) and in an undeviating path down the central aisle of the aircraft approximately 50 cm from him. The blue-white sphere had no structure, and was somewhat limb-darkened and optically thick [i.e. not transparent], hence appearing almost solid. It did not seem to radiate heat, and appeared to have an optical power of about 5 to 10 W. It was also seen by a terrified air stewardess as it disappeared into the toilet compartment at the rear of the aircraft.

There is still no accepted theory to explain ball-lightning. Barry (1981), Singer (1971), and Stenhoff (1999) all agree with the following statement by Hill et al.:

> There have been many theories advanced to explain ball-lightning [but] no theory is completely satisfactory . . . (Hill et al. 2010)

Finkelstein expressed the following opinion:

> We should be able to deal with it [ball-lightning] at least qualitatively from fundamental principles. We can't, and it's getting embarrassing. Nor is the reputation of science much improved by our again denying the existence of what we cannot account for. (Finkelstein 1972)

The difficulty that scientists have had—and continue to have—in finding an explanation of ball-lightning raises the question of whether we may be fundamentally on the wrong track. Theories are based on concepts. If current theories seem hopelessly inadequate, it may be that we are using inappropriate concepts, in which case it may be time to start looking for a new one. That is the purpose of this article.

We briefly list the basic facts concerning the phenomenon in the next section "Basic Facts," we comment briefly on current theories in "Current

Theories," we offer a new proposal in the section "A New Concept," and we conclude with a brief Discussion.

Basic Facts

According to Barry (1981), Singer (1971), Stenhoff (1999), and others (for a brief introduction, see Sturrock 2015), some of the basic facts concerning ball-lightning are the following:

1. The diameter of a ball-lightning is typically in the range 10–50 cm. There are few reports of ball-lightnings that are very much smaller or very much larger.
2. The lifetime is typically in the range 1–5 seconds, but there are reports of longer lifetimes.
3. Ball-lightnings are self-luminous with a luminosity comparable to that of a few-watt lamp.
4. Ball-lightnings are typically described as transparent or semi-transparent rather than solid in appearance.
5. Ball-lightnings have varying colors, common colors being red, orange, and yellow.
6. Ball-lightnings tend to move slowly, with speeds of order 1 meter per second, often erratically.
7. A ball-lightning may fade away quietly or may explode.

The phenomenon has electromagnetic characteristics:

8. Ball-lightnings tend to occur when and where lightning is occurring or is likely to occur.
9. Ball-lightnings often follow telephone lines or other electrical structures.
10. A ball-lightning may have the appearance and odor of an electrical phenomenon, with sparkling and jittering fine structure.
11. Some witnesses have experienced electric shocks by being in contact with a metal structure that was contacted by a ball-lightning .
12. Some ball-lightnings have put a magnetic compass out of action—presumably by demagnetizing it.
13. Telephones and other electrical devices, which may be some distance away, may be put out of action at the time of a ball-lightning event.

The following facts make the phenomenon particularly intriguing:

14. A ball-lightning can move independently of the atmosphere. Jennison (1969a) refers to an observation of a 20-cm ball that appeared 50 cm above the trailing edge of the wing of an aircraft in flight. It moved parallel to the wing at a speed of about 1 meter per second before being cast off at the end. The ball was not blown off despite its remarkable air speed.

15. A ball-lightning can move through a window or even a 2-foot-thick wall (Singer 1971:37).
16. Ball-lightnings have entered or formed within aircraft (Jennison 1969b). Singer mentions a case in which the pilot of an aircraft observed *a yellow-white ball approximately 45 cm in diameter enter through the windshield* (Singer 1971:40). When inside an aircraft, the ball-lightning is typically said to move at a steady speed of order 1 meter per second in a straight line from front to rear of the aircraft.
17. A ball-lightning may cause no damage or great damage. Some have been reported to destroy trees. Some have killed men or animals. According to analyses of some events, the energy released by a ball-lightning can be as high as 3 megajoules.
18. A ball-lightning may melt metal, for instance pitting an aircraft wing or propeller.
19. There appears to be little or no correlation between the energy released by a ball-lightning and its appearance (size, luminosity, etc.).

Current Theories

If we accept as a basic premise the principle of conservation of energy, leading present-day theories can be divided into two categories. In one category, energy emitted by a ball-lightning has been stored in the ball-lightning itself. In the other category, energy emitted by a ball-lightning is fed into the ball-lightning as an electrical current or as electromagnetic waves such as microwaves. Barry, Singer, and Stenhoff consider a number of stored-energy models but find none satisfactory. A recent example of such a model is given by Oreshko (2015).

The fact that some ball-lightnings can move independently of the atmosphere is a problem for all such models. (See, for example, item 14 above.) Another general problem, noted by Singer, is that typically there is no decrease of size or brightness or change of color during the lifetime of a ball-lightning (Singer 1971:93). Finkelstein and Rubenstein examined the implications of the virial theorem for plasmoid models, and found that it sets too low a limit on the energy that can be stored in such a structure (Finkelstein & Rubinstein 1964). The virial theorem holds not only for a nonrelativistic plasma configuration but also for a relativistic plasma configuration such as the *spherical plasma bubble* model recently proposed by Wu (2016).

A major problem with injected-current and injected microwaves proposals is the difficulty of understanding how an electrical current or electromagnetic waves could penetrate the metal shell of an aircraft.

Since the two current categories of theory are widely considered inadequate for explaining the properties of ball-lightning, it seems there is nothing to be lost in looking for a third category.

A New Concept

We now argue as follows:

(a) Since there is no known way for the required energy to be stored in the ball-lightning, there must be a reservoir of energy remote from the ball-lightning (presumably related to the electrical energy responsible for lightning).

(b) Since the reservoir is remote from the ball-lightning, there must be some way to transfer energy from the reservoir to the ball-lightning. We therefore conceive of a *duct* that connects the reservoir to the ball-lightning.

(c) A ball-lightning may now be regarded as a *port* through which energy in the duct can be released into the atmosphere.

Concerning the duct, we require that, in addition to its electromagnetic properties or capabilities,

(a) its motion is not restricted by the atmosphere;

(b) it can penetrate a wall or window without causing any damage;

(c) it can penetrate a metal structure such as an aircraft fuselage; and

(d) it is invisible.

These characteristics are suggestive of a modification of our familiar *overt* space, which we can think of as a different but parallel *covert* space. The transition from the overt space to the covert space may be an on–off proposition or a matter of degree.

These thoughts suggest the following hypothesis:

> *A ball-lightning is a port connecting our overt space to a covert space with similar but not identical properties*.

As a metaphor for such a concept, one may consider a sheet of paper, and suppose that a population of ants lives on one side of the sheet (the *overt* space). The ants have no reason to suspect that there is another dimension to their universe (the other side of the paper, the *covert* space).

However, suppose there is a sudden event (such as a lightning flash) that temporarily punctures a hole in the paper. For a short interval, the ants will get a glimpse of something unfamiliar—which we know is a brief glimpse of a dimension that has been there all along, but with which they are normally unfamiliar.

This model seems to be compatible with items 1 through 7 above. Just as the appearance of a household electrical outlet bears no relation to the current being drawn from the outlet, this model can explain why the size, luminosity, and other manifest properties of the ball-lightning seem to bear no relation to the energy released by the ball-lightning.

This model seems also to be compatible with items 8 through 13 above, since in this model a ball-lightning is coupled to a remote reservoir of electromagnetic energy. We note in particular that this model can accommodate item (13); the reservoir may be far from the ball-lightning so that the duct may have influences far from the ball-lightning. The sudden eruption of a duct to form a ball-lightning may trigger a disturbance throughout the duct that results in electromagnetic events remote from the ball-lightning (reminiscent of an Alfven wave traveling along a magnetic flux tube).

Discussion

Concerning the two fatal or near-fatal events described briefly in the Introduction, each event may have involved a ball-lightning, or conceivably two ball-lightnings comprising an entry port and an exit port.

Is there any evidence for a duct in ball-lightning events? Singer mentions two cases in which a bright *ray* or *line of fire* extends from a ball-lightning (Singer 1971:29, 39). These rays may be manifestations of the hypothesized ducts.

Is there any evidence that the interior of a ball-lightning has unusual properties? Singer mentions a case in which two witnesses encountered a large bright ball 4 m in diameter:

> The ball sank through the telegraph wires, which glowed, and then enveloped the couple. They stood in a thick white sea of light in which the sensations of odor or heat were absent. There was no breeze from the motion of the ball, and they could not feel the outside wind. They could see only the pebbles of the road. (Singer 1971:45).

Are there any other phenomena that have points of similarity with this concept of ball-lightning? We have recently drawn attention to the phenomenon known as *Mobile Luminous Objects* (MLOs) that form in superconducting cavities at very low temperatures in response to strong radiofrequency electromagnetic fields (Sturrock 2015, Anthony et al. 2009). These seem to resemble ball-lightnings but are much smaller, with diameters of order 1 millimeter. An MLO may be an exit port rather than an entry port: Electromagnetic energy from the RF field may pass through a mini–ball-lightning (an MLO) to inject energy into a reservoir. After the RF field is turned off, the reservoir may return some or all of the energy in the reservoir for a short time via the same mini–ball-lightning.

We may also ask whether there are other phenomena that lead one to consider possible extra spatial dimensions. A review of UFO-type phenomena has led us to consider this possibility (Sturrock 2009). There is an interesting case in the Condon Report involving reports from an aircraft traffic control site of a object that was tracked by radar but was invisible (Condon & Gillmor 1969).

A possible experimental approach would be to reproduce the Richmann experiment (hopefully without the fatality) by imposing a very high voltage (supplying a very high current) on a conductor penetrating a protective metallic chamber. Such events have occurred by accident in connection with the switching of submarine batteries (Silberg 1962). There have been attempts to initiate similar events by triggering a discharge by the rocket-and-wire technique (Hill et al. 2010). Another avenue of research would be to pursue the investigation of MLOs (Anthony et al. 2009).

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