Forces That May Explain Ball Lightning's Motion

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Abstract: The motion of ball lightning described by many eyewitnesses is one of its most puzzling aspects. One would expect that a glowing ball hot enough to emit light would have a density less than that of air, and would rise like a hot-air balloon. But only a minority of ball-lightning reports mention vertical or upward motion. More typically, ball lightning executes horizontal or slanted movements. Some reports say the object remains almost stationary over its lifetime. Any theory that can satisfactorily account for ball lightning must deal with this unusual aspect of horizontal as well as vertical motion.

In this paper, we show that a simple assumption regarding the density of material inside the visible ball-lightning object leads naturally to an explanation for many aspects of the observed motion of ball lightning.

If we assume that ball lightning is an autonomous object which carries its energy source mostly within itself, we must account for the motion of the object with reference to surroundings which are basically unaffected by the object's presence. This means that the density of air surrounding the object can be calculated according to the usual methods, which means over a range of 87 meters or less, we can assume that the density of the surrounding air varies linearly with height.

The assumption critical to this theory is that the ball-lightning object consists of matter having the density of air at an equilibrium

height, but which is much less compressible than a gas. In other words, while the object's shape may change, its mass per unit volume remains substantially constant during its lifetime. This assumption leads to behavior that is consistent with many eyewitness reports of ball lightning.

Figure 1 shows the calculated vertical motion of a 30-cm-diameter sphere with neutral buoyancy at the equilibrium height, and internal viscosity ranging from zero to that of a solid object.

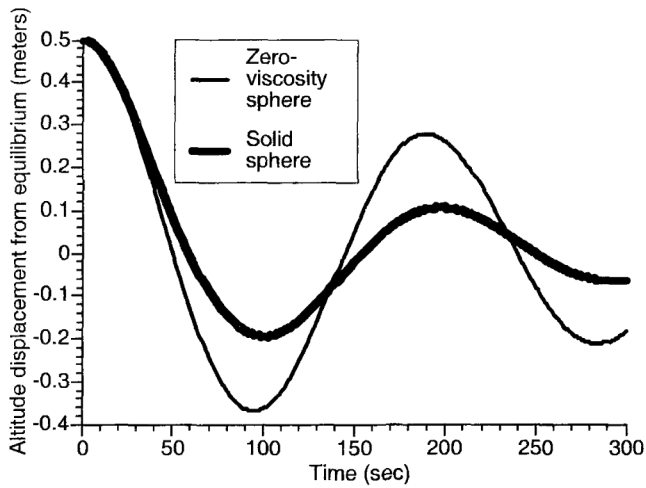

Fig.1 Theoretical altitude displacement from equilibrium altitude z_0 versus time for a sphere with radius $r_0 = 0.15$ m initially displaced 0.5 m from equilibrium, with viscosity ratios $k = 0$ (zero-viscosity sphere) and 1000 (solid sphere) as parameter.

As the figure shows, the object undergoes a slow oscillation with a period exceeding 1 minute. While most ball lightning has a lifetime shorter than this, the theory shows how it is at least possible for such an object to maintain an approximately constant height above the ground while moving horizontally in response to external forces such as wind currents. The paper develops this theory in more detail and presents the differential equation of motion from which Fig. 1 was derived.