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Plasma Globe 7″

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BACKGROUND:

Most lightning is an electrical discharge between oppositely charged parts of clouds. The kind we are most familiar with is the electrical discharge between the clouds and the oppositely charged ground below. (Hewitt, pp. 502)

Plasma is the fourth state of matter. Everyone is familiar with the other three: solids, liquids, and gases. To understand what plasma is, think about how matter changes states. In all states of matter, the atoms are constantly in motion. In solids, molecules vibrate about fixed positions. If the rate of vibration is increased by adding energy, then the molecules slowly start to shake apart and wander throughout the material, vibrating in non-fixed positions - liquids. If even more energy is added, the liquid might boil. In this case, the molecules break away from each other altogether and form the gaseous state. If we heat the gas even more, then the atoms themselves actually start to shake apart. This produces a gas of free electrons and bare atomic nuclei. This is the plasma state. (Hewitt, pp. 248)

It takes energy to loosen electrons from their orbits. In the case of lightning, this energy is supplied by the electrical potential energy of the cloud and ground. For a brief time the individual atoms in the atmosphere lose an electron or two. We say that the gas changes into plasma, or ionizes. Ions don't roam freely for very long, however, especially when there are recently freed electrons floating around right next to them. So, the electrons find their homes again in the energy levels of the atoms that lost them. This in turn causes the electrons to release the energy it took to separate them. This energy is released in the form of light and heat.

PRODUCT INFORMATION:

The plasma globe consists of a partially evacuated glass sphere containing a mixture of inert gases. The smaller glass sphere at the center contains a power source similar to a Tesla coil. It supplies an alternating, high voltage, high frequency, yet small current to the inner sphere.

Why don't you get a shock from the globe? An electrical shock is caused by electric current flowing through body parts. The larger the current, the more severe the shock.

The current from the plasma globe is very small, but more importantly, it is a high frequency alternating current. This type of current flows on the outside of a conductor (including a body), not through it. However, if you leave a finger at one spot on the globe, it will get hot. After a long time, the heat can be enough to burn skin. Do not leave a finger or anything else stationary on the surface of the globe.

The plasma globe simulates lightning. The Tesla coil generates a large potential difference between inner and outer spheres, just as a cloud has a high potential difference with other clouds and the ground underneath it. Like all potential differences, this one tries to even itself out - by discharging. The plasma globe uses the inert gases trapped inside as the vehicle. They complete the circuit to the outer sphere. These gases give off light and heat as electrons jump off and on the atoms that make up the gas. During this stage, the gas is said to be in the plasma state, or ionized.

ACTIVITIES:

1. The first thing you and your students will notice about the sphere is that by placing a conductor (your finger will do nicely) near the surface of the globe, the streams of plasma seem attracted to it. Since the plasma streams are composed of ionized gas molecules, these charged particles are attracted to an uncharged object, similar to the way a charged balloon is attracted to a neutral object (like the wall of your room). You may want to encourage your students to experiment and see if they can attract more streams with different types of conductors or insulators. (How about a magnet?)

2. Your students may notice that if they hold their fingers in one place for a bit, the temperature of the glass at that point increases. Some of the energy carried by the plasma is transferred to the glass, raising its temperature.

3. The gasses in the plasma globe give off distinctive colors while the globe is operating. These colors are characteristic of the specific gasses in the tube. Your students can see the individual frequencies of light emitted by the globe if you darken the room and allow them to view the glowing gas through small pieces of diffraction grating (Arbor Scientific catalog #33-0980).

4. You may want to try placing a neon light bulb near the globe. Your student's will see the bulb light up. Try holding the bulb at different distances from the globe.

BIBLIOGRAPHY:

Conceptual Physics by Paul Hewitt. Pearson Education, Inc. pp. 248, 502.

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