Plasma Globe

Presented by: Hands On! Discovery Center In partnership with: BrightRidge

About Plasma Globes

A plasma globe is a device based on the plasma lamp originally invented by Nikola Tesla. Filled with a mixture of gases such as helium and neon, the plasma ball contains filaments of plasma. These filaments glow and emit electromagnetic radiation in different ways depending on the items placed near the globe. The plasma globe creates electromagnetic waves by emitting a high frequency that ionizes the gas inside the sphere and turns it into plasma. When the gas is ionized, energy is emitted in the form of colorful "streamers".

The plasma globe is basically a miniature Tesla coil. Inside the globe is a coil of wires that have a very high frequency current going through them. The electrons in the wires are oscillating (moving back and forth) very quickly. This shakes the atoms around the wires so much that the electrons start to fall off and a plasma is formed. Inside the glass globe is a partial vacuum, and some of the air has been sucked out. Since there is not as much air in there, it is easier to make electric sparks that can be seen.

SAFETY NOTICES:

A plasma globe is a high-voltage electrical device and should be used with caution. The frequencies it emits may interfere with cell phones, microphones, Wi-Fi, and cordless phones. Because the plasma ball emits electromagnetic radiation, it can interfere with pacemakers. All care should be taken if trying to use the plasma ball to create burning or fire effects, and nothing flammable should be left in contact with the plasma globe.

- Always use the plasma globe with close adult supervision.
- Always use the plasma globe in a well ventilated area.
- Check the cord/wire for damage prior to use. Always turn off and unplug the plasma globe when not in use and between experiments.
- Do not attempt to remove or open the base of the ball.
- Do not expose the plasma globe to moisture. This will create a fire/shock hazard and damage the globe.
- Do not use the plasma globe near heat sources.
- Do not a hold finger, hand, or any other object on the plasma globe for an extended period of time as this will create a burn/fire/shock hazard.
- Avoid touching with fingernails, as they conduct electricity better than skin and underneath the nail is a tissue that is densely packed with pain nerves.

Touch Mode

When the switch is moved to the "ON" position, the plasma globe will respond to touch. Your hand attracts the plasma as it moves closer to the sphere. You may feel a slight tingling sensation, but it's perfectly safe. This sensation is a vibration caused by the electrons hitting the glass. This is due to the polarization of your body since it's a conductor. As you approach the plasma ball you become polarized by the electric field and this attracts more charge to you. Move your hand around the globe, and the plasma will move with you!

Sound Mode

When the switch is moved to the "AUDIO" position, the plasma globe will respond to sounds of 80 decibels or more. Sparks will respond and undulate in sync with the sound.

What is plasma?

Plasma may be known as the fourth state of matter, however, plasma is the most common state of matter in the universe. Plasma is a gas-like collection of atoms that have a large number of free electric charges. This means that newly created plasma has undergone ionization, the phase transition after melting and boiling. When the freed electrons are regained by ionized atoms the bonding energy is released as visible light. In fact, glowing is a signature

attribute of most plasma. Like gases, plasma has no fixed volume, and like other fluids, it does not have a fixed shape. Plasmas can usually be controlled by magnetic fields, but this will not be visible on the plasma of a plasma globe. Plasma is also an excellent conductor so, once one filament forms, it becomes generally stable allowing for more current to flow through it, much like a lightning strike. This is more obvious when you bring a finger to the plasma ball. It is important to remember that plasma is very hot and it will slowly conduct heat through the glass.

Illuminate a fluorescent bulb

Materials

- Plasma Globe and A/C adapter
- 12" fluorescent light tube
- Wooden chair/stool **(DO NOT USE ANYTHING METAL TO STAND ON!)** (not included)
- Pennies (not provided)
- Low humidity day if possible (not included)

Instructions:

1. If possible, turn off the lights so that you can see the plasma ball glowing.
2. Put your hand on the plasma ball. What happens?
3. Now bring the fluorescent light tube close to the plasma ball. What happens?
4. This step requires a classmate/student, so have one close by and ready to help. Stand on a chair or stool **(NOT METAL!)** and put your hand on the ball.
5. Now have your classmate hand you the light tube. Do you see it light up? What happens if your friend lets go? **Be careful to not touch the ends (metal prongs) of the light tube – it gets hot!**
6. Put a penny on the top of the plasma ball. Carefully touch the penny with another penny. **Don't use your finger – you'll get a shock!**

Take it further…

The starting point of the tube must be close to the plasma ball where the electric field is largest (voltage is changing the fastest). This can be demonstrated by moving the tube closer and then further around the globe. At certain distances, the tube will not glow. There is a minimum electric field required to ionize the mercury gas and if the field is not strong enough the tube will not light. Make a chart to see what distances work best to light up the fluorescent bulb. Perhaps try different types of bulbs to see if there are different outcomes.

What science is at work?

The electrons repel each other and want to get as far away from each other as possible. They are always trying to reach the ground, and because it's so big, the electrons can get very far away from each other. They can get to the ground by traveling through you. The tube lights up because some of the electricity gets through the glass ball. It's enough to light up the fluorescent tube. This is an interesting example of how fluorescent lights use much less energy than incandescent bulbs! The electricity is going through you, into the light tube, and then through your friend into the ground. It doesn't work because the electricity goes into the ground and there's not any left to light up the bulb. The penny is a conductor, so electrons move through it easily. When enough electrons build up, they jump to the other penny and make a spark! The penny is acting like a capacitor, a device that stores energy.

Create a human short-circuit

While you have the fluorescent tubes out, demonstrate that the electric field can be diverted to a grounded, shorter circuit if a classmate grabs part of the tube. This will reinforce the idea of lightning and currents taking the path of least resistance. It will also awaken students to the reality that their bodies are paths through which electricity can flow. A valuable lesson in electrical safety!

Demonstrate convection

The plasma "threads" or "streamers" are hot and will rise due to their buoyancy in the other gases inside the plasma globe. Because of this, it is difficult to get a horizontal streamer to remain unbroken for more than a second, much like a

Jacob's Ladder. However, a vertical streamer at the top will be stabilized by the buoyancy. With practice, you should be able to get just a single vertical thread. Once again, be cautious because the glass will heat up.

Relighting the Plasma Globe

You can relight a plasma ball briefly after it's been turned off by using your own body to conduct electricity. Place your hand on the plasma ball while it's on, then turn the ball off. Place your hand back on the plasma ball immediately, and you will see electric bolts flash up to your hand. Remove your hand and clap several times. With each clap, you should see more electric bolts run through the plasma ball, even though the electricity to the ball is turned off.

Key Terms

- **Atoms**-The basic building block for all matter in the universe. Atoms are extremely small and are made up of even smaller particles-electrons, protons, and neutrons.
- **Protons**-Particles that have a positive charge of electricity and travel around the nucleus of an atom.
- **Electrons**-Particles that have a negative charge of electricity and travel around the nucleus of an atom.
- **Plasma**- Plasma may be known as the fourth state of matter, however, plasma is the most common state of matter in the universe. Plasma is a gas-like collection of atoms that have a large number of free electric charges.
- **Conductor**- Conductors (copper, silver, and aluminum) allow electricity to easily pass through.
- **Insulators**- Insulators (glass, air, plastic, and wood) oppose electrical currents.
- **Oscillating**-Moving back and forth at a regular speed.

Tennessee Science Curriculum Standards addressed:

3.PS1.1, 3.PS1.2, 3.PS1.3, 3.PS3.1, 3.PS3.2, 3.ETS1.1, 3.ETS1.2, 3.ETS2.1, 4.PS3.1, 4.PS3.2, 4.PS3.3, 4.ETS2.3, 5.PS1.1, 5.PS2.1, 5.PS2.2, 5.ETS1.3, 5.ETS2.2, 5.ETS2.3