Teaching Plasma Physics Through Classroom Demos

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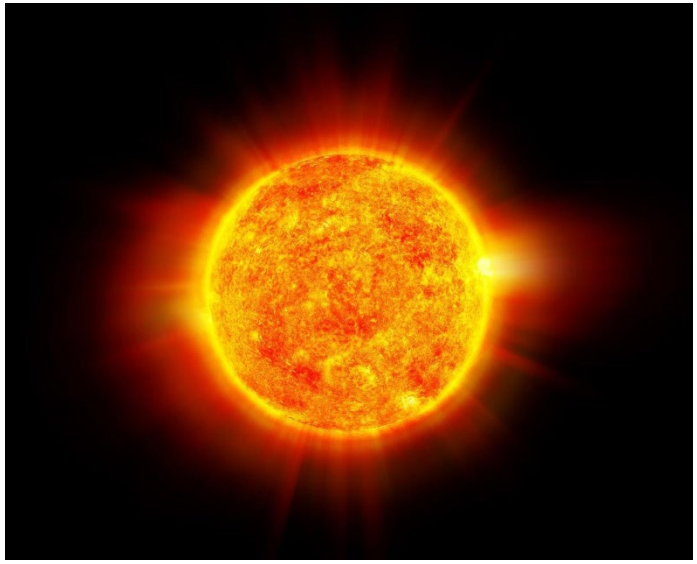
Key Plasma Concepts

- Plasma is a state of matter
- Plasmas occur in nature
- A gas can be excited into a plasma by adding energy, this can be done with an electrical discharge
- Electrons and Ions move freely
- A plasma is electrically conductive
- A plasma responds to a magnetic field
- Excited electrons recombine with ions and emit spectrum lines

Plasmas in Nature

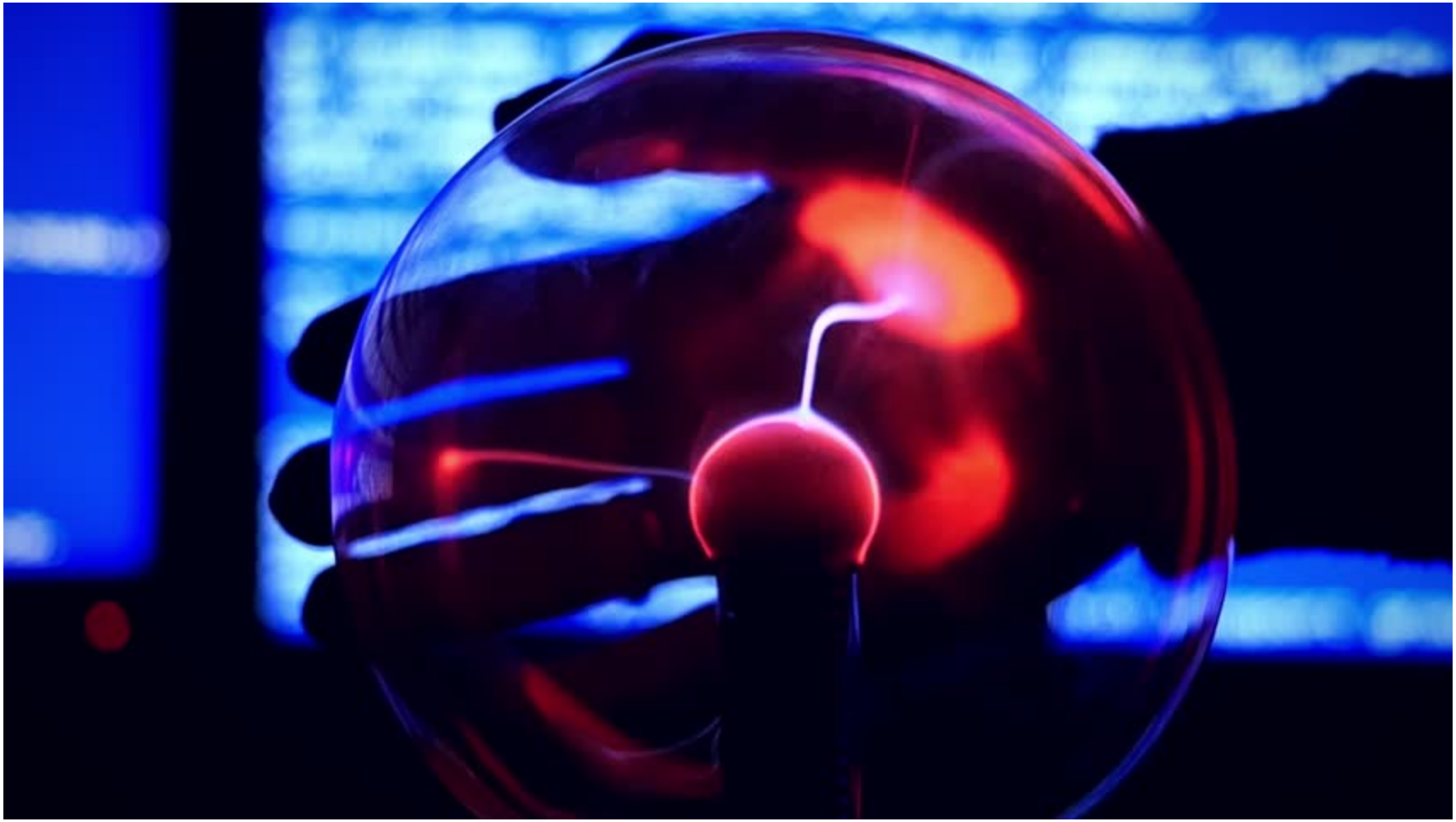
The Sun



Aurora

Lightning

Plasmas in Your Classroom: A Plasma Ball



How Does a Plasma Ball Work?

Questions to ask:

- **What is the plasma made of?**
- **Why do we need the glass sphere?**
- **Why is the plasma attracted to your hand?**
- **Why does the plasma glow?**

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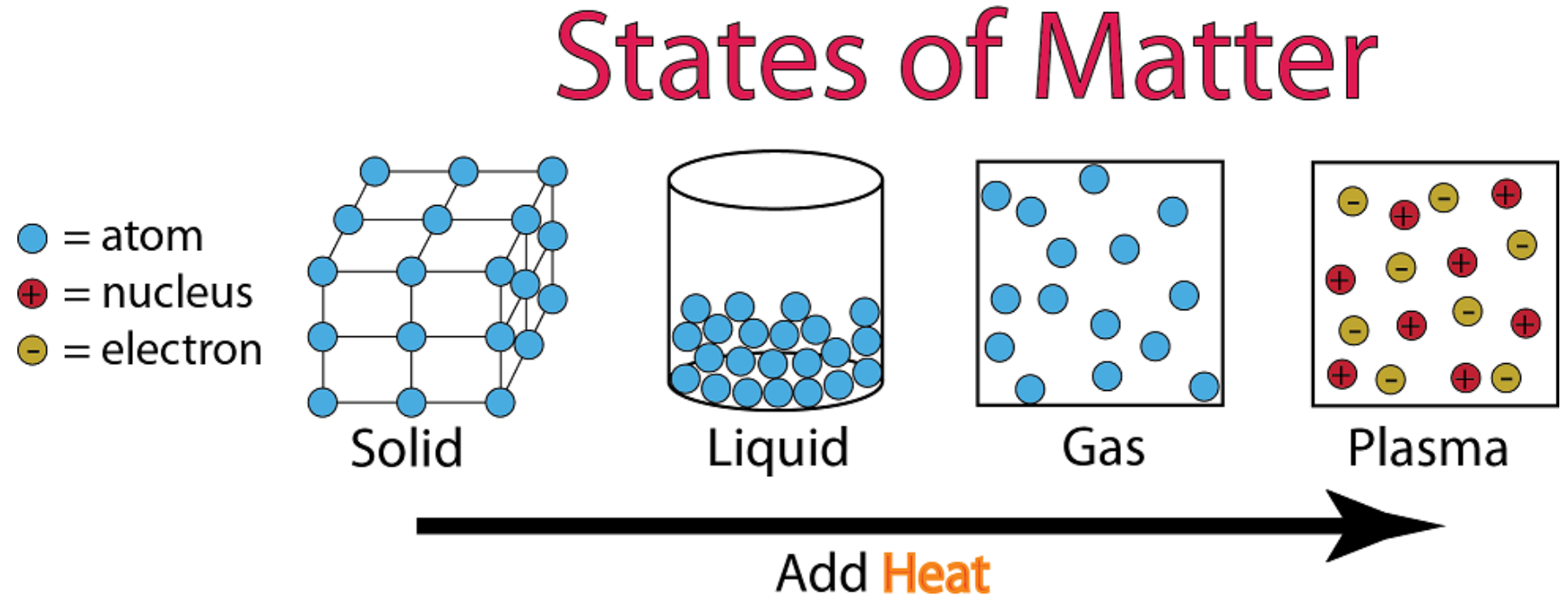
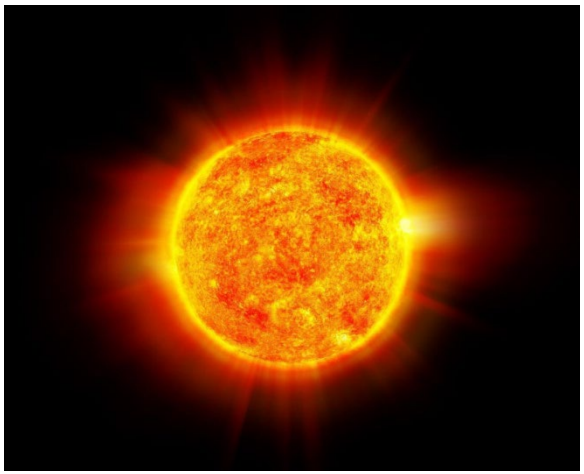
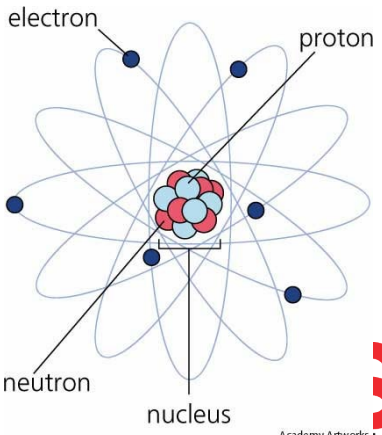
Plasma is Made of *Ionized* Atoms







Academy Artworks

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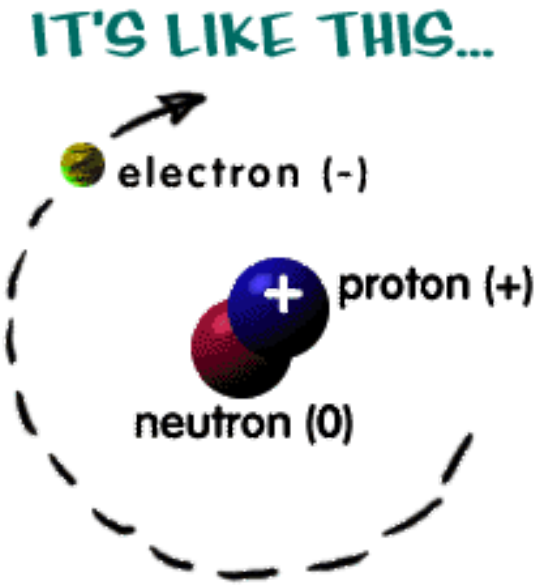
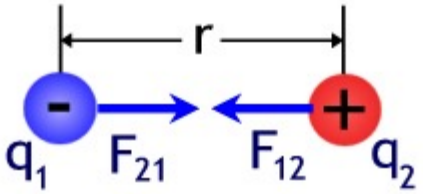
Back to Atoms for a Little Bit

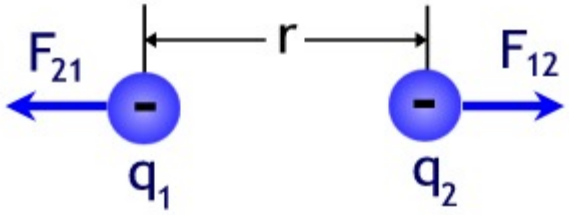
- Atom: Two main parts
  - Nucleus (positive)
  - Electrons (negative)
- Opposite charges attract
- Electrons are bound to the nucleus



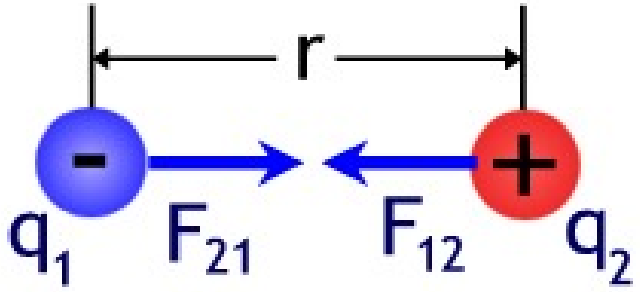
- Low temperature:
  - Not enough energy for electron to escape



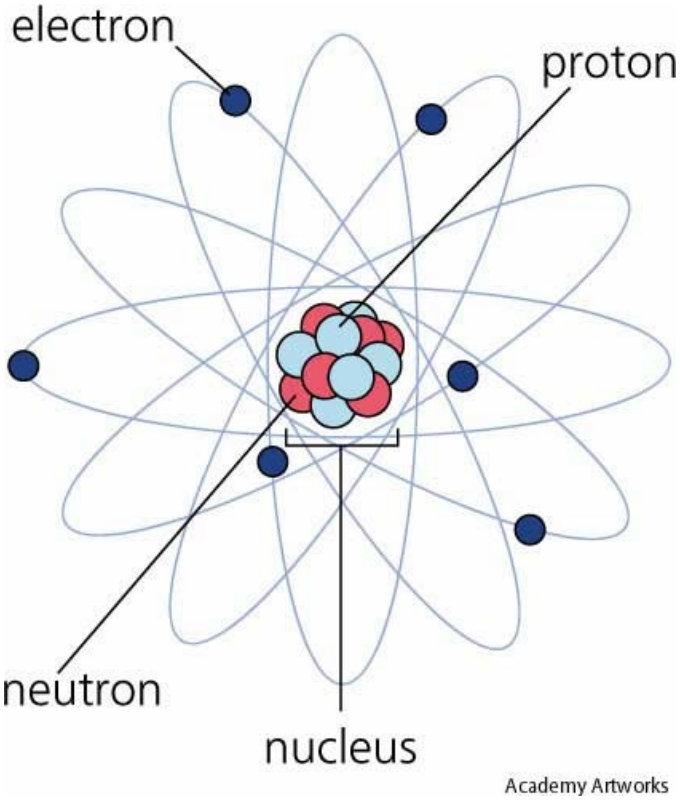
- High temperature:
  - (next page)➔

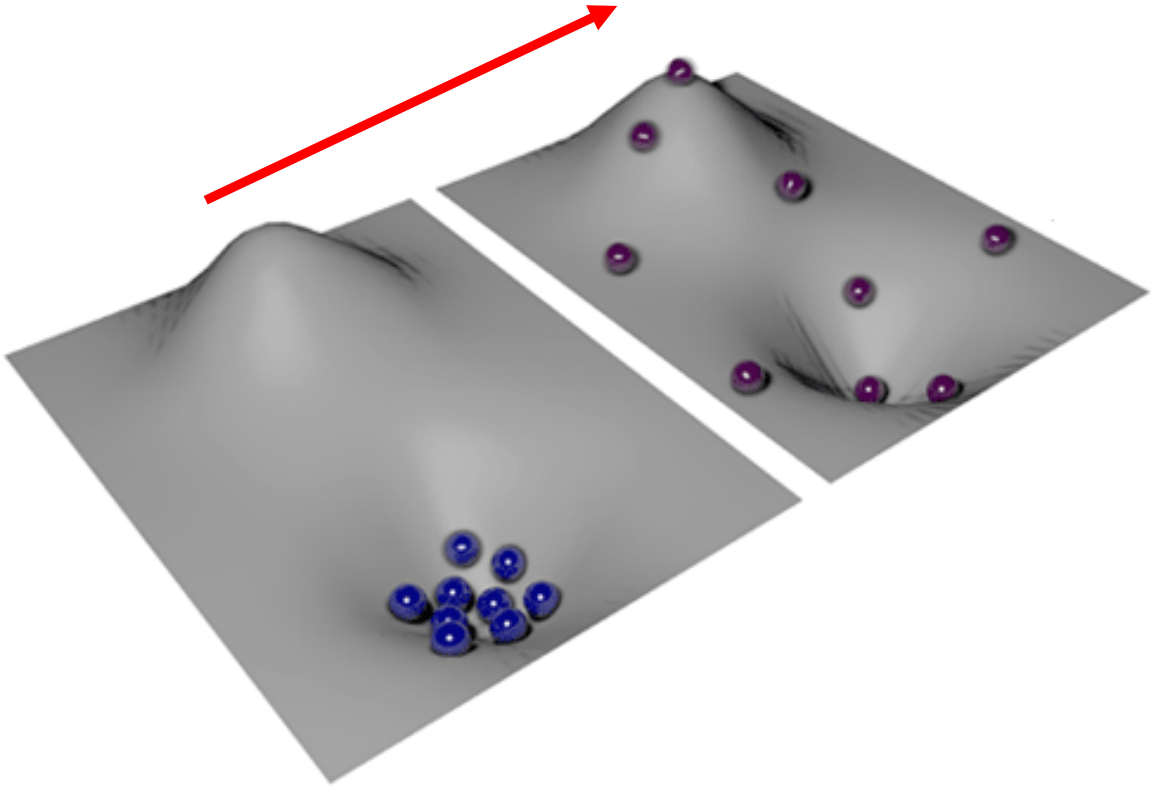


With Enough Energy (High Temperature)

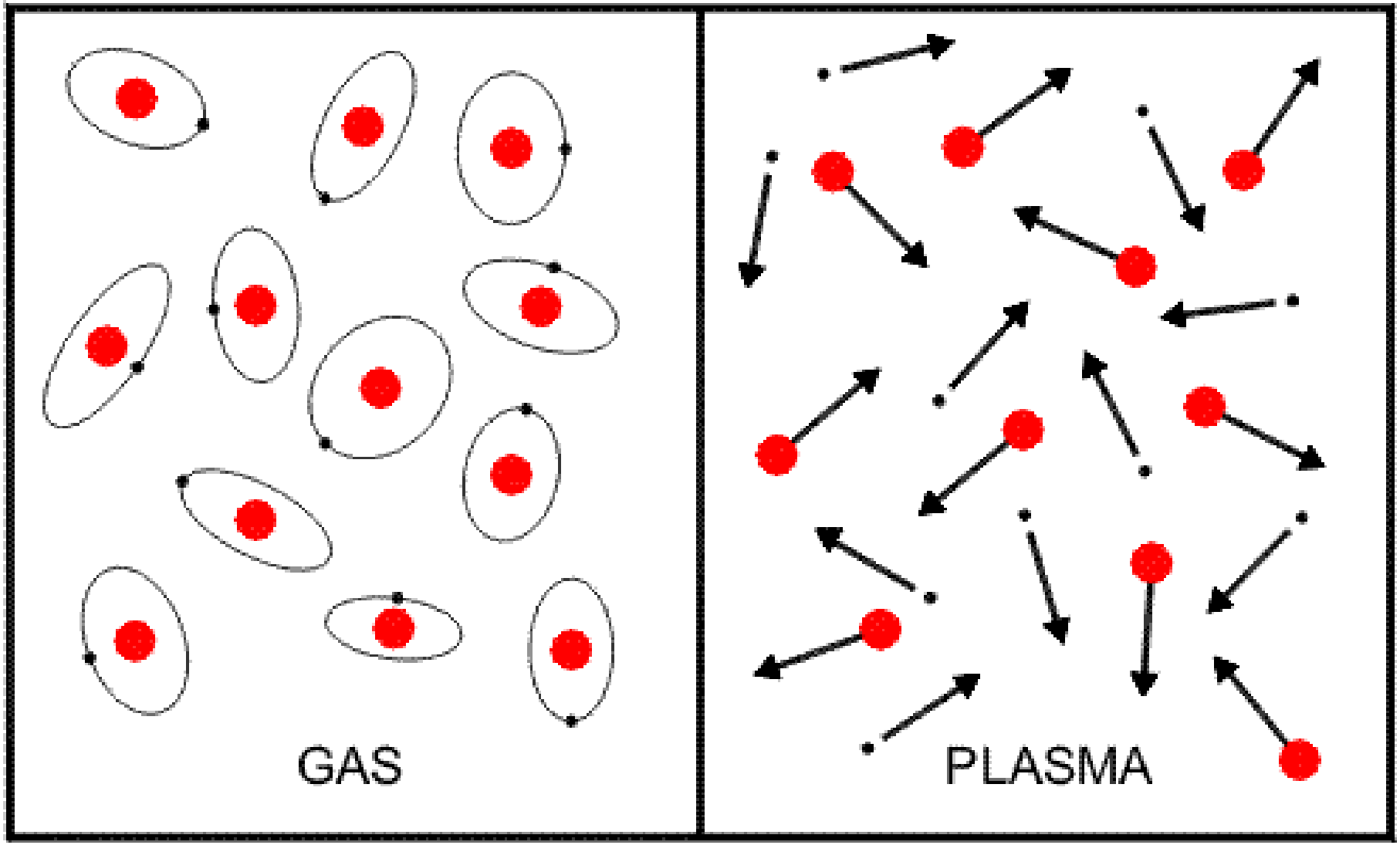


Electrons escape from the nucleus at high temperatures



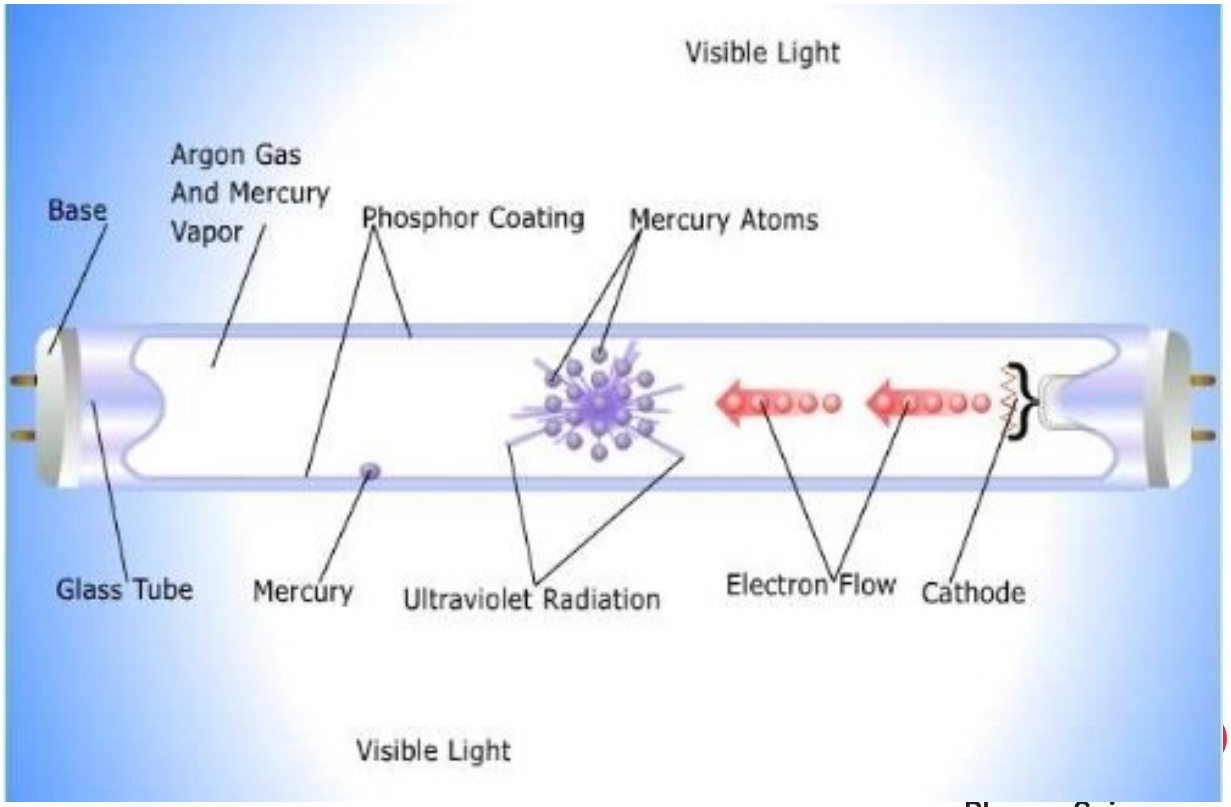


Electrons / Ions Move Freely in a Plasma



How Do We Heat a Gas into a Plasma?

- One way is with electrical current
- Like in a fluorescent light



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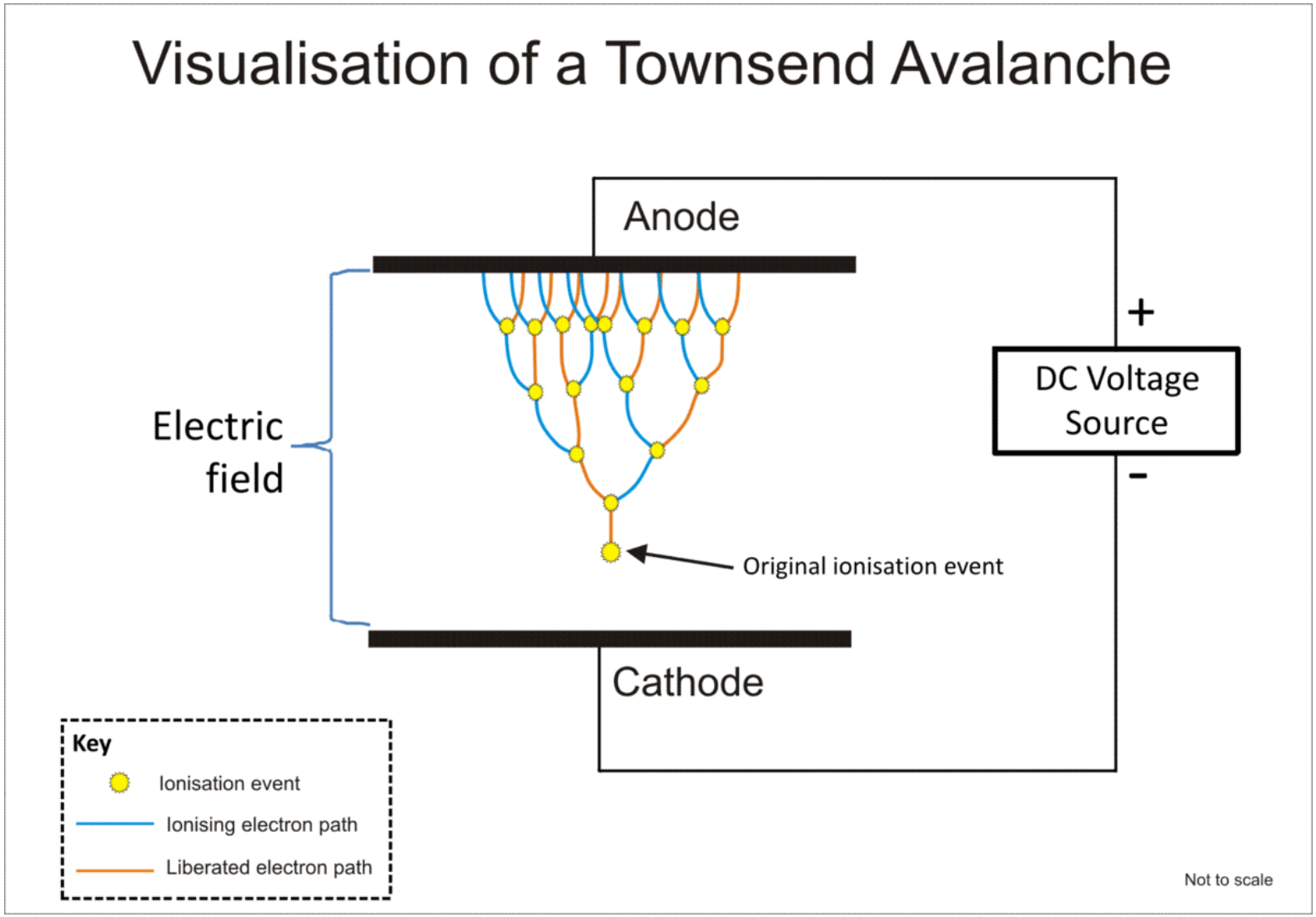
Breakdown Voltage Depends on Pressure

Electrons have to be accelerated a long enough distance before colliding with un-ionized gas to have sufficient energy to ionize the atoms.



Build Your Own Vacuum Chamber

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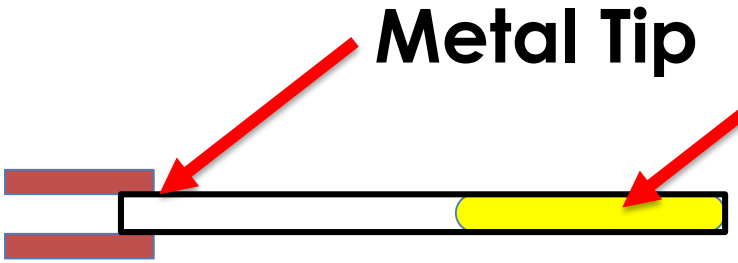
Build Your Own Vacuum Chamber

Use a syringe dispenser tip (blunt, not a needle) filled with glue.



Metal shaft serves as electrical contact to the inside of the vacuum chamber

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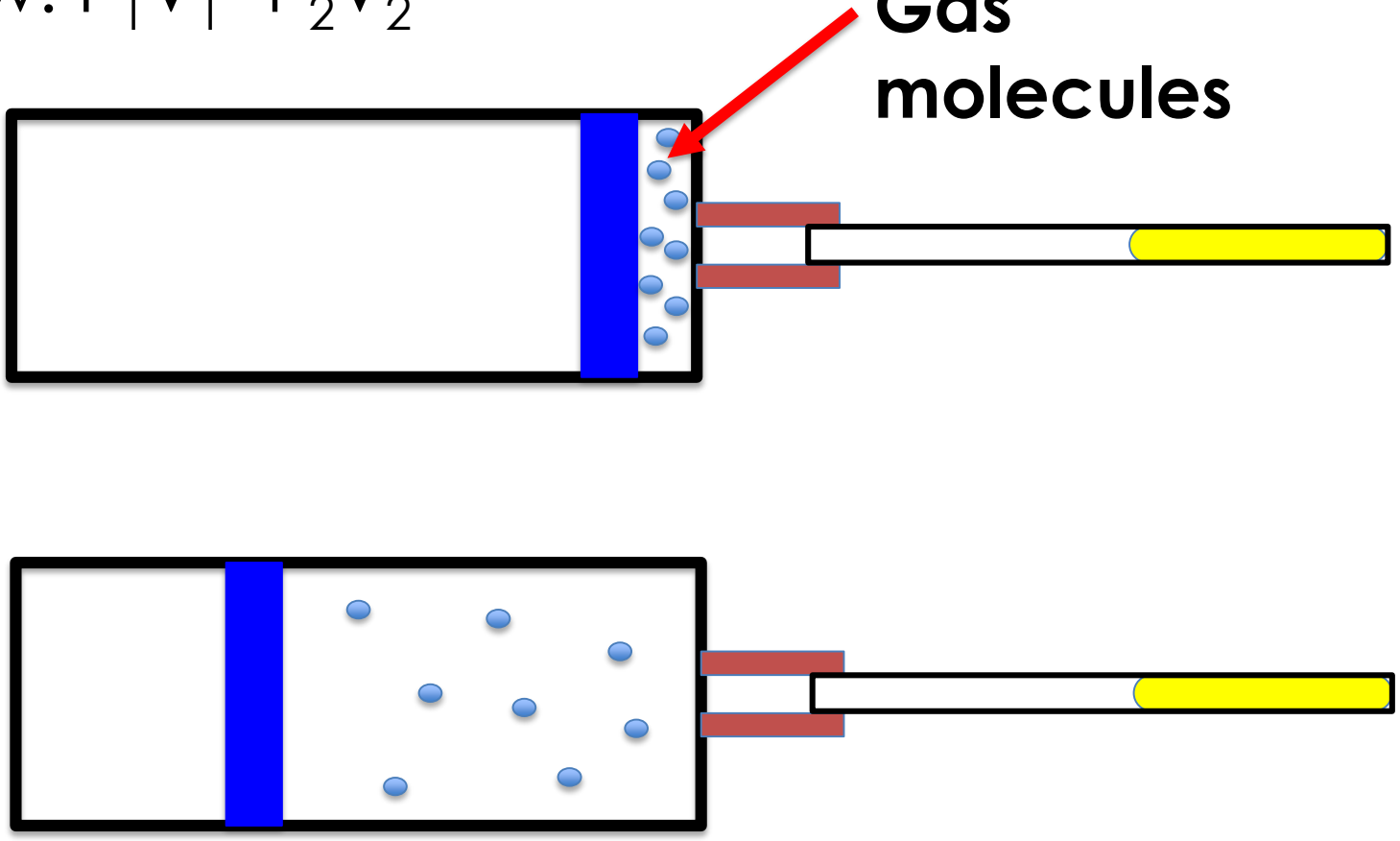
Create a Vacuum

Pulling back plunger decreases gas pressure:
Boyle's law: $P_1V_1=P_2V_2$



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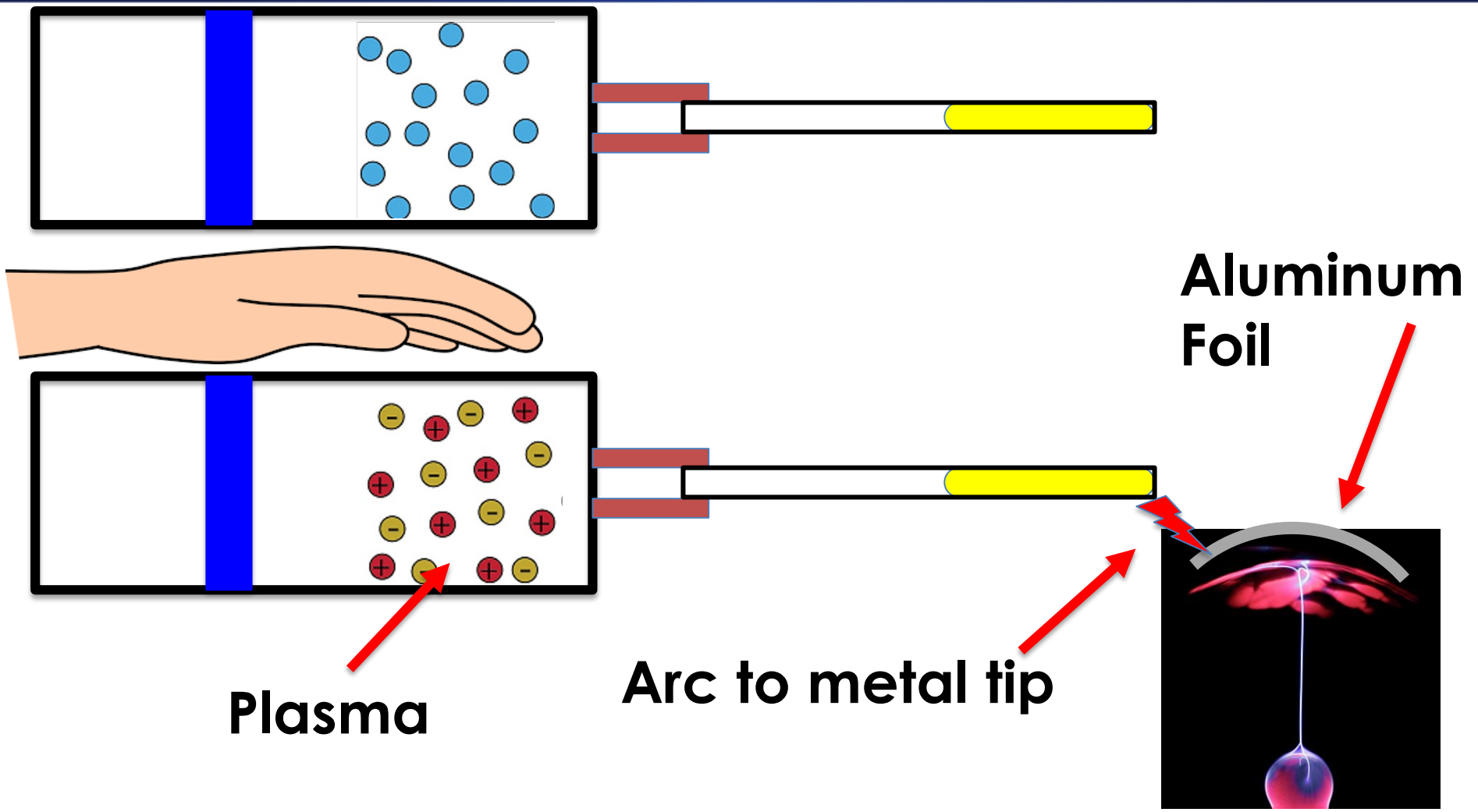
Create a Plasma



The rarified gas is easier to excite into a plasma by using the plasma globe

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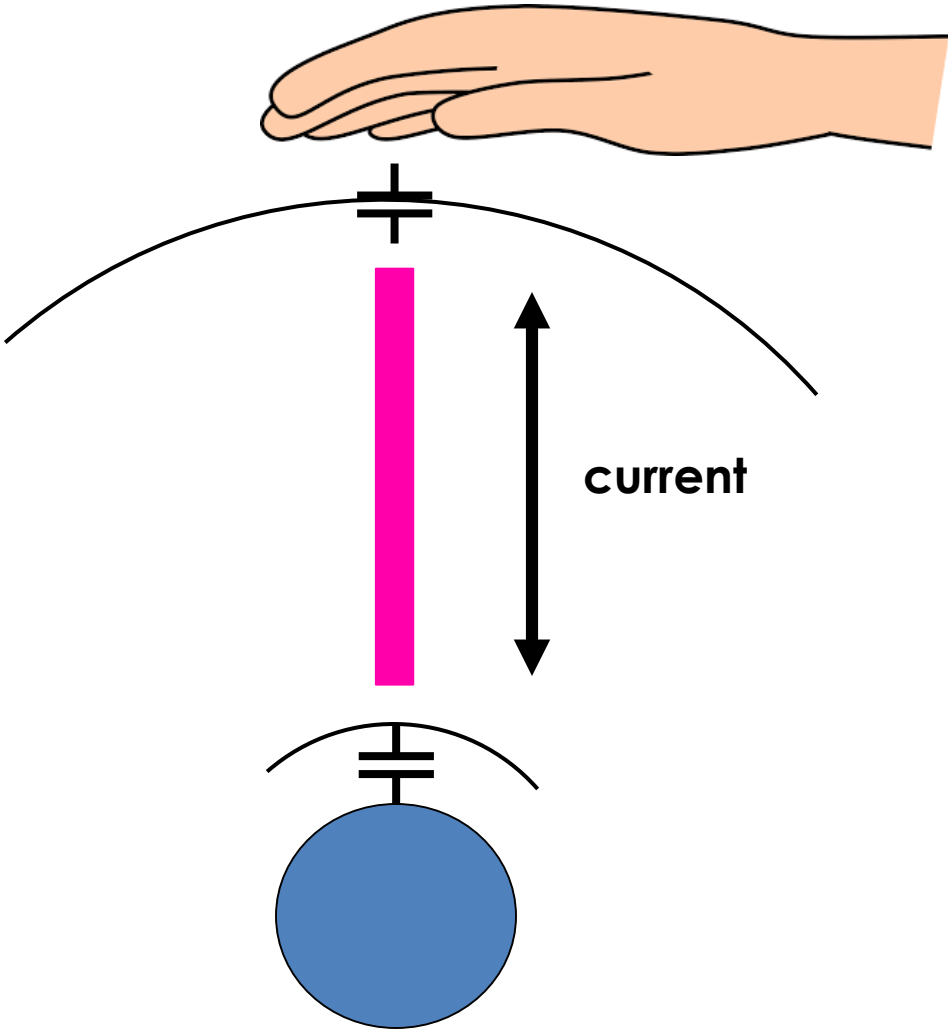
Your Body Acts as a Reservoir of Charge



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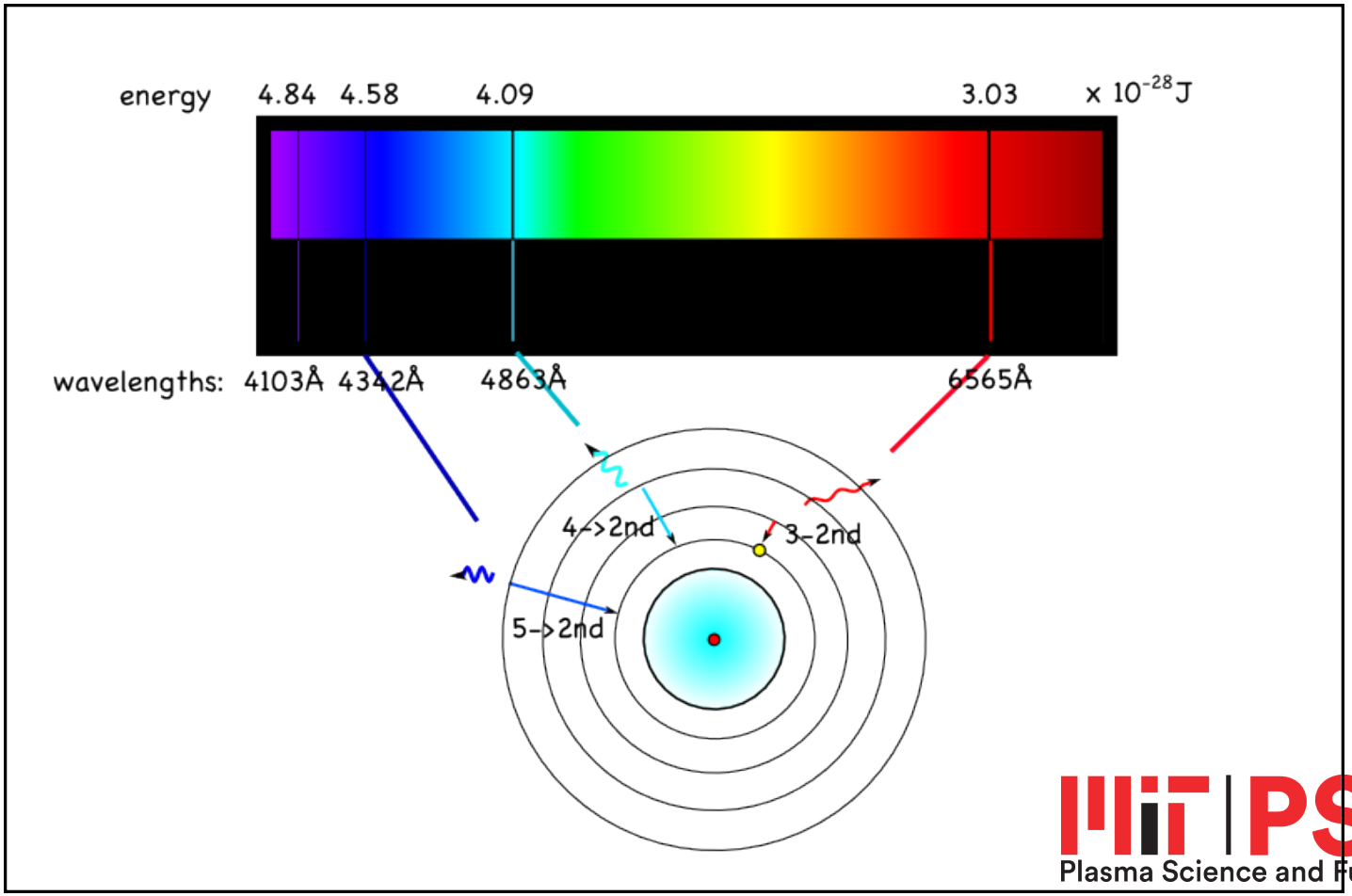
Why Does a Plasma Glow

- Remember: the atoms in a plasma were excited by the electric current.
- What happens when the electrons recombine with the nuclei?

Energy is Released as Light When Excited Electrons Re-combine with the Nucleii

- The energy used to excite the electrons is released as light, but only in certain distinct wavelengths



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We Can See These Distinct Lines With a Spectroscope

Observe the Neon Bulb with your Spectroscope

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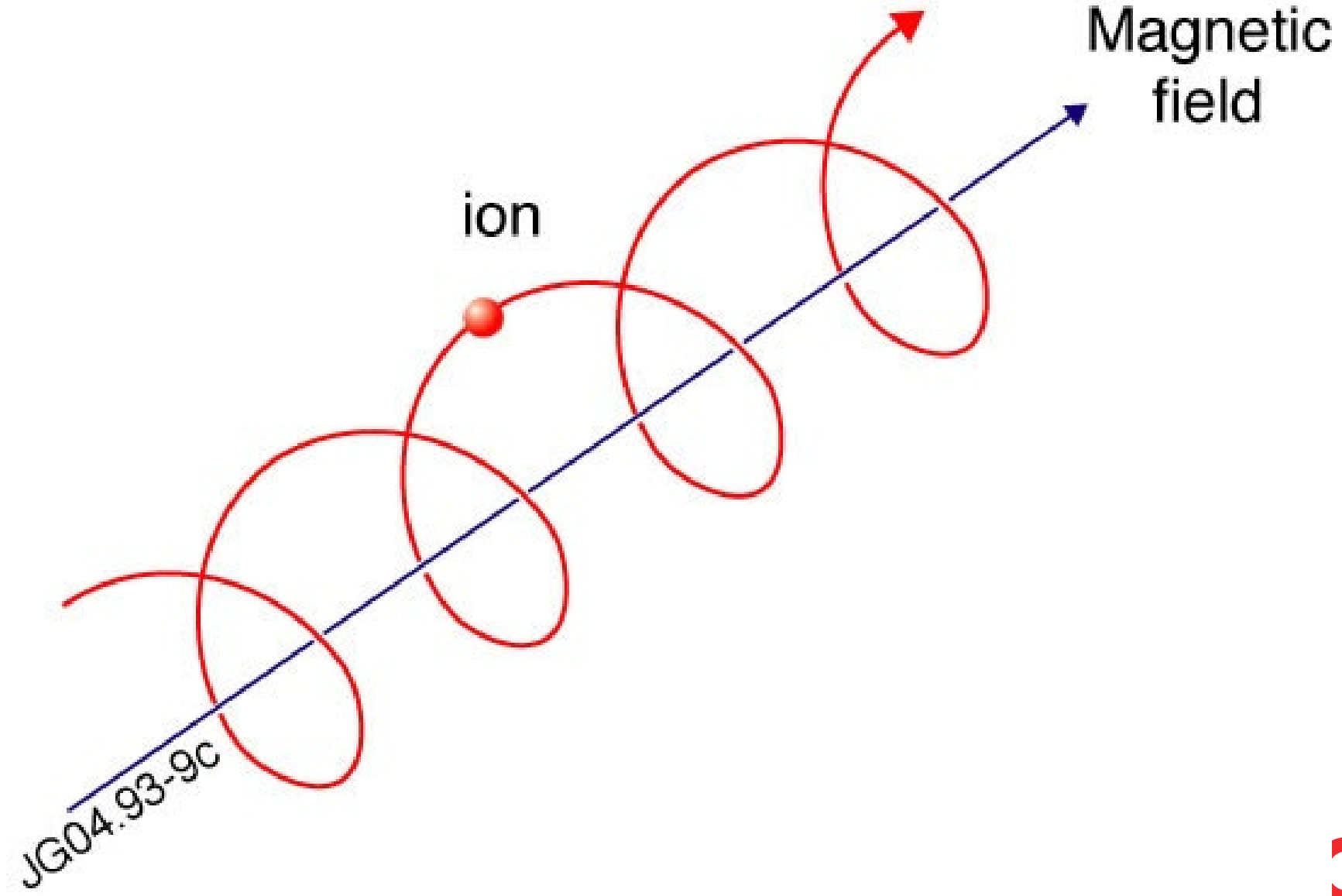
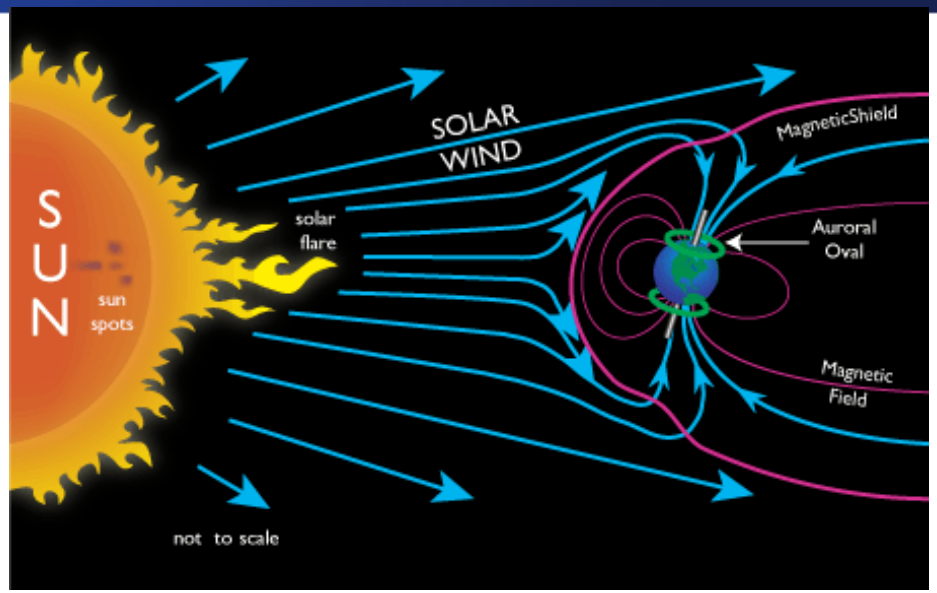
Ions/Electrons Follow Magnetic Field Lines



Plasma Trapped by Earth's Magnetic Field

The Aurora

- The Sun is made of plasma
- Plasma hits the earth.
- Earth has a magnetic field from north to south poles, this traps some plasma
- The plasma bounces back and forth in the magnetic field until it hits the poles
- Glow in the sky

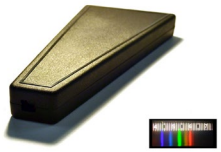


Supplies:

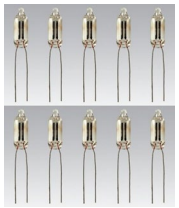
Fluorescent light in the microwave:
GE Lighting 11084 22-Watt T9 Kitchen and Bath Circline
https://www.amazon.com/dp/B000QRDM2U/ref=pe_2640190_232748420_TE_item

Syringe and dispenser tip:
4 Pack 50ml Syringes with 14Gx1.0" Blunt Tip Fill Needles and Storage
https://www.amazon.com/dp/B07C2QSN6K/ref=pe_2640190_232748420_TE_item

High Voltage Pulse Transformer
High Voltage Pulse Transformer DC 12V to 60kV Boost Step-up Power Module
High-Voltage Arc Generator 60000V
https://www.amazon.com/dp/B075RDV3PC/ref=pe_2640190_232748420_TE_item



Spectroscope:
EISCO High Resolution Quantitative Spectroscope, 400-700 nm, 5nm
https://www.amazon.com/dp/B00FGARIAO/ref=pe_2640190_232748420_TE_item



Neon Bulb:
Eiko A-1B A1B (Amber) Bulbs, 110 V, 0.04 W, Wire Terminal Base, T-2 shape (Box of 10)
https://www.amazon.com/dp/B00JS9RBBK/ref=pe_2640190_232748420_TE_item

Magnet:
1/2" x 1/4" Disc - Plastic Coated - Blue - Neodymium Magnet
https://www.apexmagnets.com/magnets/1-2-x-1-4-disc-plastic-coated-blue-neodymium-magnet

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Classroom Plasma Demos

- **Electrical excitation of a gas into a plasma is demonstrated with the plasma globe**
  - High frequency electric source excites the gas through a glass sphere due to capacitance
- **The plasma globe is used to excite gas in a vacuum chamber build out of a dispenser syringe**
  - Gas under a vacuum is easier to break down into a plasma
- **The spectrum lines of electrons recombining with ions is observed with the spectroscope**