PLASMA SCIENCES EXPO 2018
November 24 and 25
Suggested Student Questions
(WITH ANSWERS)

Auburn University / Wittenberg University
Edward Thomas, Jr. (etjr@physics.auburn.edu)
Jeremiah Williams (jwilliams@wittenberg.edu)
Lori Scott, (lcs0044@auburn.edu)

Students will be asked to predict an outcome of a demonstration, observe the demonstration, then explain the result.

PREDICT: Using your intuition and prior knowledge, write down what you think will happen in the demonstration.

OBSERVE: Watch closely and write down what you see happening.

EXPLAIN: Was your prediction right? How can you explain what happened? Ask questions and refine your explanation.

APS-DPP Outreach
James Roche (roche@aps.org)

What does LED stand for?
Answer: Light-emitting diode

What is a diode?
Answer: A circuit element that only allows current to flow in one direction – a one-way street for electrons.

Which leg of the LED needs to be on the positive side of the battery?
Answer: The long leg

Barry University
Sanja Zivanovic
szivanovic@barry.edu

How does a star, particularly the sun, evolve, in simple terms?
Answer: Stars spend most time in equilibrium, where the gravity force (that tries to squeeze them) is compensated by a pressure that comes from nuclear reaction rates. With MESAPlot, we can see the energy produced in various nuclear reaction rates. In the sun, the reactions are producing He from H. We can see that the amount of He grows with time while the amount of H decreases. Once the H decreases, we end up with a He core and a H shell that surrounds it. The nuclear reactions continue in the shell but not in the core. In this stage the star expands and the surface becomes colder. These are known as Red Giant stars. Red indicates that the surface is "colder" while Giant indicates that the star is very big. The sun will become a RG in about 5 billion years. Try seeing how big the sun is in this phase using MESAPlot. You can also plot surface temperature and radius versus time, to see how it becomes colder and larger. Meanwhile, the core cannot ignite since the temperature and density is not yet sufficient for reactions that use He to produce Ca and O. However, the star core keeps warming up and, eventually, ignites also the He. This event is called the He-flash. After that, the star shrinks again and the surface becomes hotter. Meanwhile, in its core there are reactions that produce Ca and O from He. This is called the Horizontal branch phase. When even He in the core is exhausted, the sun will not ignite other reactions and

become a white dwarf, a very compact star that is not producing energy through nuclear reactions. A white dwarf is just losing energy.

People say that we are made of star dust. Is that true? What does that mean?

Answer: A lot of the elements we are made of, for example Ca and O, are produced in stars, through nuclear reactions. You need a lot of heat and density for nuclear fusion to happen. In general, we need stars bigger than the sun. To be fully clear, the very light elements such as H and He are produced during the Big Bang. However, that stage is too fast for other heavier elements to be produced. Instead, the cores and shells of big stars are hot for a long time and can produce elements. For a star about 10 times more massive than the sun, the nuclear reactions (fusion) continue all the way to the production of Fe. From nuclear physics we know that it is not energetically convenient to produce elements heavier than iron through fusion. So, the star cannot sustain its own gravity and eventually explodes as a Supernova (SN). Doing this, puts out all the elements. Other, heavier elements are produced in the explosion process. So, in a sense we are made of star dust.

Contemporary Physics Education Project (CPEP)
Sam Lightner (lightner@westminster.edu)
Cherie Harper (gsphysics@live.com)

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Florida Atlantic University
Alexandra DeCesare (adecesare2013@fau.edu)

What is the Van De Graff generator used for?

Answer: The Van de Graaff generator was developed as a particle accelerator for physics research; its high potential is used to accelerate subatomic particles to great speeds in an evacuated tube.

It was the most powerful type of accelerator of the 1930s until the cyclotron was developed. Van de Graaff generators are still used as accelerators to generate energetic particle and X-ray beams for nuclear research and nuclear medicine.

What makes your hair stand up when you touch etheVan De Graaff generator?

Answer: When the Van de Graaff generator starts charging, it transfers the charge to the person who is touching it. Since the person's hair follicles are getting charged to the same potential, they try to repel each other. This is why the hair actually stands up.

FIU Applied Research Center
Leo Lagos (lagosl@fiu.edu)

How do robots work?

Answer: On the most basic level, human beings are made up of five major components:

- *A body structure*
- *A muscle system to move the body structure*
- *A sensory system that receives information about the body and the surrounding environment*
- *A power source to activate the muscles and sensors*
- *A brain system that processes sensory information and tells the muscles what to do*

Of course, we also have some intangible attributes, such as intelligence and morality, but on the sheer physical level, the list above about covers it.

A robot is made up of the very same components. A typical robot has a movable physical structure, a motor of some sort, a sensor system, a power supply and a computer "brain" that controls all of these elements. Essentially, robots are man-made versions of animal life -- they are machines that replicate human and animal behavior.

By this definition, robots are distinct from other movable machines, such as cars, because of their computer element. Many new cars do have an onboard computer, but it's only there to make small adjustments. You control most elements in the car directly by way of various mechanical devices. Robots are distinct from ordinary computers in their physical nature -- normal computers don't have a physical body attached to them.

Why do we need robots/remote systems when dealing with nuclear waste?

Answer: Cleaning up nuclear waste is an obvious task for robots and it has been one of the key drivers for the development of robotics technology. Since the Three Mile Island nuclear disaster in 1979, automated robots have been designed to get right into the action, conducting test and inspection works, as well as decommissioning tasks that are considered too dangerous for humans.

Dr Antonio Espingardeiro, Institute of Electrical and Electronics Engineers (IEEE) member and member of IEEE Robotics and Automation Society, says:

"Robots have been used in nuclear facilities for a long time. Scenarios such as maintenance tasks in nuclear facilities or even disasters like radioactive leaks or search and rescue operations have proven to be quite successful. We are talking about robotic arms or remote operated vehicles with some end effectors built in to handle dangerous situations."

American Association for the Advancement of Women in STEM (AWSTEM)
Tulika Srivastava (tsriv001@fiu.edu)

What are your STEM interests? Are you interested in a STEM career? This booth has advice about pathways to a future in Science, Technology, Engineering and Math.

Florida International University / Society of Physics Students
sps@fiu.edu

What interests you about the exhibit by FIU SPS? Make up a question and get the answer.

Question:

Answer:

Florida Polytechnic University
Sesha Srinivasan (ssrinivasan@floridapoly.edu)

What interests you about the Florida Polytechnic University display? Make up a question and get the answer.

Question:

Answer:

General Atomics
Rick Lee (leer@fusion.gat.com)

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The Laboratory for Laser Energetics (University of Rochester)
Reuben Epstein (reps@lle.rochester.edu)

What do the letters in the name LASER stand for?
Answer: Light Amplification by the Stimulated Emission of Radiation.

What amount of seawater contains an amount of fusion energy equivalent to the energy in the world's oil reserve? In other words, what volume of seawater, in cubic kilometers, would this be?
Answer: One cubic kilometer.

What kind of rocket is used to compress fusion fuel to high density?

Answer: The rocket is a spherical rocket, compressing the spherical fuel volume to a greatly reduced volume. The rocket is also a laser-driven rocket, where the laser heats the outer surface of the fuel capsule. This causes the outer surface to vaporize and expand rapidly, creating the rocket thrust.

What is the fusion reaction we are studying, and how is it different from a fission reaction?

Answer: In fusion, two heavy hydrogen nucleii combine to form a larger helium nucleus. In fission, a large fuel nucleus, like uranium, splits into smaller nucleii. One could say more: The hydrogen nucleii are tritium and deuterium, rather than uranium. The differences between fusion and fisson include their practical aspects, such as the fact that the products of fusion are safe, while the products of fission are hazardous and the fact that fusion fuel is abundant in nature, while fission fuel is scarce.

Lawrence Livermore National Laboratory

Steve Allen (allen18@llnl.gov)

How do radio waves, visible light, and X-rays differ as components of the electromagnetic spectrum?

Answer: Each has its own unique wavelength and frequency.

Why do astronomers use radio, visible light and X-ray telescopes to collect data about the sun and other stars?

Answer: The universe contains numerous types of stars that emit energy at different parts of the electromagnetic spectrum.

Lawrence Livermore National Laboratory (continued)

What COLOR is common to the plasmas that we see on earth (like the tokamak) and in the sky (like the Orion Nebula)?

Answer: Red, because the light is from hydrogen, which is both an abundant element in the universe and also the fuel for plasma fusion experiments.

What is the fusion reaction we are studying, and how is it different from a fission reaction?

Answer: In fusion, two heavy hydrogen nuclei combine to form a larger helium nucleus. In fission, a large fuel nucleus, like uranium, splits into smaller nuclei.

Los Alamos National Laboratory

Liz Merritt (emerritt@lanl.gov)

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MIT Plasma Science and Fusion Center
Paul Rivenberg (rivenberg@psfc.mit.edu)

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NASA / Exploration Ground Systems
Genger Benson Perez (genger.k.bensonperez@nasa.gov)

What is the job of Exploration Ground Systems at NASA?

Answer: Exploration Ground Systems is based at NASA's Kennedy Space Center in Florida. EGS was established to develop and operate the systems and facilities necessary to process and launch rockets and spacecraft during assembly, transport and launch, as well as utilizing the skills and talents of the NAVY to recover the crew capsule upon arrival back to earth. EGS's mission is to transform the center from a historically government-only launch complex to a spaceport that can handle several different kinds of spacecraft and rockets—both government and commercial.

What is the Crawler Transporter and how much does it weigh?

Answer: The two-tracked Crawler Transport 2 will move the Mobile Launcher Platform holding the Space Launch System (SLS) from the Vehicle Assembly Building (VAB) to the Launch Platform at a top speed of .1 mile per hour. It weighs 6 million pounds. Length: 40 meters wide, 35 meters long. Height is 6 meters (20 feet) to meters (26 feet) adjustable. The top deck is flat and square, and about the size of a baseball infield, 90 feet on a side.

What was the computer launch system for the Apollo Program called?

Answer: The Apollo Guidance Computer (AGC) was a digital computer produced for the Apollo program that was installed on board each Apollo command module (CM) and Apollo Lunar Module (LM). The AGC provided computation and electronic interfaces for guidance, navigation, and control of the spacecraft. Astronauts communicated with the AGC using a numeric display and keyboard called the DSKY (for display & keyboard, pronounced 'DISS-key').

NIF Laser Road Show
Patrick Lestie Poole (poole11@llnl.gov)

Where are fiber optics used in the NIF laser, and why can't they be used everywhere?

Answer: Fiber optics are used to "build" the initial laser pulse (of small size and low energy) and transmit it to the first amplification stage. However, it can't be used after that point because the beam becomes too powerful and too large for a simple optical fiber to handle.

What colors of light does the NIF laser use?

Answer: Most of the system operates in the infra-red (1064 nm) because that is a good wavelength for the laser amplifier glass to use, but just before the target chamber that light is converted to green (532 nm) and then blue (351 nm) because that is better for the plasma physics being studied in the experimental interaction

Northeast High School / Lemelson-MIT InventTeam
Randa Flinn (Randa.flinn@browardschools.com)
Lise Mabour (lise.mabour@browardschools.com)

Would your invention, the Mosquito Agitator, eliminate all mosquitoes in an area?

Answer: Not all mosquitoes spread harmful diseases and male mosquitoes serve as pollinators, which makes them very important in some environments. The Mosquito Agitator does not eliminate all mosquitoes in a given area, the device was invented to reduce disease-spreading mosquitoes in populated areas around man-made water bodies and some natural water bodies.

How can other students become inventors?

Answer: Everyone is capable of becoming an inventor, no matter what they are interested in. Good inventors are problem solvers; therefore, the first step of inventing is identifying a problem to solve. After, the inventor will think of the possible ways they can solve that problem to enhance the lives of those it impacts. Most problems are solved in teams, at this stage, some inventors gather a team to help provide different perspectives and skills. The lengthiest part of inventing is usually the designing and building phases. Inventors can test and re-design an idea many times before they reach a working version of the invention. For more information, students and their teachers can follow this link to learn more about students inventing from Lemelson Center's Spark Lab: https://invention.si.edu/try/sparklab.

Ohio State University
Christopher Orban (orban.14@osu.edu)

What are three different ways to predict what is going to happen in a physics experiment?

Answer: 1. Pencil and paper math! 2. Do a computer simulation. 3. Wild guess!

Charged particles have what kind of field?

Answer: 1. Electric field

Princeton Plasma Physics Laboratory

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STEM + Computer Science / Broward County Public Schools
Lisa Milenkovic (Lisa.milenkovic@browardschools.com)
Rebecca Malones (rmalones@browardschools.com)

How can I get involved in computer science, robotics or environmental initiatives in my school?

Answer: Depends on the grade level and the school. See booth staff for answers.

Telops
Ben Saute (Benjamin.saute@telops.com)

Why does a thermal image look different than a visible image?

Visible cameras capture light over the approximate spectral range of 350-1000 nm. The majority of the photons that reach your camera are generated by sunlight reflecting off of the objects within a scene. Thermal cameras capture light in the infrared spectral range, typically with spectral range of 3-5 um. The majority of photons that reach a thermal camera are generated by emission of infrared photons by objects within a scene ("blackbody" emission). These differences in operational principles lead to qualitative differences between visible and thermal images.

How does a multispectral thermal camera differ from a broadband thermal camera?

A broadband thermal camera will be sensitive across a broad spectral range such as the midwave (3-5 um) or longwave (8-12 um) infrared. Multispectral thermal cameras incorporate filters or other optical components to allow the collection of data within specific subregions of the spectral range. This can be useful when monitoring for the presence of specific gases like in a combustion reaction, or when trying to measure the temperature of a metal plate in an extreme environment like a tokamak reactor vessel.

University of California Los Angeles (UCLA)
Gurleen Bal (gurleenkbal@physics.ucla.edu)

How is plasma created from a gas?

Answer: By heating up the gas until the electrons break away from their nuclei.

How does a plasma produce light?

Answer: When an electron in a plasma cools down, it recombines with an ion to create a neutral particle. This recombination produces a small burst of light, and the color of light that's emitted is unique to the type of gas.

What are some examples of plasma in everyday life?

Answer: Neon signs, fluorescent lightbulbs, lightning, the sun

UCSD Center for Energy Research
Saikat Thakur (saikat@ucsd.edu)

What does an electric motor do and what is the source of energy for the motor? How does this compare to an electric generator/dynamo?

Answer: An electric motor converts electrical energy into mechanical energy. Most electric motors generate a rotational force due to the interaction between magnetic fields and electric current. The source of energy for this electric motor is the energy stored in the battery, which is converted into mechanical energy. This is opposite of what a dynamo or electrical generator does: a dynamo generates electricity by converting mechanical energy into electrical energy.

What are the most common sources of energy production in the world? Can you quantify how much? Can you name some renewable sources of energy?

Answer: Fossil fuels: namely oil (32%), coal (28%) and natural gas (22%). They constitute 82% of the total world energy consumption. Nuclear energy accounts for 5% and the rest (13%) is from renewable energy sources. Some renewable sources of energy are: hydro-electricity, wind, solar, solar-thermal, bio-fuels, geo-thermal etc.

What is "plasma"? How do you make plasma? Have you ever seen naturally occurring plasma?

Answer: Plasma is a state of matter (solid, liquid, gas and plasma) that occurs at very high temperatures. It is mainly "ionized gas", consisting of positively charged ions (atoms or molecules missing one or more electrons) and free electrons, that can respond to external electric and/or magnetic fields. You make plasma by providing energy to heat gas to high enough temperatures to ionize a significant portion of the neutral atoms/molecules. An example of a naturally occurring plasma is a lightning bolt, in which an electrical current flows through the air, heating and ionizing the molecules. The aurora is also an example of naturally occurring plasma on earth. The sun and all other stars are big balls of plasma.

University of Florida / Society of Physics Students
Jonathan M. Gant (sps@phys.ufl.edu)

What interests you about the University of Florida's exhibit? Make up a question and get the answer.

Question:

Answer:

University of Michigan
Michigan Institute of Plasma Science and Engineering
Carolyn Kuranz (ckuranz@umich.edu)

What is a plasma?

A plasma is a hot gas made up of charged particles

How do you turn a single laser beam into two beams?

With a beam splitter! This optic transmits part of the laser light and reflects the other part.

What happens to a wave at an interface between 2 fluids of different densities?

If it meets the conditions for instability, the waves will grow in amplitude due to the Kelvin-Helmholtz instability.

University of Central Florida / Laser and Plasma Laboratory
Martin C. Richardson (mcr@creol.ncf.edu)

How does a laser form a plasma filament?

Answer: When a laser has high peak power, which can happen when the laser pulse is compressed into a very small amount of time, the air or other medium that the laser is passing through will act like a positive lens, focusing the beam. When the laser focuses, it reaches high intensities, meaning the energy is in a small amount of time and space. At these intensities, the light particles, or photons, ionize the medium, as the electrons get enough energy from the photons to leave the molecules. The plasma acts like a negative lens, making the beam defocus. The two effects balance, focusing and defocusing the beam, resulting in a narrow channel of plasma along the beam path.

University of Iowa - Planeterrella
Scott Baalrud (scott-baalrud@uiowa.edu)

What causes an aurora?

Answer: Energetic charged particles (plasma) trapped in Earth's magnetic field that hit the upper atmosphere near the magnetic poles, exciting atomic transitions and causing the atmospheric gas to emit light.

What is the solar wind?

Answer: A stream of charged particles (plasma) emitted from the Sun

What are the Van Allen radiation belts?

Answer: Zones of energetic charged particles (plasma) that are trapped in Earth's magnetic field. Most of these charged particles originate from the solar wind.