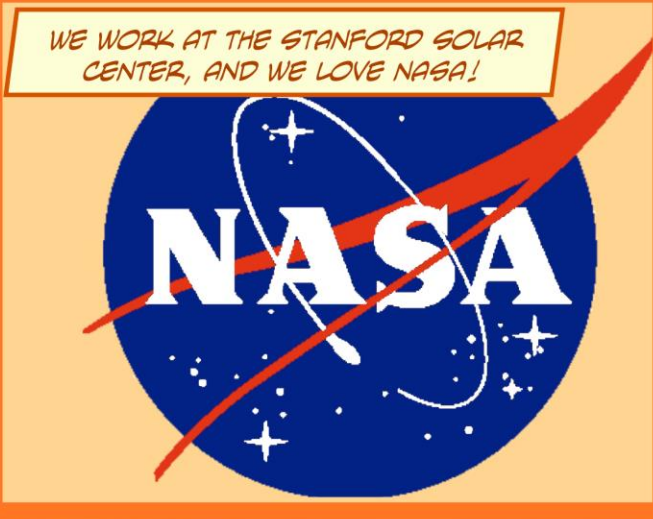


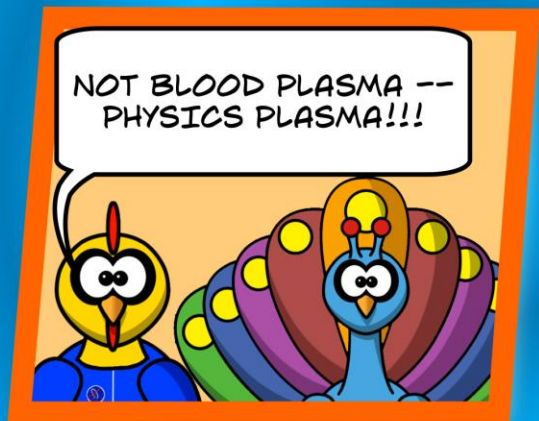
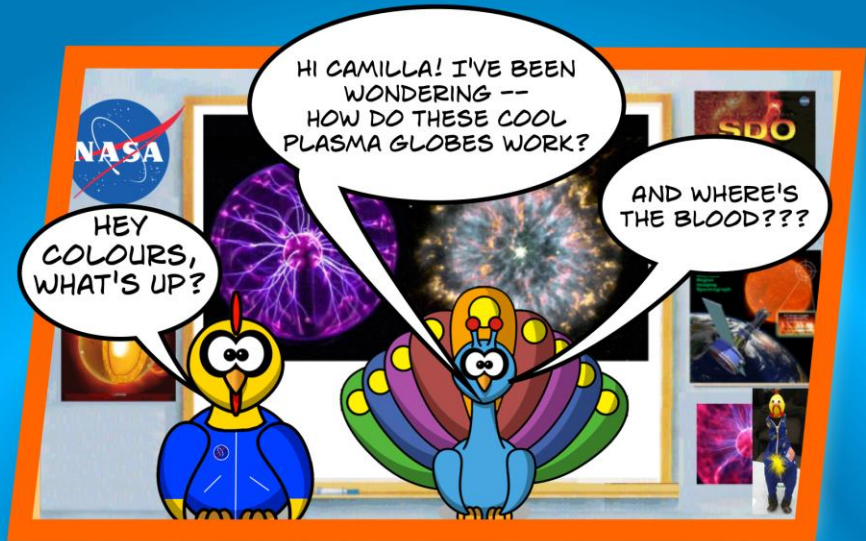
TALES FROM STANFORD SOLAR



PLASMA GLOBES
HOW DO THEY WORK?

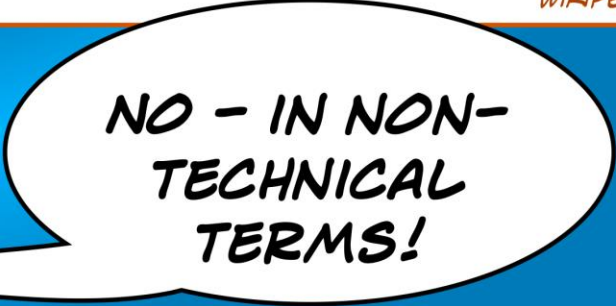







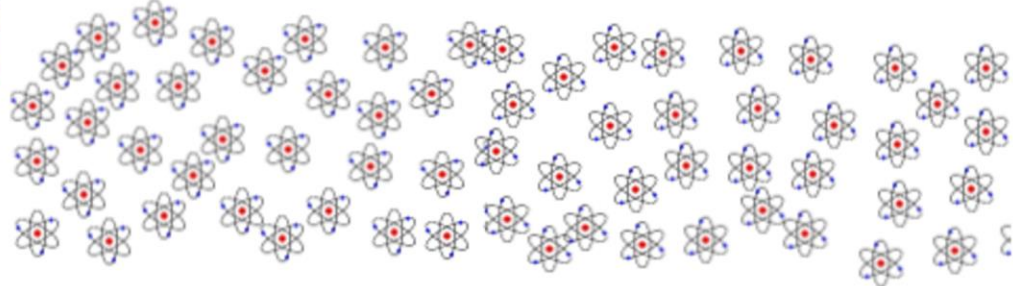
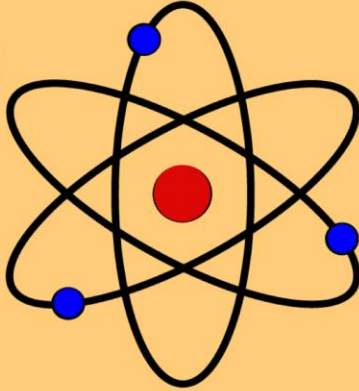
The clear glass orb is filled with a mixture of various noble gases with a high-voltage electrode in the center of the sphere. Plasma filaments extend from the inner electrode to the outer glass insulator. They are driven by high-frequency alternating current energy at approximately 35 kHz, 2–5 kV. This energy comes from a lower-voltage DC power supply usually connected to main power, and flows through a high-voltage transformer combined with a high-frequency electronic oscillator circuit which together output a high frequency and high voltage AC to the electrode. The radio-frequency energy is admitted into the larger space by capacitive coupling through the glass.

WIKIPEDIA






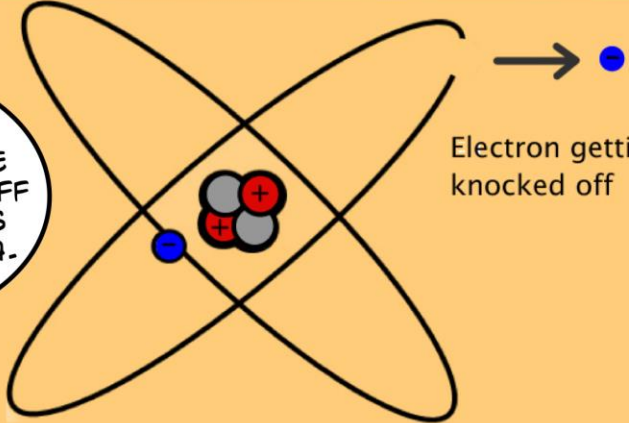
OK. REMEMBER THAT ATOMS HAVE A NUCLEUS WITH ELECTRONS GOING AROUND IT?



AND THAT A GAS HAS NORMAL ATOMS BOUNCING AROUND IN IT



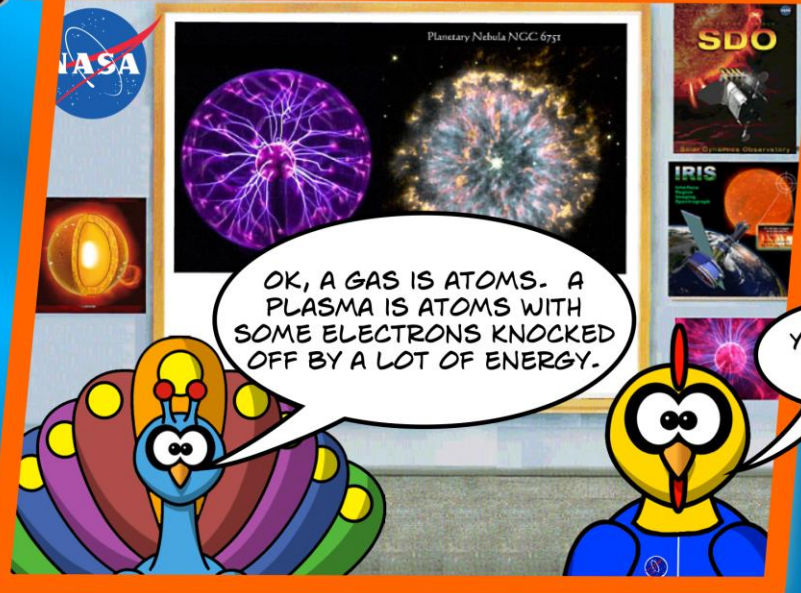
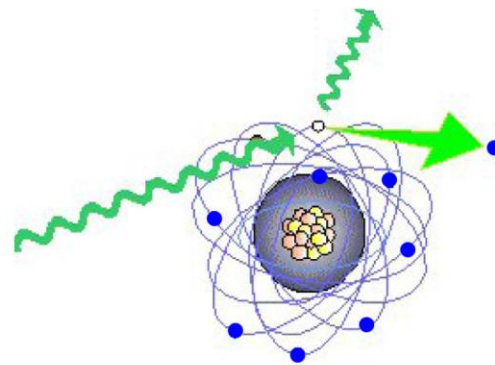
A GAS WHERE ELECTRONS HAVE BEEN KNOCKED OFF THEIR ATOMS IS CALLED A PLASMA.



Electron getting knocked off

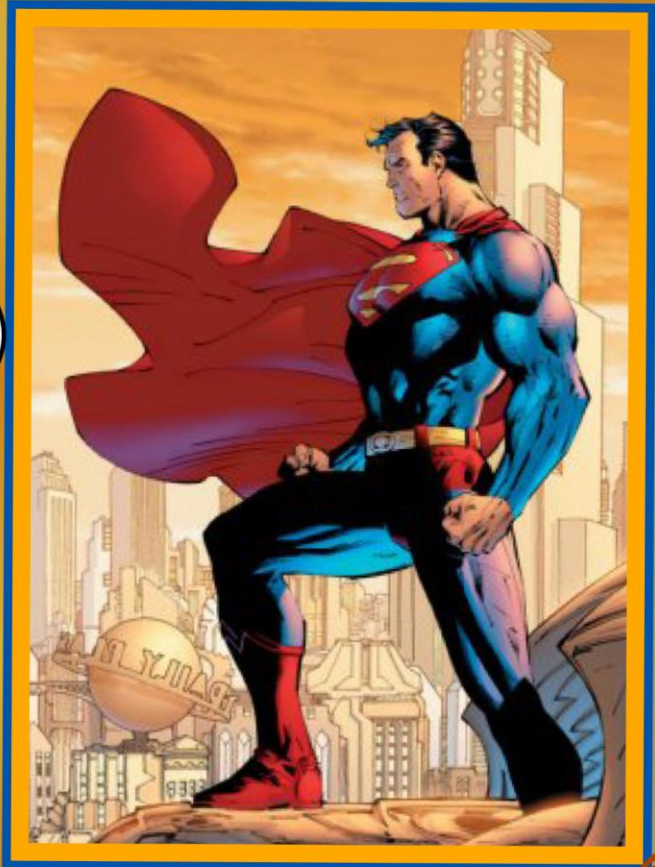
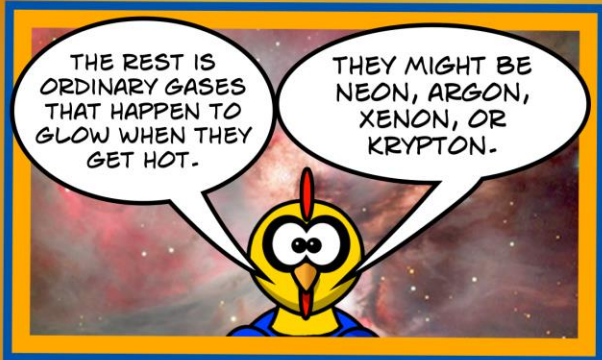
HENCE THE NAME "PLASMA GLOBE".

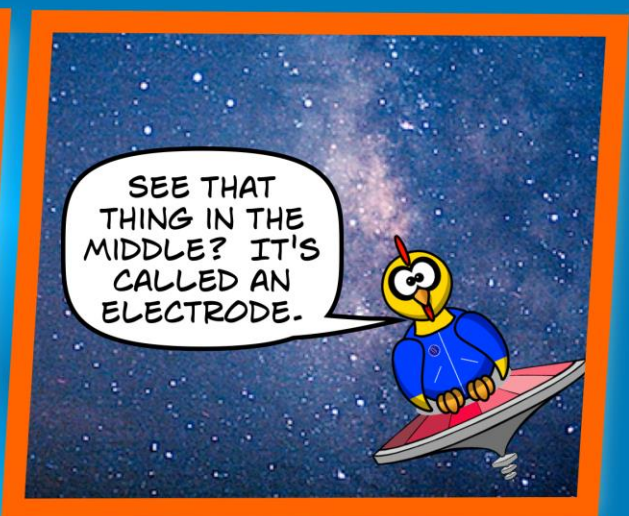
OUR SUN, THE STARS, AND MOST OF THE UNIVERSE ARE A PLASMA.



OK, A GAS IS ATOMS. A PLASMA IS ATOMS WITH SOME ELECTRONS KNOCKED OFF BY A LOT OF ENERGY.

YOU GOT IT!





THE ELECTRODE IS POWERED BY SOME ELECTRONICS IN THE GLOBE BASE. IT IS A RADIO TRANSMITTER -- IT SENDS OUT RADIO WAVES.



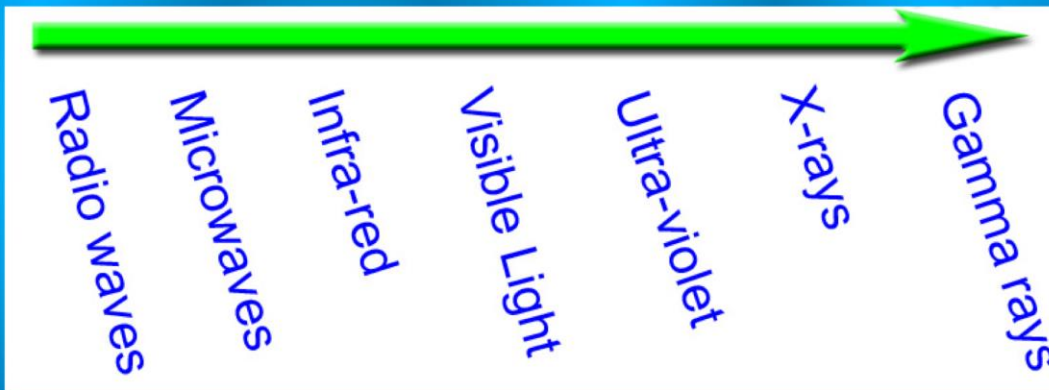


I'M NOT QUITE SURE WHAT RADIO WAVES ARE.....

RADIO WAVES ARE ELECTROMAGNETIC RADIATION, WHICH IS ENERGY -- LIKE LIGHT FROM THE SUN, OR ENERGY FROM A HYDROGEN BOMB, OR X-RAYS. THERE ARE FORMS OF ENERGY OUR EYES CANNOT SEE. THE TYPES OF LIGHT/ENERGY INCLUDE RADIO WAVES, MICROWAVES, INFRARED, VISIBLE LIGHT, ULTRAVIOLET LIGHT, X-RAYS, AND GAMMA RAYS.



← LESS ENERGY MORE ENERGY →



THE DIFFERENT TYPES OF LIGHT HAVE DIFFERENT AMOUNTS OF ENERGY. RADIO WAVES HAVE THE LEAST, GAMMA RAYS THE MOST.



PLASMA GLOBES USE RADIO WAVES BECAUSE THEY CARRY JUST ENOUGH ENERGY TO KNOCK ELECTRONS OFF ATOMS TO MAKE THE PLASMA. IF PLASMA GLOBES USED X-RAYS OR GAMMA RAYS, THEY WOULD BE VERY DANGEROUS!

OK, I GET THAT.



Radio wave energy

SINCE THE RADIO WAVE ENERGY IS STRONG ENOUGH TO KNOCK ELECTRONS OFF THE ATOMS IN THE GAS...

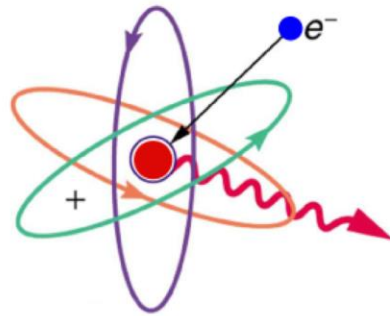
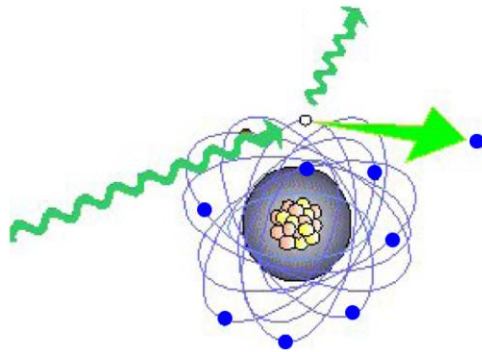
...THAT MAKES THE GLOBE FULL OF GAS, ELECTRONS, AND ATOMS MISSING ELECTRONS.

AS THE ELECTRONS AND ATOMS DART AROUND, THEY OCCASIONALLY CLUMP TOGETHER.

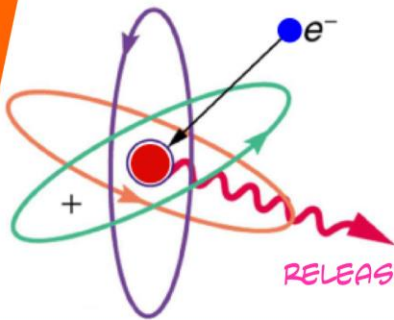
AS THE CLUMPS BOUNCE AROUND, THEY MAKE IT EASIER FOR OTHER CLUMPS TO JOIN THEM, MAKING A STREAMER.

THE RADIO WAVE ENERGY ALSO PUSHES THE STREAMER, OR TENDRIL, TOWARDS THE GLASS.

WHILE THE ELECTRONS ARE RACING AROUND IN THAT PLASMA TENDRIL, THEY SOMETIMES KNOCK OTHER ELECTRONS OFF THE GAS ATOMS.



BUT THE ATOMS WANT THEIR ELECTRONS BACK, SO THEY GRAB THE CLOSEST ONE.



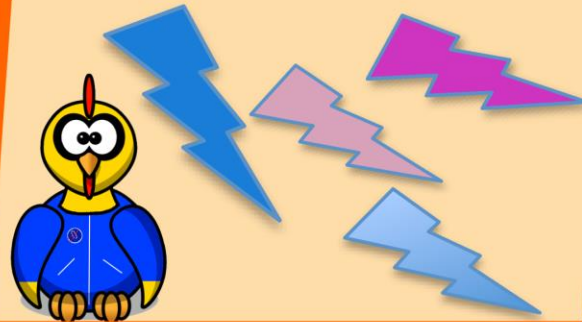
RELEASED ENERGY

WHEN A LOST ELECTRON SNAPS BACK WITH A NUCLEUS, ENERGY IS RELEASED.



JUST LIKE ENERGY IS RELEASED WHEN YOU LET GO OF A STRETCHED RUBBER BAND.

THE LITTLE PIECE OF ENERGY, WHICH IS LIGHT, THAT IS RELEASED IS THE COLOR YOU SEE IN THE TENDRILS. YOU GET DIFFERENT COLORS FROM THE DIFFERENT GASES.

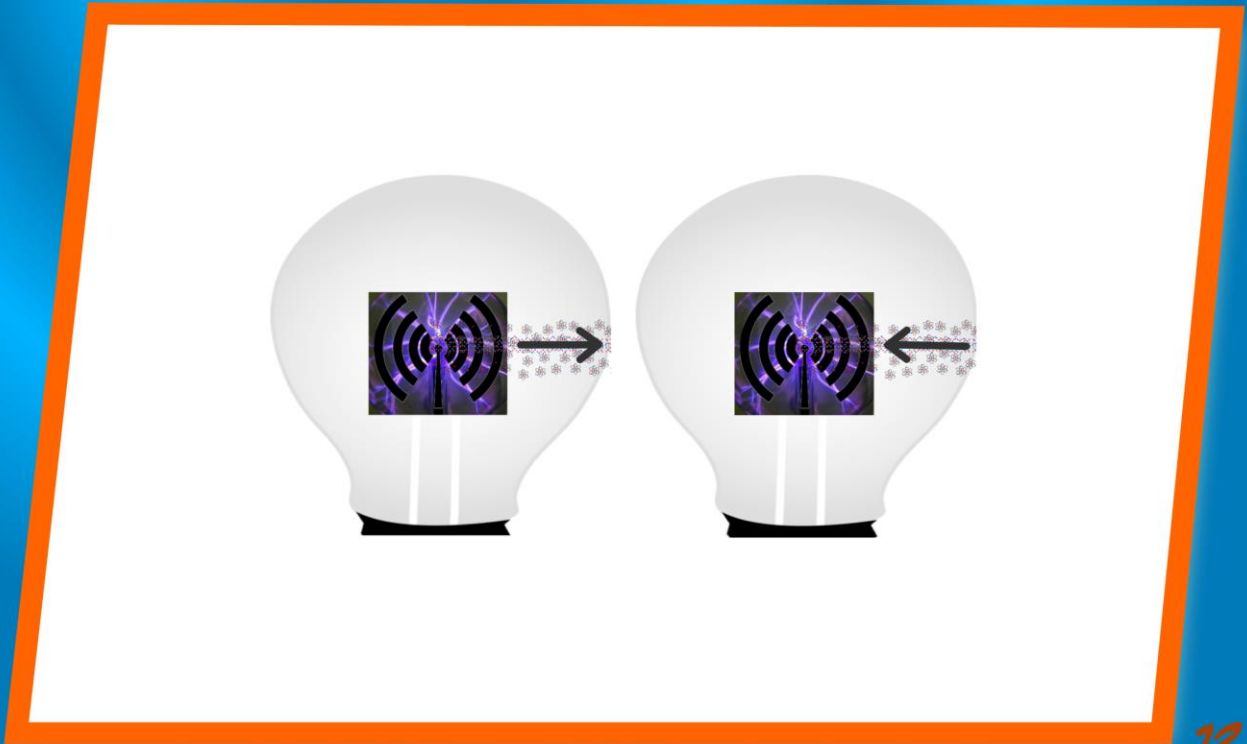
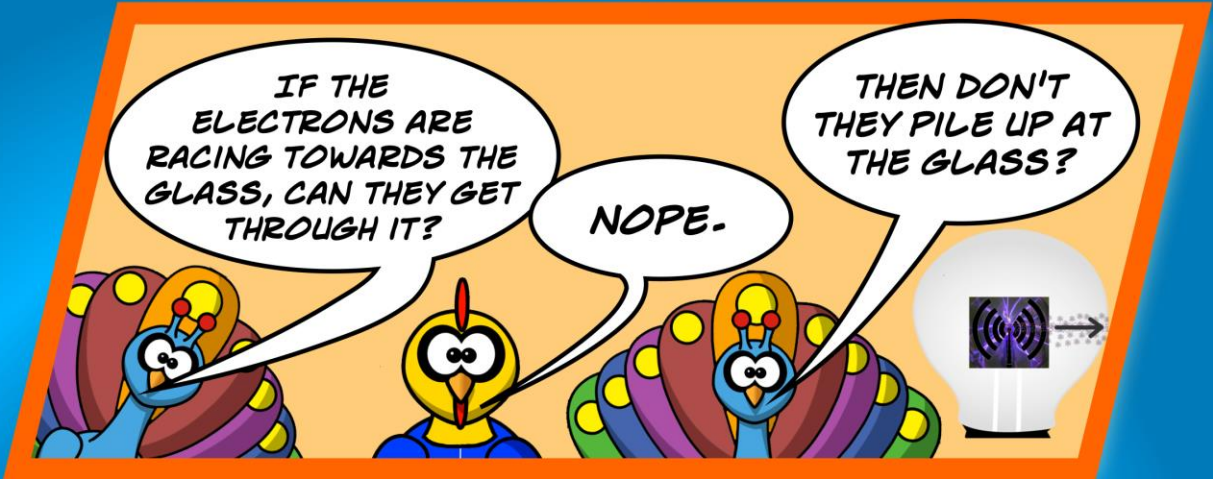


AWESOME



SO THE GLOWING LIGHT
COMES FROM ATOMS
RECAPTURING LOST
ELECTRONS IN A PLASMA!







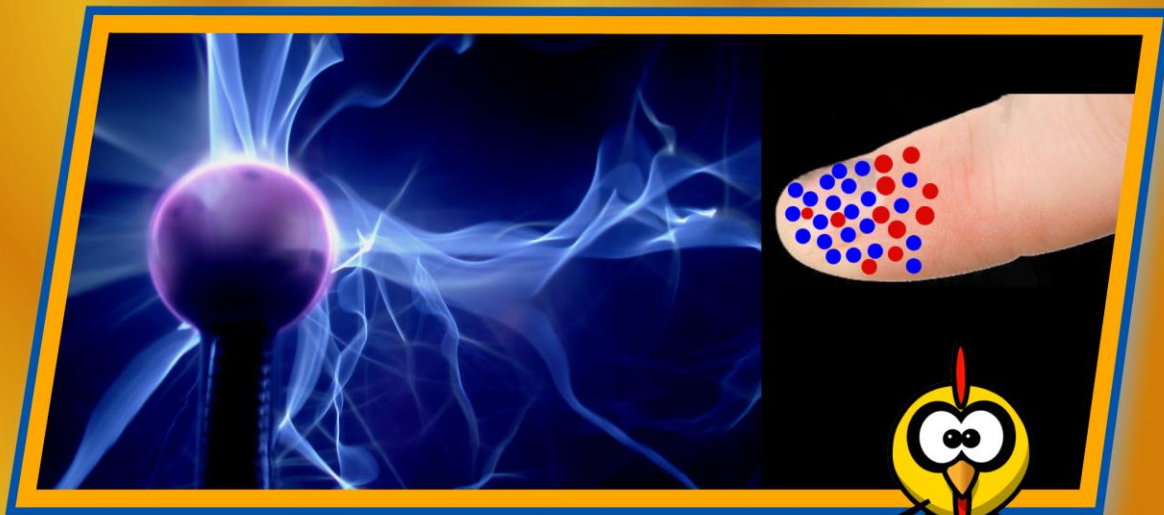
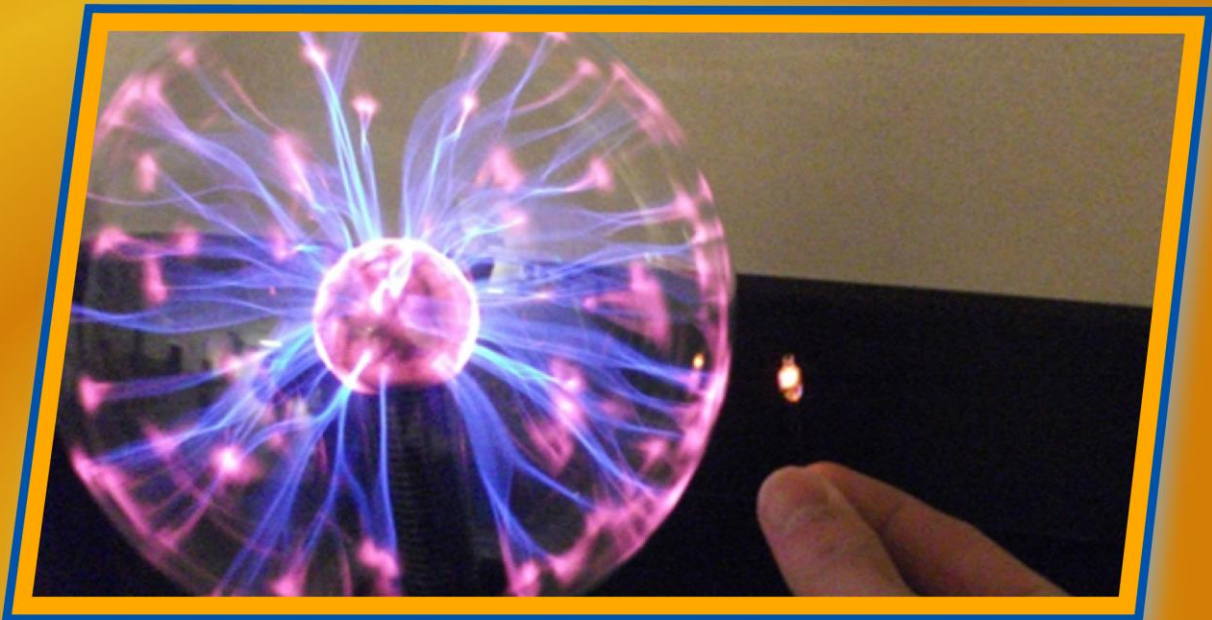
WHY DO THE TENDRILS GO TO YOUR FINGER WHEN YOU TOUCH THE GLOBE?



THE TENDRILS WANT TO FOLLOW THE ELECTRIC FIELD. IT GOES OUT OF THE GLASS IN ALL DIRECTIONS, EVEN THOUGH THE ELECTRONS CAN'T. NORMALLY, THAT ELECTRIC FIELD GOES INTO THE AIR. ELECTRONS IN THE TENDRILS WANT TO FIND ATOMS MISSING ELECTRONS (POSITIVELY CHARGED IONS). THERE ARE MORE IN YOUR FINGER THAN IN THE AIR/GAS AROUND IT, SO THE TENDRILS HEAD IN THAT DIRECTION!



THAT ELECTRIC FIELD IS WHY YOU CAN LIGHT LITTLE NEON BULBS AND FLUORESCENT TUBES BY HOLDING THEM OUTSIDE OF THE GLOBE. THEY PICK UP THE ELECTRIC FIELD THERE!

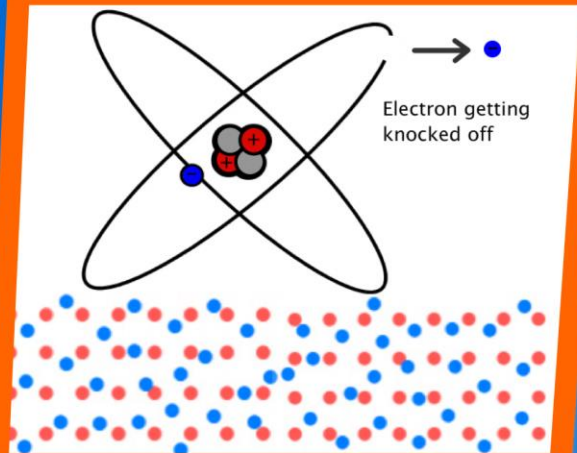


THE ELECTRIC FIELD IS ALSO MAKING ELECTRONS AND ATOMS COME AND GO IN YOUR FINGER, WHICH IS WHY YOUR FINGER GETS HOT WHEN YOU TOUCH THE GLOBE!

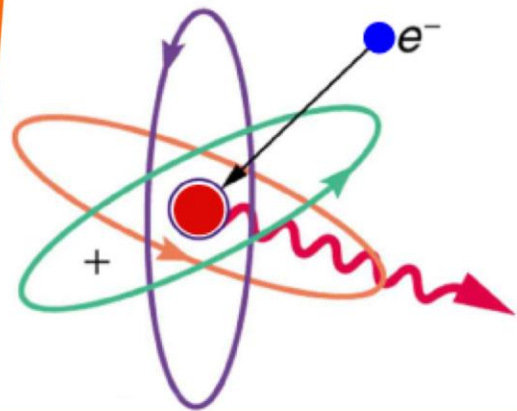




THE ELECTRODE IN THE CENTER GENERATES RADIO WAVES, WHICH CARRY ENERGY.



THE ENERGY KNOCKS ELECTRONS OFF THE GAS ATOMS IN THE GLOBE, MAKING A PLASMA.



THE ATOMS RECAPTURE LOST ELECTRONS, AND EMIT A BIT OF LIGHT IN THE PROCESS. EACH GAS MAKES A DIFFERENT COLOR OF LIGHT.



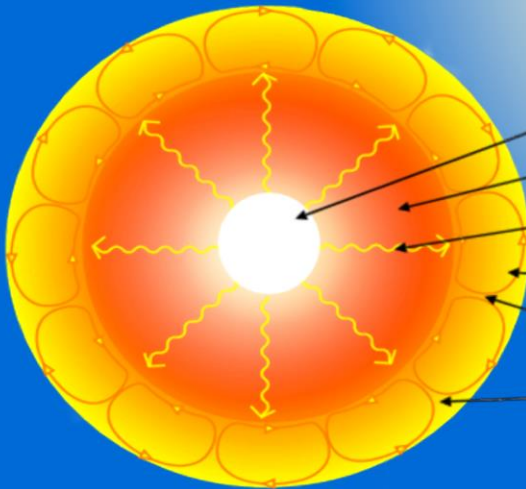
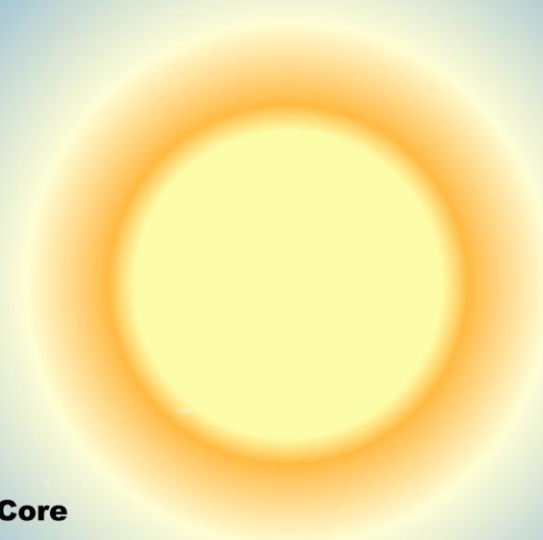
THE ELECTRIC FIELD GOES ON OUTSIDE THE GLOBE AND CAN LIGHT LITTLE BULBS OR BE ATTRACTED TO YOUR FINGER.



YES!!!!



AND ITS
KINDA LIKE THE
SUN-



Core

Radiative Zone

Photon/energy

Convection Zone

Hot plasma rising

Cool plasma sinking

??????



THE SUN IS A PLASMA, LIKE THE
STREAMERS IN THE GLOBE.

THE INSIDE OF THE SUN, ITS CORE,
GENERATES ENERGY -- BUT BY CRUSHING
ATOMS TOGETHER, NOT BY ELECTRICITY.

THE ENERGY FROM THE CORE RADIATES
OUT IN ALL DIRECTIONS AND CAUSES
ELECTRONS TO CRASH INTO EACH OTHER,
LOSING ENERGY IN THE COLLISIONS.
JUST LIKE THE PLASMA GLOBE.



THE HIGH-ENERGY GAMMA RAYS EMITTED IN THE CORE GET ABSORBED AND RE-EMITTED MANY, MANY TIMES ON THEIR WAY OUT OF THE SUN. SOME OF THEIR ENERGY IS ABSORBED BY THE MATERIAL, HEATING IT UP. SO THE ENERGY OF THE PHOTON GRADUALLY DECREASES ON THE WAY UP FROM THE HOT INTERIOR TO THE LESS-HOT SURFACE.



SINCE THE SUN IS SO BIG, IT TAKES THE ENERGY HUNDREDS OF THOUSANDS OF YEARS TO WORK ITS WAY TO THE SURFACE!

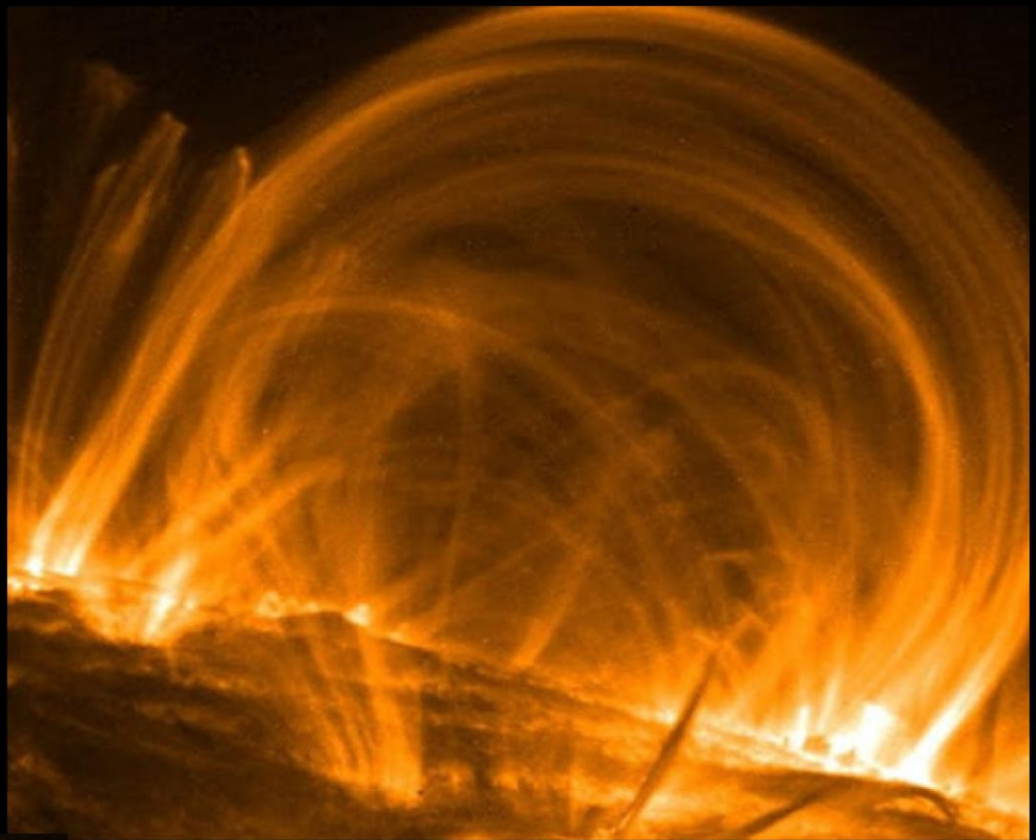
BY THAT TIME, THE GAMMA RAYS HAVE LOST ENOUGH ENERGY TO BE EMITTED FROM THE SUN'S SURFACE AS VISIBLE LIGHT.

ALSO, IN THE UPPER ATMOSPHERE THE ENERGY KNOCKS ELECTRONS OFF ATOMS. WHEN THE ATOMS RECAPTURE THE ELECTRONS, THEY MAKE LIGHT JUST AS IN THE PLASMA GLOBE!

WOW



THE SUN HAS
'TENDRILS' TOO!



THESE ARE PLASMA TENDRILS, MUCH LIKE THOSE
IN THE GLOBE. BUT THESE ARE A LOT BIGGER.
THEY LOOP DOWN, RATHER THAN GOING STRAIGHT
UP, CAUSE THEY ARE PULLED AND HELD TOGETHER
BY MAGNETIC FIELDS ON THE SUN.

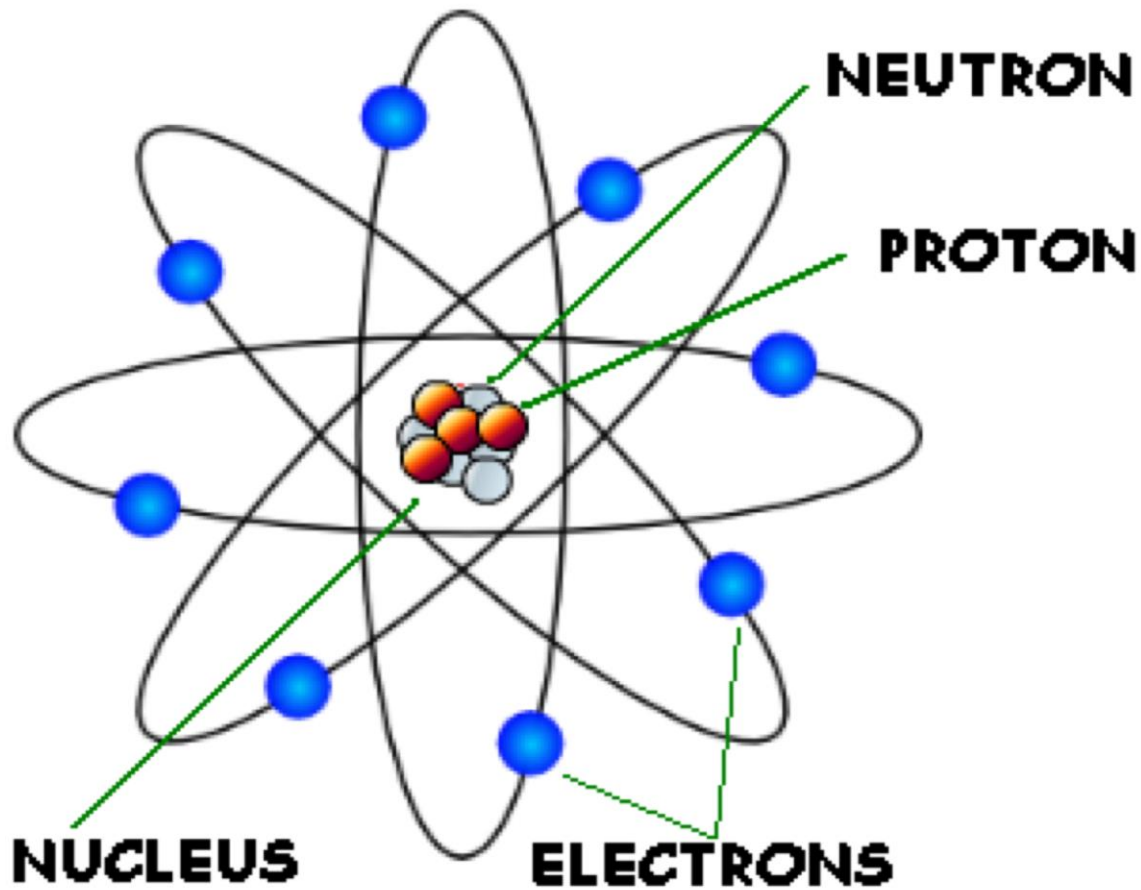


WOW -- THANKS,
CAMILLA, FOR TEACHING
ME ABOUT PLASMA GLOBES
AND THE SUN!!!

COLOURS HAS TROUBLE MEMORIZING TECHNICAL TERMS,
SO CAMILLA HAS TRIED NOT TO USE THEM. BUT IF YOU
REALLY WANT TO KNOW, HERE ARE THE TERMS:

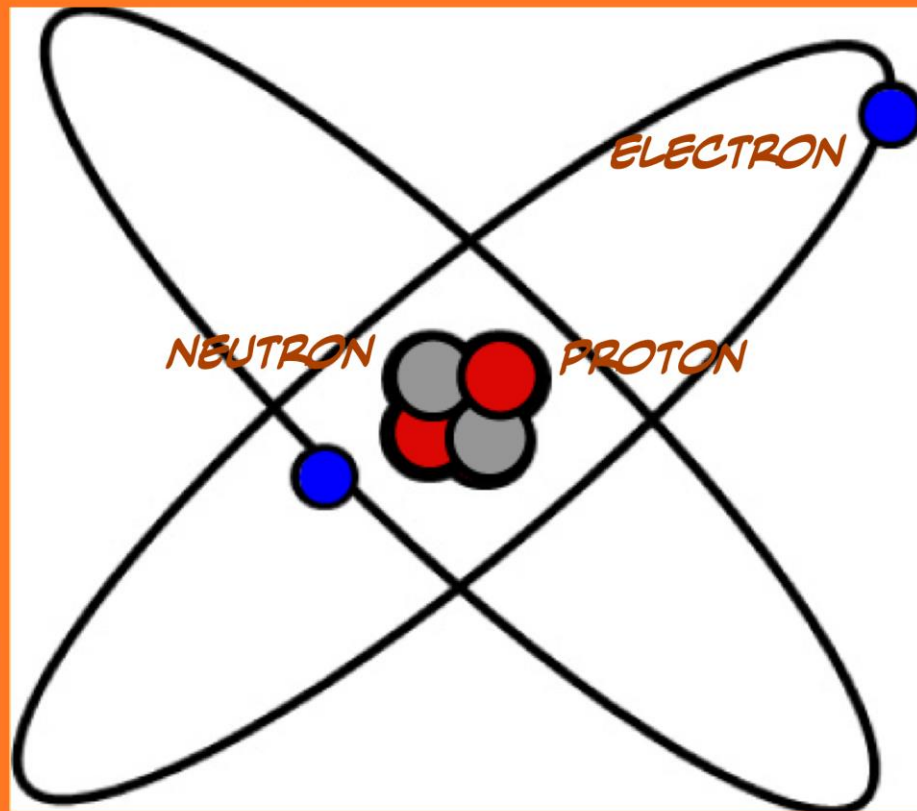
GLOSSARY

PARTS OF AN ATOM



GLOSSARY

THE NUCLEUS HAS 2 TYPES OF THINGS
- PROTONS AND NEUTRONS.



THE BLUE
THINGS ARE
ELECTRONS

(WE CAN IGNORE THE GREY
NEUTRONS BECAUSE THEY
DON'T HAVE ANYTHING TO DO
WITH PLASMAS OR ELECTRIC
FIELDS.)

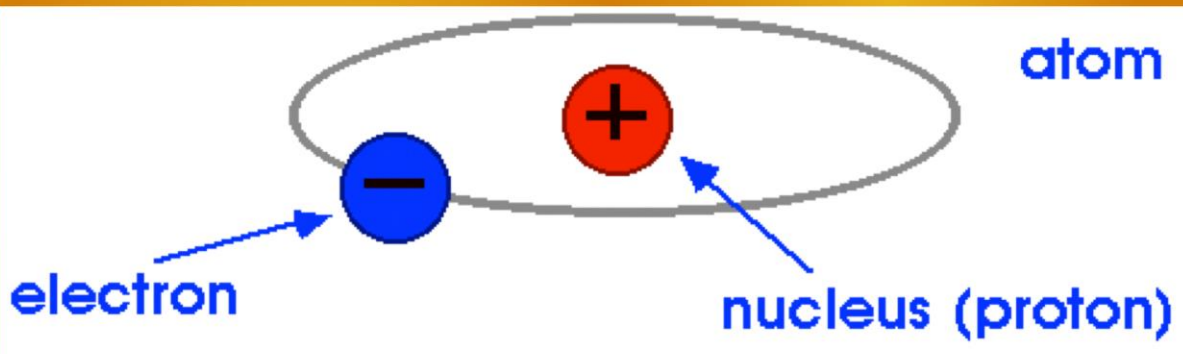
THE RED
THINGS ARE
PROTONS.

IN A NORMAL ATOM, THERE ARE
ALWAYS THE SAME NUMBER OF
ELECTRONS AND PROTONS, THE
BLUE THINGS AND THE RED THINGS.

GLOSSARY

CHARGE

THE ELECTRONS AND PROTONS ARE ATTRACTED TO EACH OTHER LIKE OPPOSITE POLES OF A MAGNET ARE.



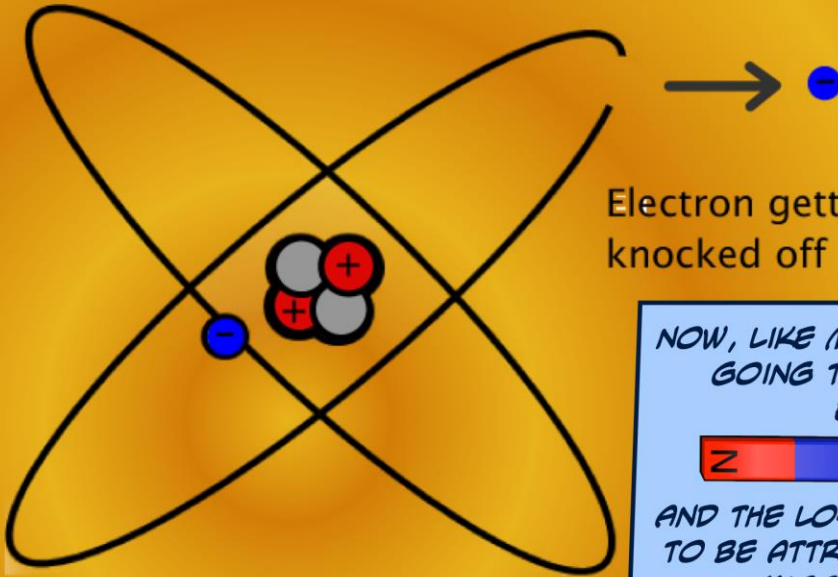
THIS IS CALLED CHARGE. BY CONVENTION, WE SAY THAT ELECTRONS HAVE A NEGATIVE (-) CHARGE, AND PROTONS A POSITIVE (+) ONE. THIS CHARGE IS WHAT HOLDS ATOMS TOGETHER!

GLOSSARY

CHARGE

THERE'S ONE OTHER IMPORTANT DETAIL.

IF ONE OF THE ELECTRONS GETS KNOCKED OFF, LIKE IN A PLASMA, THE ATOM BECOMES UNBALANCED:
IT HAS 2 PLUSSES (+) AND ONLY 1 MINUS (-)



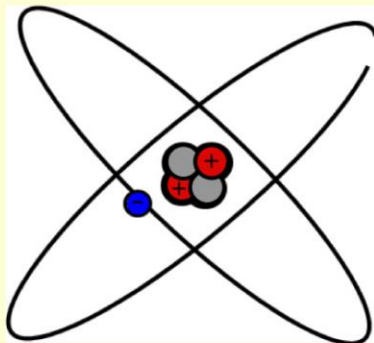
Electron getting knocked off

NOW, LIKE MAGNETS, THAT ATOM IS GOING TO BE ATTRACTED TO ELECTRONS.



AND THE LOST ELECTRON IS GOING TO BE ATTRACTED TO ATOMS WITH MISSING ELECTRONS.

HELP!!!!



I NEED AN ELECTRON!



I NEED A NUCLEUS!

GLOSSARY

ELECTRIC FIELD

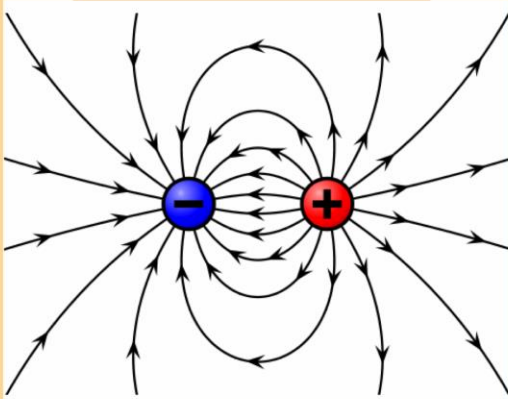


IF AN ELECTRIC FIELD IS THE PULL/PUSH ATTRACTION BETWEEN ELECTRONS AND PROTONS, THEN HOW COULD IT GO OUTSIDE THE GLOBE?

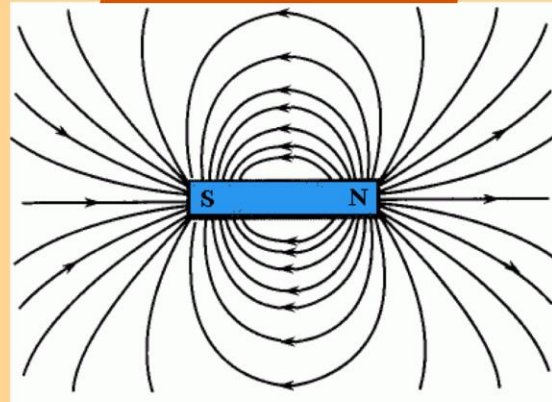
AN ELECTRIC FIELD IS LIKE A MAGNETIC FIELD, THEY ARE A FORCE AND BOTH CAN GO THROUGH GLASS.



ELECTRIC FIELD



MAGNETIC FIELD

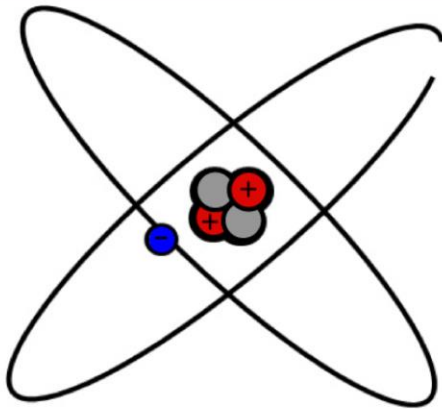
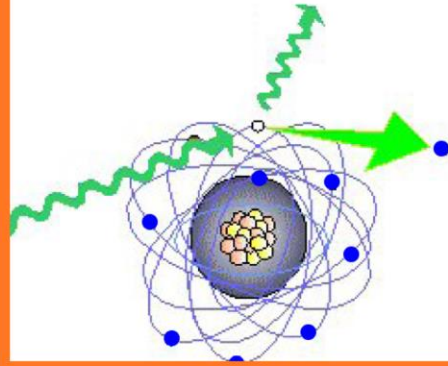


THEY LOOK THE SAME!

THERE ARE BILLIONS AND BILLIONS OF ATOMS AND LOOSE ELECTRONS BOTH INSIDE AND OUTSIDE THE GLOBE. THE RADIO WAVES CARRY THE ELECTRIC FIELD -- THEY ARE OSCILLATING ELECTRIC AND MAGNETIC FIELDS MOVING THROUGH SPACE, AIR, GLASS, ETC.

GLOSSARY ION, CHARGED PARTICLE

REMEMBER, THE PLUS (+) OF A PROTON AND THE MINUS (-) OF AN ELECTRON ARE CALLED THEIR CHARGE.



IF AN ATOM HAS LOST AN ELECTRON, OR AN ELECTRON HAS LOST A NUCLEUS, THEY ARE CALLED CHARGED PARTICLES, OR IONS.

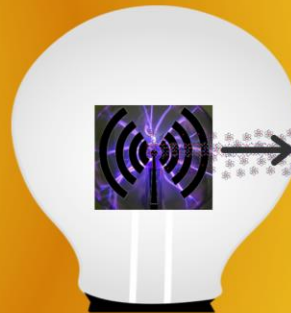
GLOSSARY

CURRENT, ALTERNATING CURRENT, DIRECT CURRENT

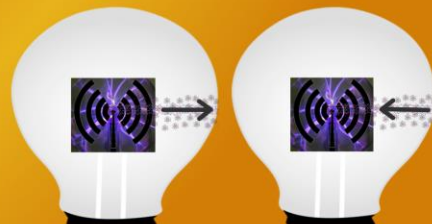
WHEN ELECTRONS ARE BEING PUSHED IN AN ELECTRIC FIELD, WE CALL IT **CURRENT**. IT'S MUCH LIKE THE CURRENT THAT FLOWS IN WATER.



IF THE CURRENT IS PUSHING ONLY 1 DIRECTION, IT'S CALLED **DIRECT CURRENT**. BATTERIES WORK LIKE THIS.



IF THE CURRENT IS CHANGING DIRECTIONS BACK AND FORTH, IT'S CALLED **ALTERNATING CURRENT**. THIS IS USED TO AVOID PILE-UPS OF ELECTRONS AT ONE END OF THE CURRENT AND IT'S HOW ELECTRICITY USUALLY WORKS.



GLOSSARY

CONDUCTOR

CERTAIN MATERIALS ARE EASY FOR A CURRENT TO GO THROUGH. THIS MEANS THEY ARE EASY FOR ELECTRONS TO MOVE IN. OTHER MATERIALS ARE HARD FOR ELECTRONS AND A CURRENT TO MOVE IN. A MATERIAL THAT IS EASY FOR A CURRENT OR AN ELECTRON IS CALLED A CONDUCTOR.



FINGERS ARE GOOD CONDUCTORS, SO ARE METALS, PLASMA, AND EVEN WATER.

AIR IS A BAD CONDUCTOR, AS ARE GLASS AND RUBBER.

GLOSSARY

ELECTRODE

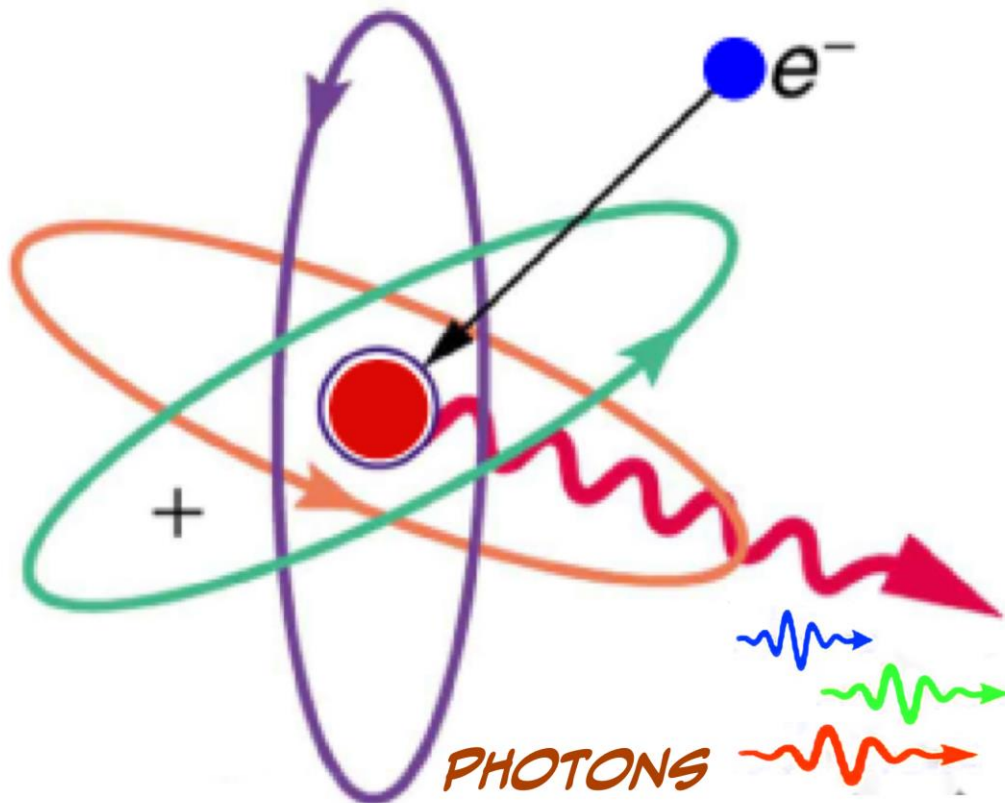
AN ELECTRODE IS A PLACE WHERE ELECTRICITY CAN LEAVE (OR ENTER) AN OBJECT. IN A PLASMA GLOBE, THE ELECTRODE IS THE CENTER BALL, AND IT LAUNCHES ENERGY AND ELECTRONS INTO THE GLOBE.



GLOSSARY

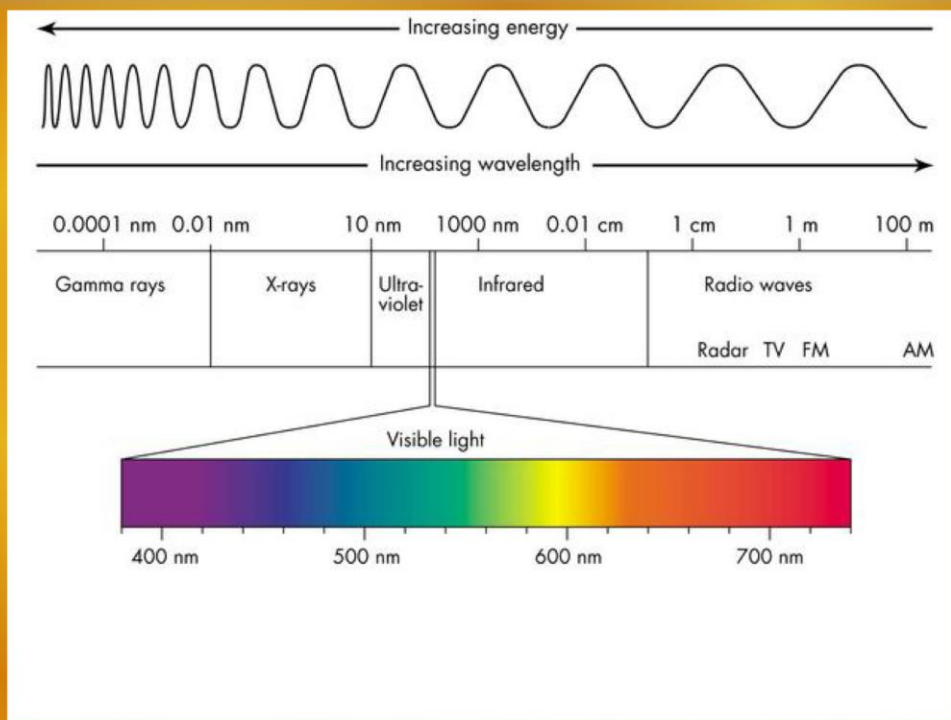
PHOTON

LIGHT COMES IN PACKETS OR CHUNKS. THE LITTLE PIECE OF LIGHT EMITTED WHEN AN ATOM GRABS BACK AN ELECTRON IS CALLED A PHOTON. PHOTONS COME IN DIFFERENT SIZES AND COLORS, EVEN COLORS THAT THE HUMAN EYE CANNOT DETECT.



GLOSSARY ELECTROMAGNETIC RADIATION

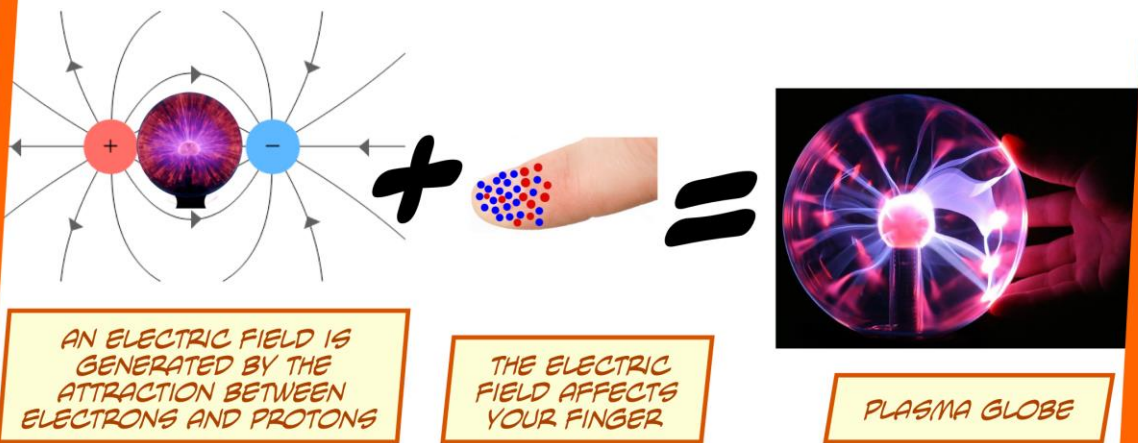
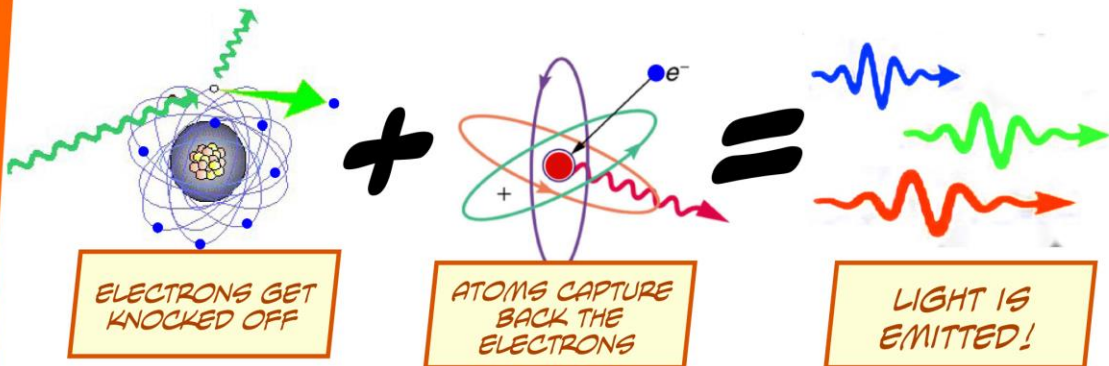
ELECTROMAGNETIC RADIATION IS ENERGY, OR LIGHT, EVEN LIGHT OUR EYES CANNOT SEE. THE TYPES INCLUDE RADIO WAVES, MICROWAVES, INFRARED, VISIBLE LIGHT, ULTRAVIOLET LIGHT, X-RAYS, AND GAMMA RAYS.



THE TYPES OF LIGHT DIFFER BY THEIR AMOUNTS OF ENERGY. RADIO WAVES HAVE THE LEAST, GAMMA RAYS THE MOST.

LIGHT BEHAVES LIKE WAVES TOO. RADIO WAVES HAVE A LONG WAVELENGTH (& SMALLEST AMOUNT OF ENERGY). GAMMA RAYS HAVE THE SHORTEST WAVELENGTH (& MOST ENERGY).

QUICK SUMMARY





SOLAR RESOURCES

ABOUT NASA SOLAR MISSIONS:

SDO - [HTTP://SDO.GSFC.NASA.GOV/](http://SDO.GSFC.NASA.GOV/)

IRIS - [HTTP://IRIS.GSFC.NASA.GOV/](http://IRIS.GSFC.NASA.GOV/)

STEREO - [HTTP://WWW.NASA.GOV/MISSION_PAGES/STEREO/MAIN/](http://WWW.NASA.GOV/MISSION_PAGES/STEREO/MAIN/)

SOHO - [HTTP://SOHOWWW.NASCOM.NASA.GOV/](http://SOHOWWW.NASCOM.NASA.GOV/)

GREAT NASA ACTIVITIES:

[HTTP://NASAWAVELENGTH.ORG](http://NASAWAVELENGTH.ORG)

FOR STUDENTS:

THE STANFORD SOLAR CENTER HAS A LARGE COLLECTION OF ACTIVITIES, VIDEOS, AND IMAGES TO EXPLORE:

[HTTP://SOLAR-CENTER.STANFORD.EDU/ACTIVITIES](http://SOLAR-CENTER.STANFORD.EDU/ACTIVITIES)

FEATURES OF THE SUN -- A GREAT INTERACTIVE GAME WHERE YOU ARE A SOLAR SCIENTIST!

[HTTP://LASP.COLORADO.EDU/HOME/EDUCATION/K-12/PROJECT-SPECTRA](http://LASP.COLORADO.EDU/HOME/EDUCATION/K-12/PROJECT-SPECTRA)

SPACE WEATHER CENTER

LOTS OF GREAT GAMES AND FUN ACTIVITIES:

[HTTP://WWW.SPACEWEATHERCENTER.ORG/ACTIVITY_PAGE/01/01.HTML](http://WWW.SPACEWEATHERCENTER.ORG/ACTIVITY_PAGE/01/01.HTML)

FOR TEACHERS:

SDO FOR EDUCATORS

ELEMENTARY AND SECONDARY LEARNING UNITS

[HTTP://SDO.GSFC.NASA.GOV/EPO/EDUCATORS/](http://SDO.GSFC.NASA.GOV/EPO/EDUCATORS/)

THE STANFORD SOLAR CENTER HAS A LARGE COLLECTION OF LESSONS, MOSTLY 4-12

[HTTP://SOLAR-CENTER.STANFORD.EDU/TEACHERS](http://SOLAR-CENTER.STANFORD.EDU/TEACHERS)

NOVA'S SUN LAB - GREAT LESSONS AND STUDENT ACTIVITIES

[HTTP://WWW.PBS.ORG/WGBH/NOVA/LABS/LAB/SUN/](http://WWW.PBS.ORG/WGBH/NOVA/LABS/LAB/SUN/)

OUR STAR THE SUN

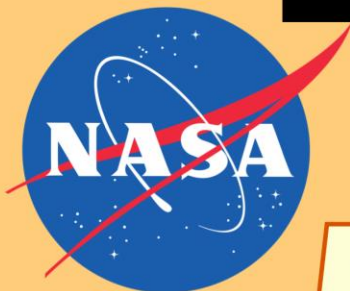
COLLECTION OF SUN-THEMED CLASSROOM RESOURCES FROM NASA'S SOLAR AND HELIOSPHERIC OBSERVATORY

[HTTP://SOHOWWW.NASCOM.NASA.GOV/CLASSROOM/CLASSROOM.HTML](http://SOHOWWW.NASCOM.NASA.GOV/CLASSROOM/CLASSROOM.HTML)

PLASMA GLOBES

STORY & DESIGN BY
DEBORAH SCHERRER

STANFORD SOLAR CENTER
[HTTP://SOLAR-CENTER.STANFORD.EDU](http://solar-center.stanford.edu)



FUNDING BY NASA'S SDO/HMI
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