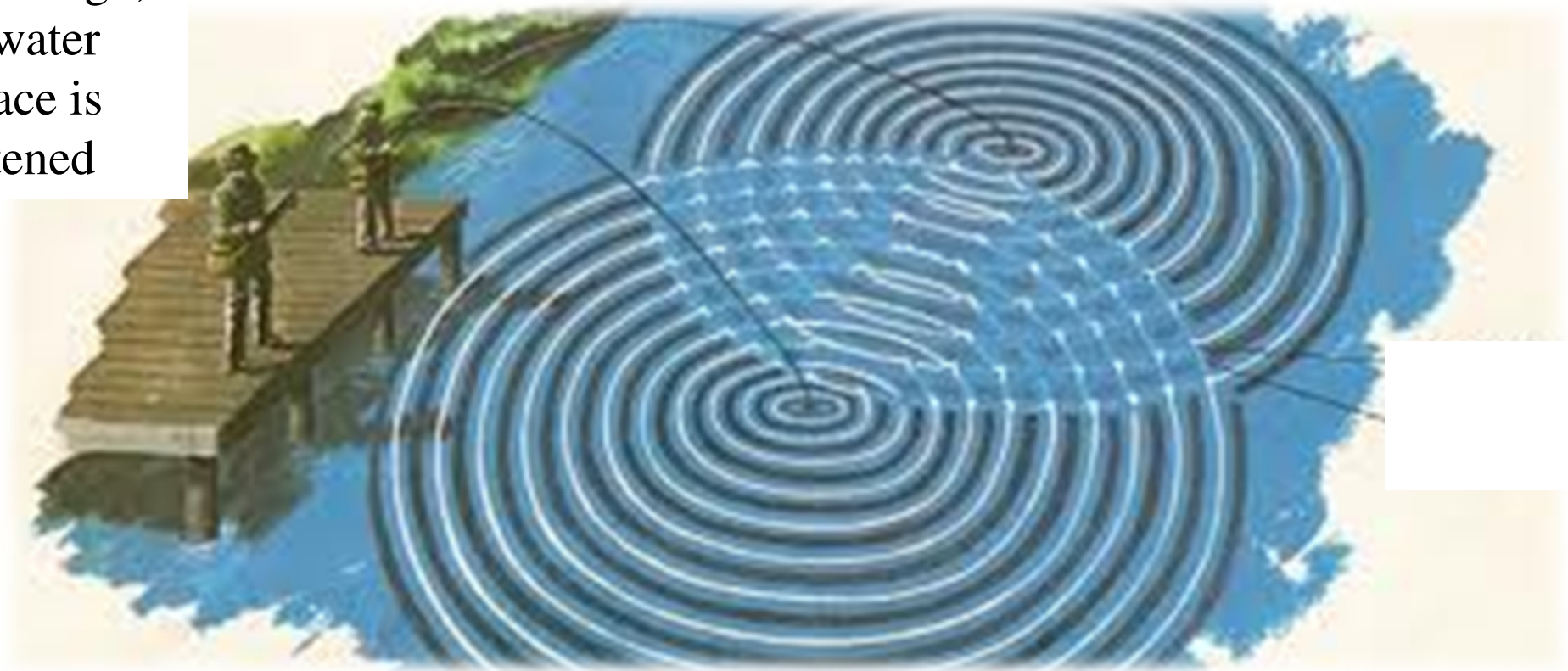


# Optional Extra Credit (April 27)

- Group Project: 1-4 people (can do alone if you want but graded by the same rubric, incentive to have to work on your groupwork skills)
- Graded based upon in-class presentation (see syllabus for detailed rubric)
- You are to pick some movie scene where you question whether the scene could physically happen. You should do calculations based on what we learned in class to analyze if the movie did it correctly.
- Worth **up to** 5 quiz points on a quiz

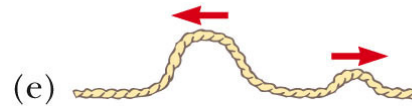
Whenever a crest coincides with a trough, the water surface is flattened

# Interference of Waves

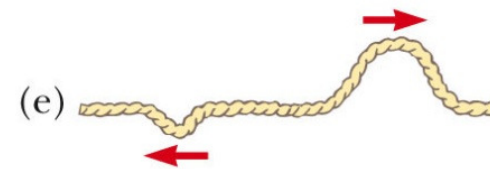
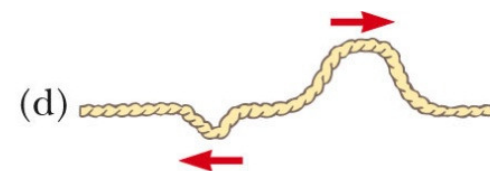
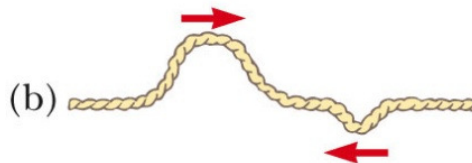
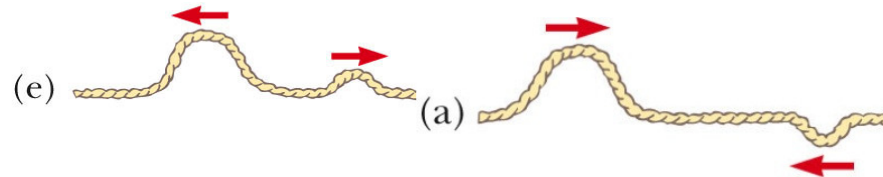


- Traveling waves can meet and pass through each other without being destroyed or even altered
- Waves obey the *Superposition Principle*
  - Meaning when 2 or more waves encounter each other, the resulting wave is found by **adding together the displacements of the individual waves**

# Constructive Interference (Add together)



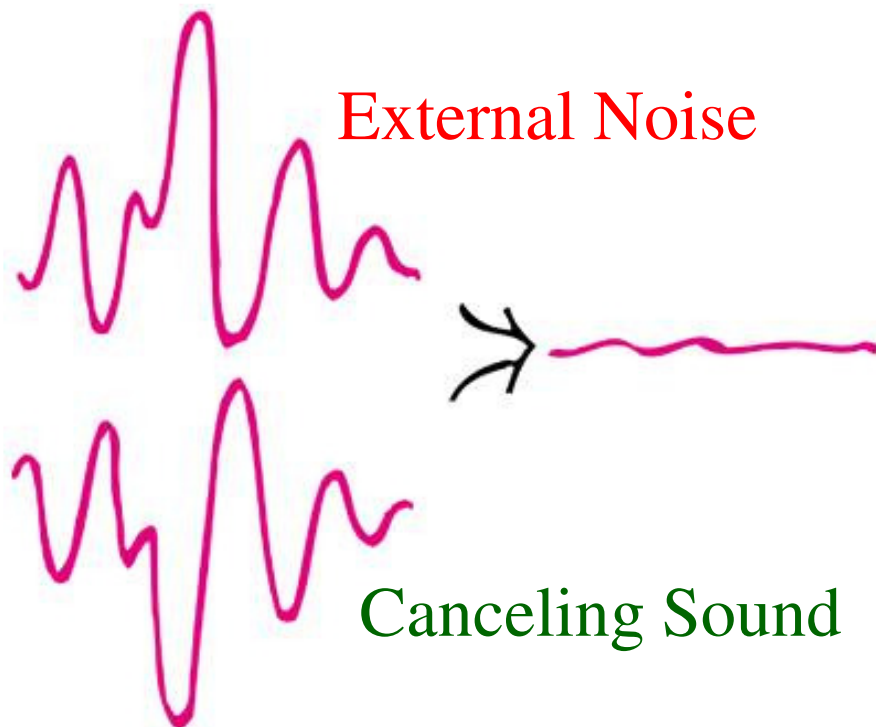
# Destructive Interference (cancel out at least some)



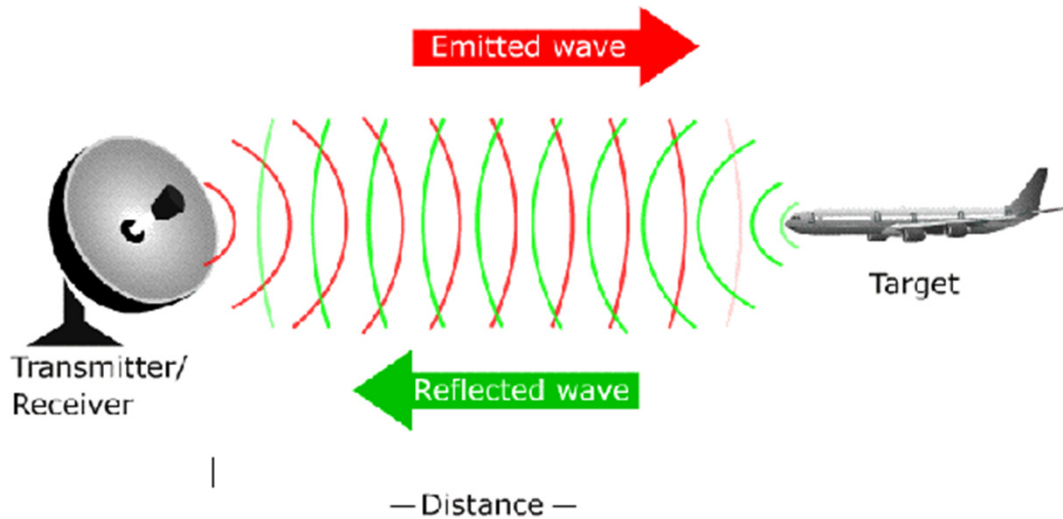
- Two pulses are traveling in opposite directions
- The net displacement when they overlap is the sum of the displacements of the pulses
- Note that the pulses are unchanged after the interference

# Noise-Canceling Headphones

Noise-canceling headphones use a microphone that listens for noise and a speaker that produces the same noise but inverted (cancellation by destructive interference)



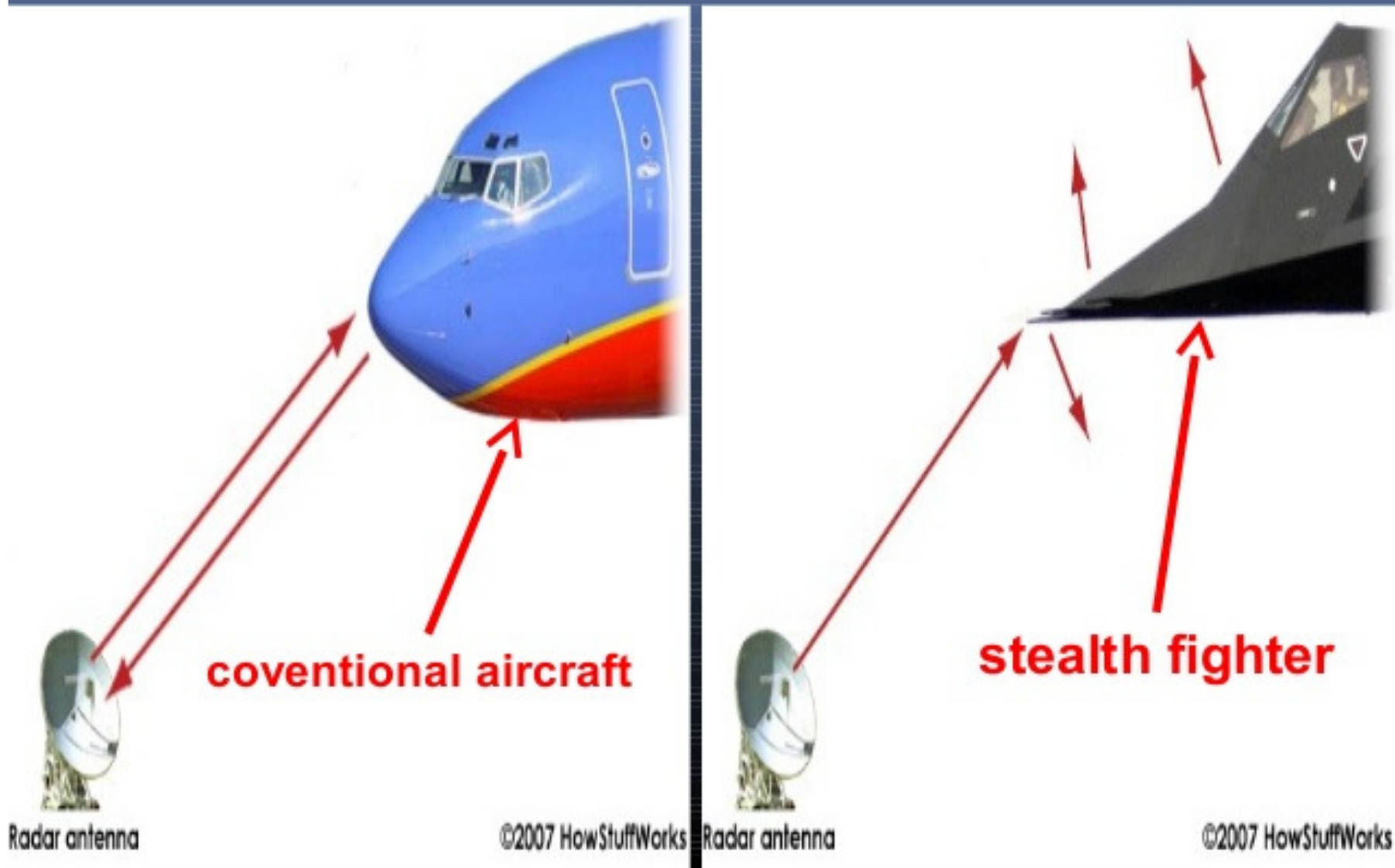
# Radar misleading fighter jets



- A French fighter plane called the Rafale uses destructive interference to avoid Radar.
- Radar (**radio detection and ranging**) can detect objects by sending electromagnetic waves out and measuring the time and frequency of the reflected wave.
- When the jet receives an incoming wave, it sends out the direct opposite pattern of the wave.

Stealth fighter jet has weird angles so waves don't bounce back to detector

## SHAPE OF AIRCRAFT



Main Ideas Today:  
States of Matter  
Density  
Pressure

For most of this course, we've talked about physics we've known about for  $> 100$  years.

Today, we'll discuss some physics we are still trying to figure out!

# The States of Matter You Know

<https://www.youtube.com/watch?v=PcoiLAsUvqc>



**Solid**

**Holds Shape**

**Fixed Volume**

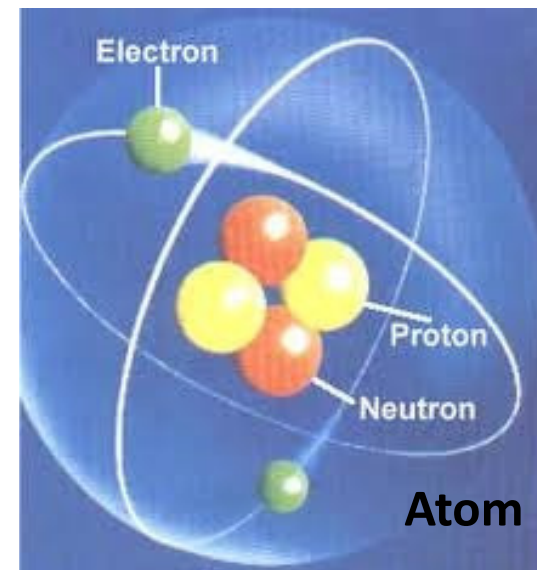
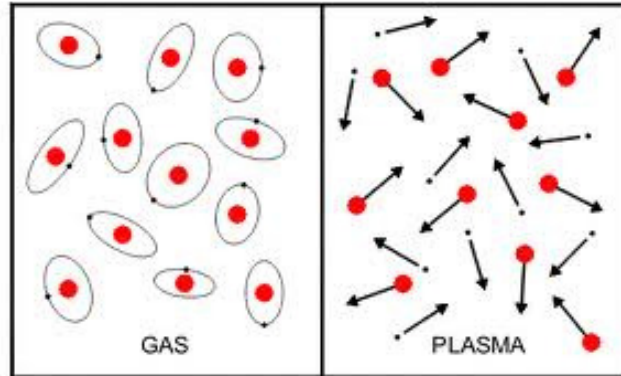
For a given temperature

Example

**H<sub>2</sub>O: Ice**



# The 4<sup>th</sup> State of Matter: Plasma



An ionized gas meaning:

Some of the atom's electrons have been stripped, resulting in a collection of ionized atoms and electrons, are no longer bound

- Unlike gases, solids, or liquids, it does not contain molecules
- Behaves differently from gases, such as in the presence of a field

More than 99% of the **known visible** universe

# Where Can I Find Plasma?



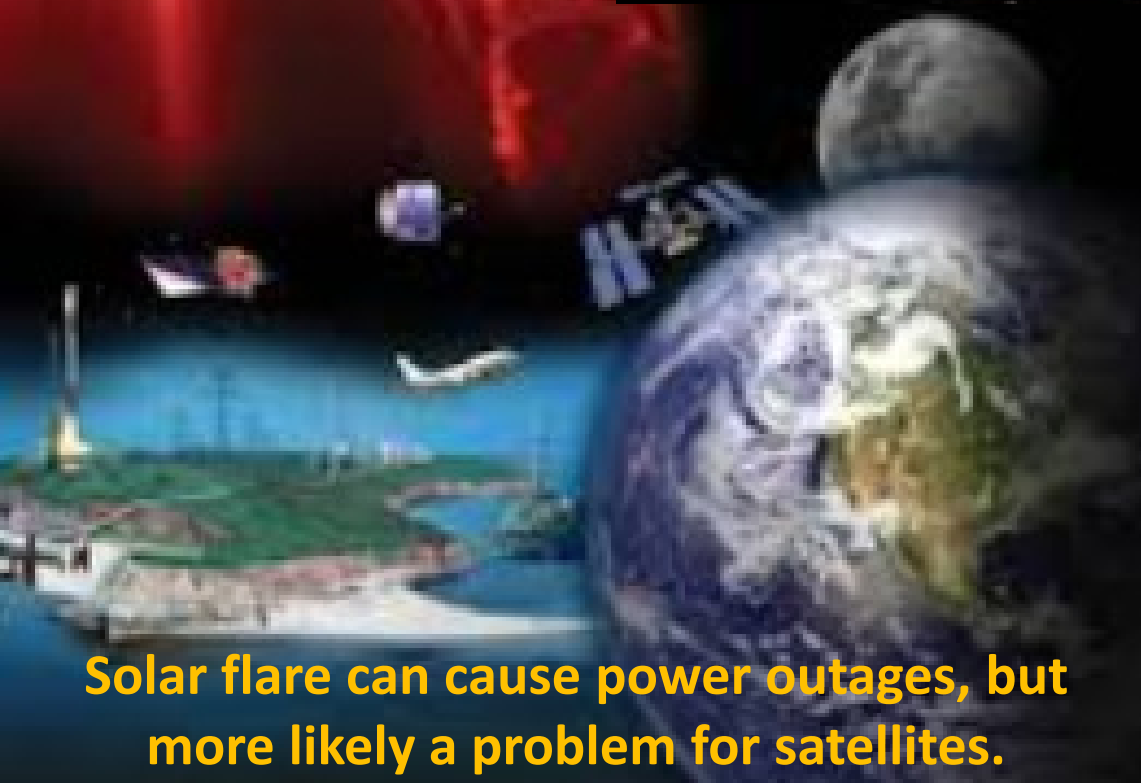
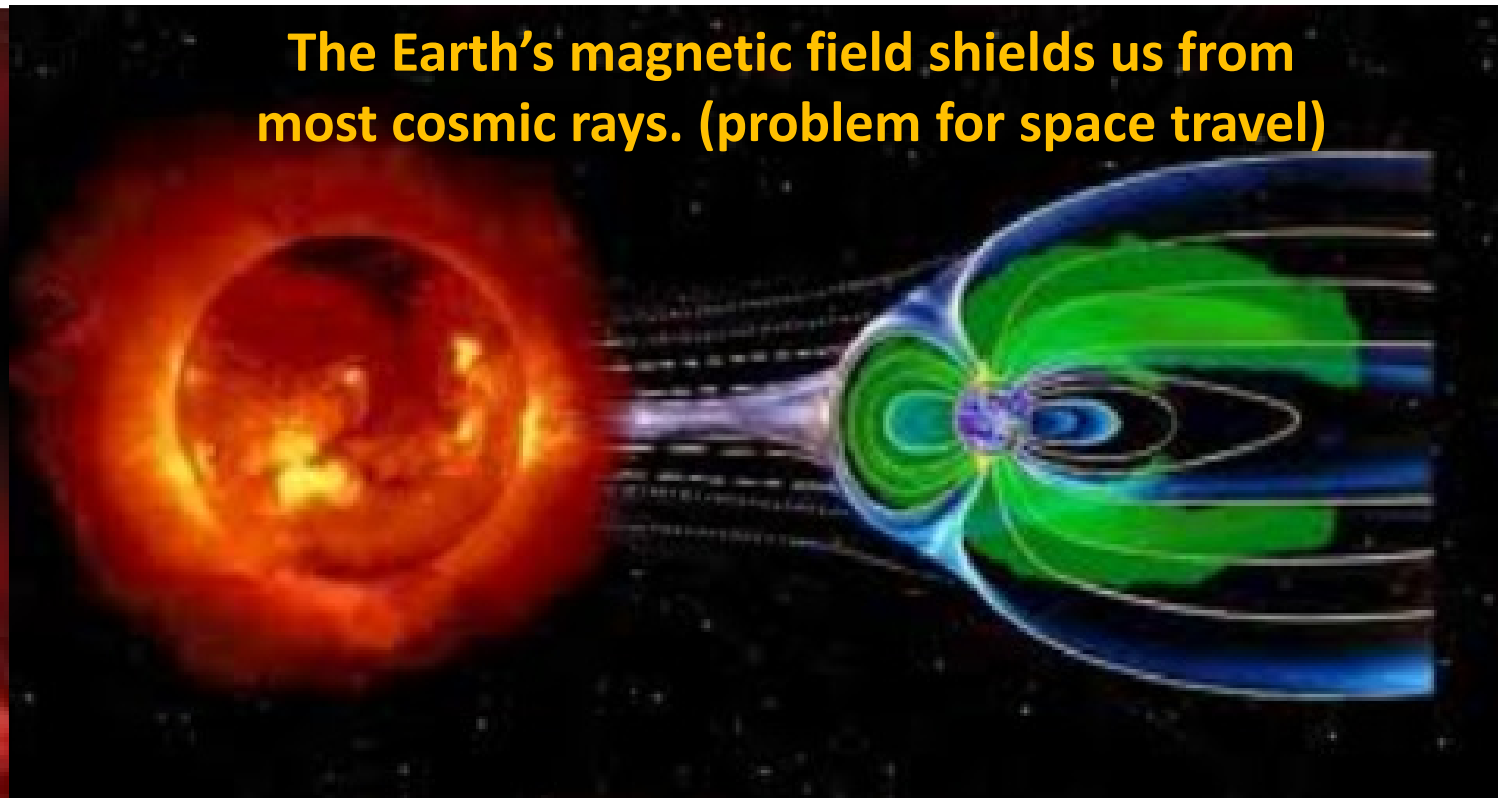
- Fluorescent Lights
- Strobe Lights
- Experimental Fusion Research Devices
- West Virginia University (Third Floor)



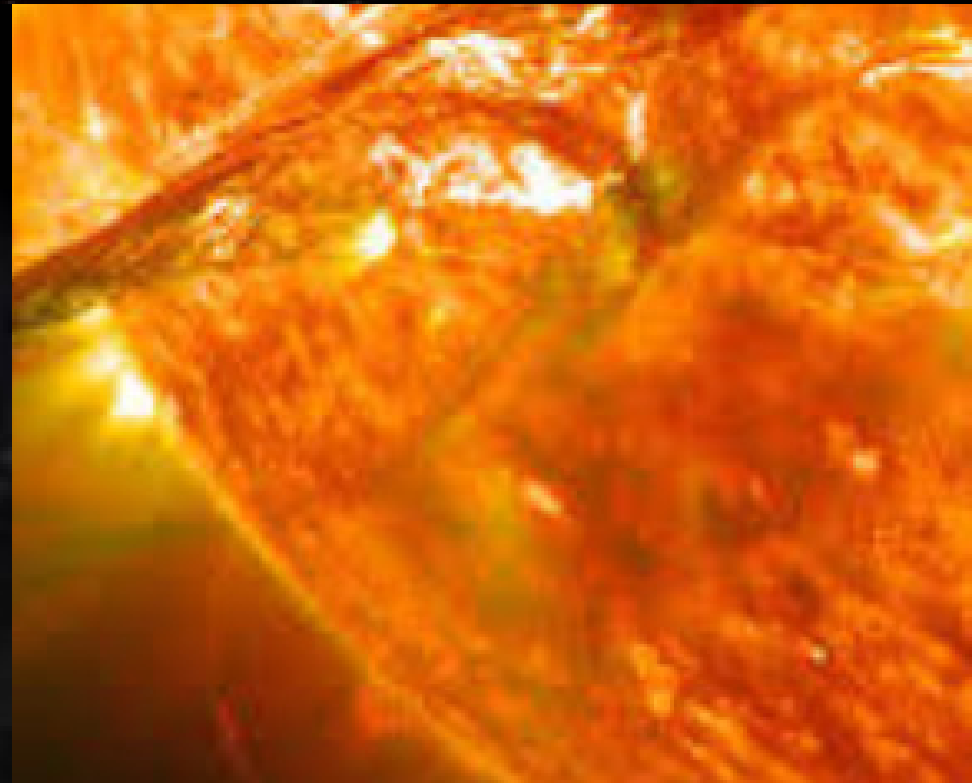
In nature:

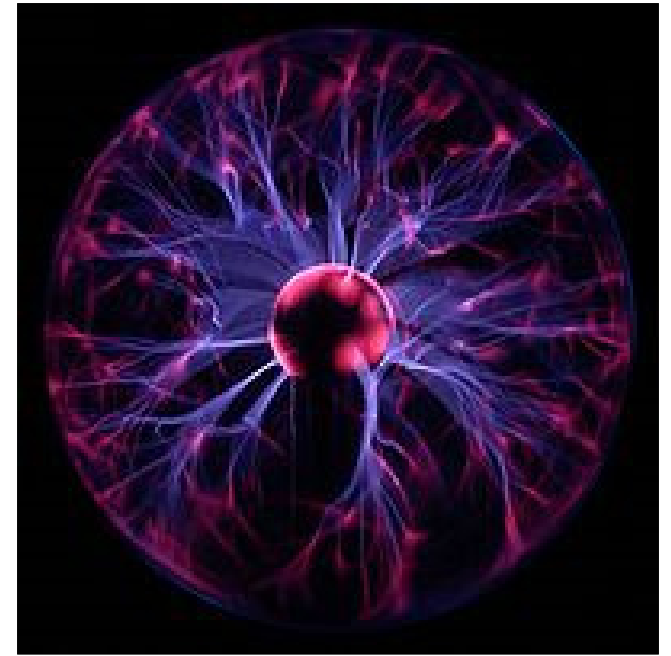
The Sun and other **stars**  
The Aurora Borealis (aka  
The Northern Lights)

**The Earth's magnetic field shields us from most cosmic rays. (problem for space travel)**



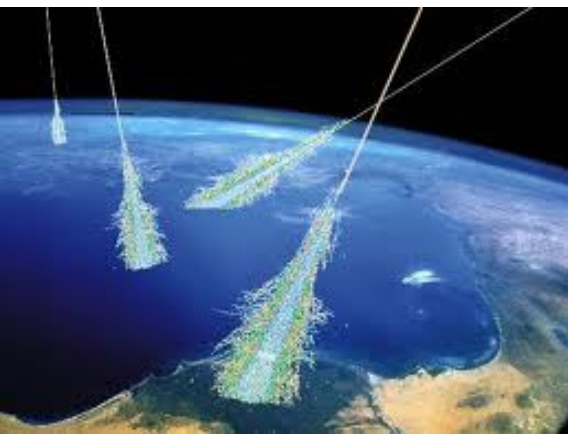
**Solar flare can cause power outages, but more likely a problem for satellites.**





# Plasma Globe

- A globe with a small amount of **gas** (type of gas affects color)
- The plasma extends from the inner electrode to the outer glass, giving the appearance of beams of colored light



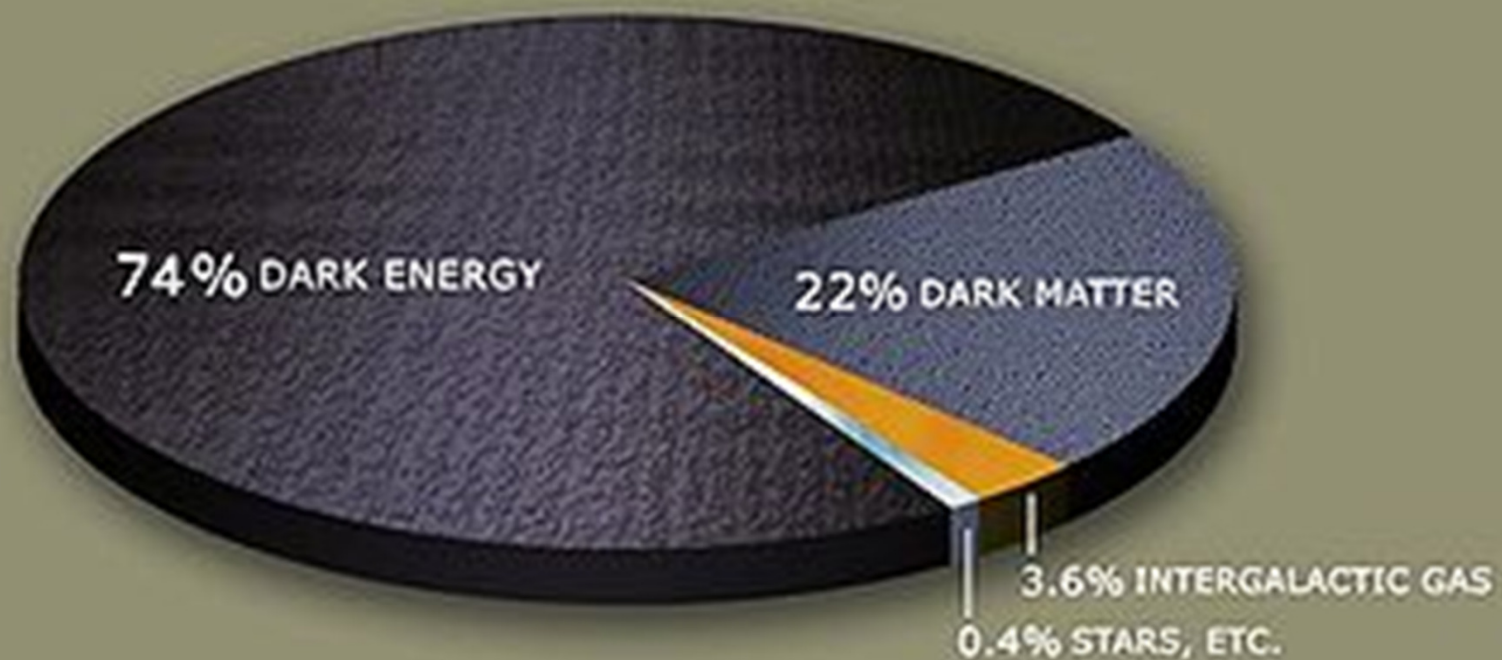
# How it Works

- Cosmic rays (that are constantly bombarding the Earth) ionize some of the gas particles
- The power supply accelerates these particles
- As they move around, they ionize other particles, creating more plasma

If plasma is > 99% of the  
**known visible** universe,  
**what don't we know?**

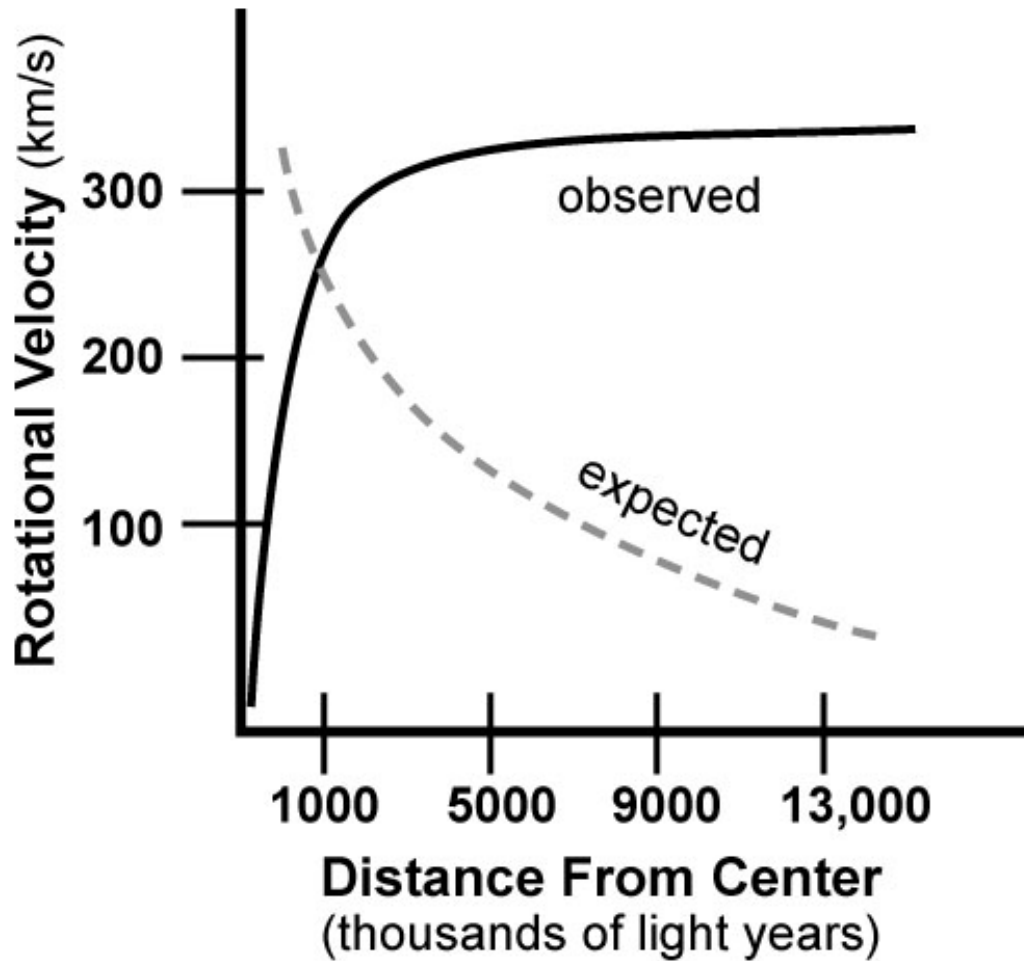


These four states of matter (solid, liquid, gas, plasma) **may** constitute <5% of all matter in our Universe!

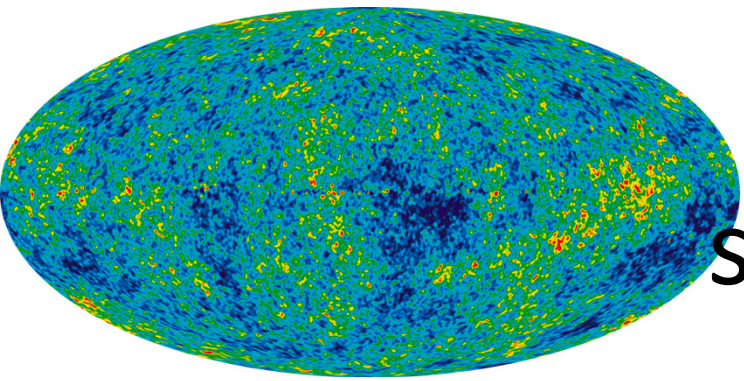


# First “Evidence” of Dark Matter

## Rotation Curves in Galaxy Spirals



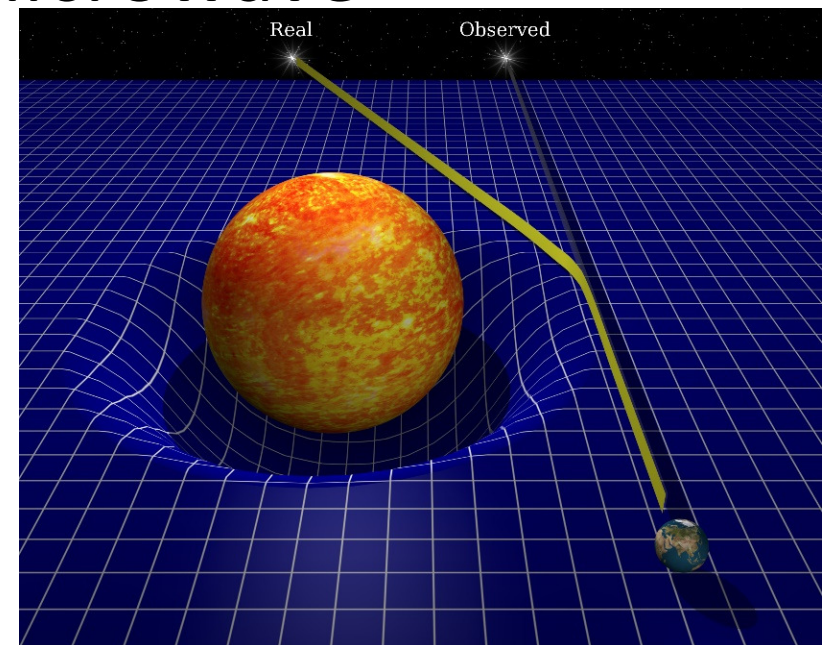
Thousands of rotation curves have been measured  
Mass of a galaxy grows with radius=Requires dark matter halo



# Other observations suggesting dark matter is real

- gravitational lensing of background objects by galaxy clusters (shift amount depends on mass)
- the temperature distribution of hot gas in galaxies and clusters of galaxies
- anisotropies in the cosmic microwave background

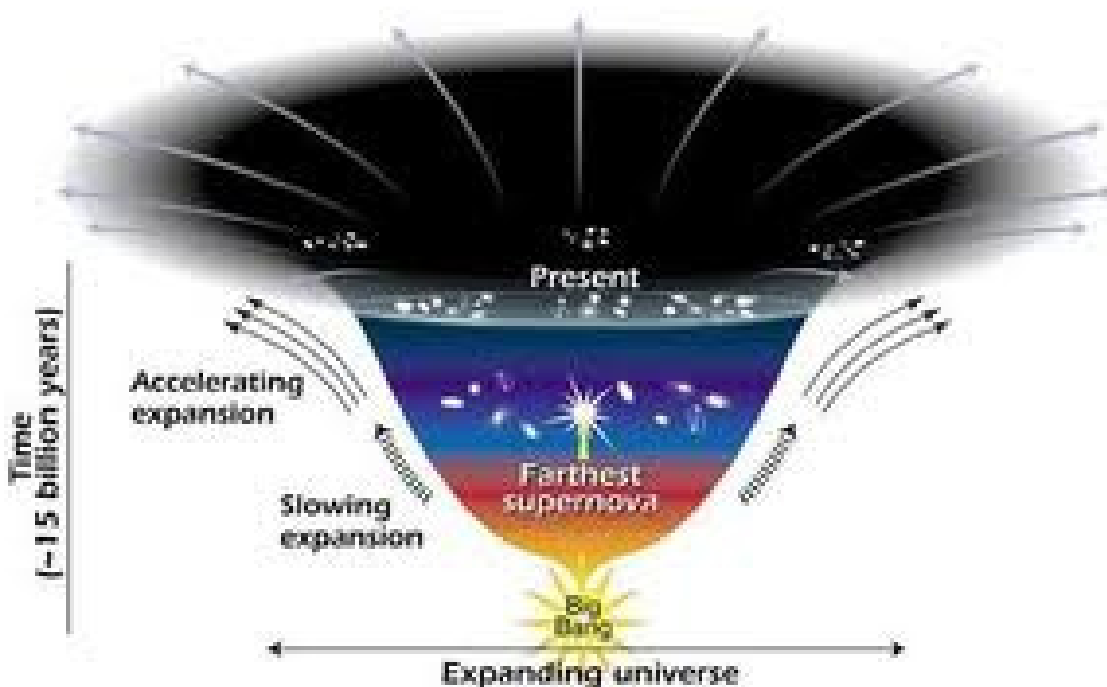
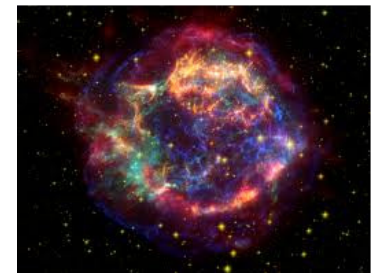
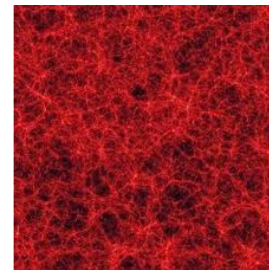
According to cosmologists, dark matter is composed primarily of a not yet discovered type of particle that does not interact with light.





# Dark Energy—Even More Mysterious!

- Several cosmological observations demonstrated that the expansion of the universe is accelerating (all stars moving away)
- What is causing this acceleration? It is called Dark Energy, but what is it?



...re the answer to this

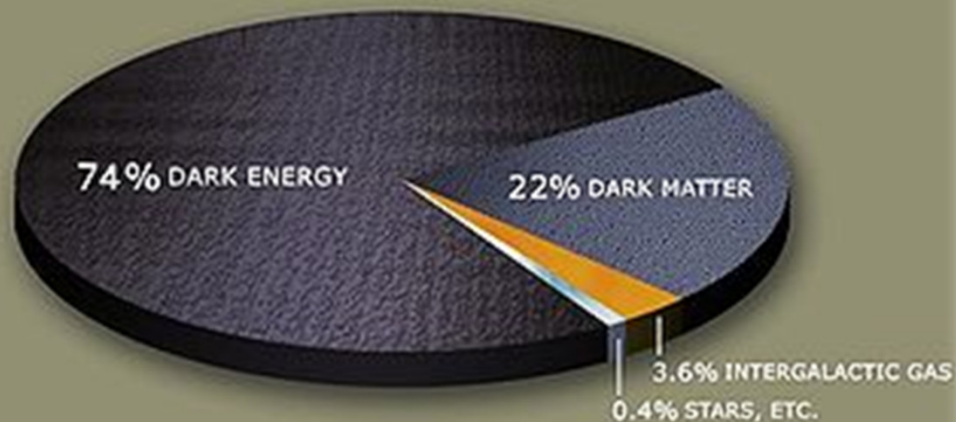
...ulsive force, or anti-  
0% of Matter!



I just want you to know that we think dark matter and dark energy exist and they may have important implications for space travel and understanding our universe.

Just a fun example of what physicists study today.

**Let's focus on what we do understand.**



You don't need to know any more about them for the test.

# Changing Between States

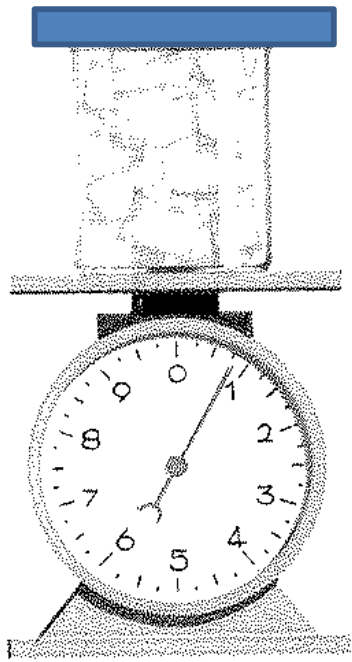
If you wait long enough **ice will melt to water**. And if you heat it, **water evaporates to water vapor** (gas).

Will the mass of the **different states** of water be **different** if the containers are sealed?

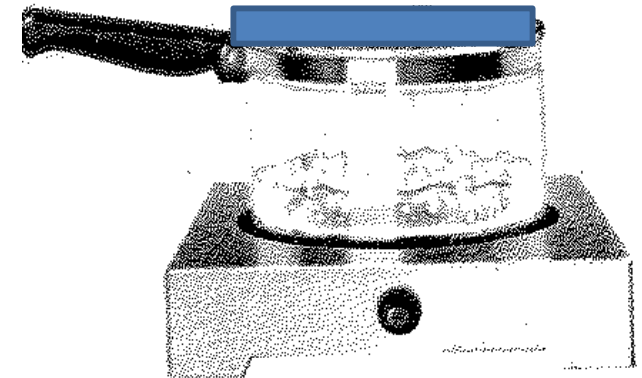
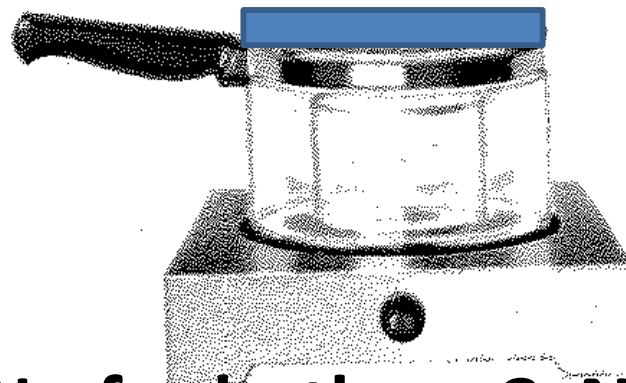
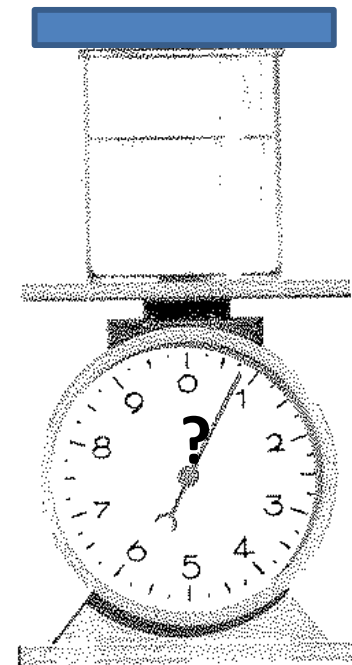
**Q118**

Will the mass of the different states of water be different if the containers are **not** sealed?

**Q119**



**lid**



**A. No for both**  
**B. Yes for both**

**C. No for ice, yes for gas**  
**D. Yes for ice, no for gas**

# Why does ice float?



BECAUSE IT'S COLD. ICE WANTS TO GET WARM, SO IT GOES TO THE TOP OF LIQUIDS IN ORDER TO BE NEARER TO THE SUN.





# Density is

$$\rho = \frac{M}{V} = \frac{\textit{mass}}{\textit{volume}}$$



**Warning:**  $\rho$  is not  $p = m v$  ! .

- The values of density for a substance vary slightly with temperature since volume is temperature dependent    Otherwise ice would not float in water

# Density is

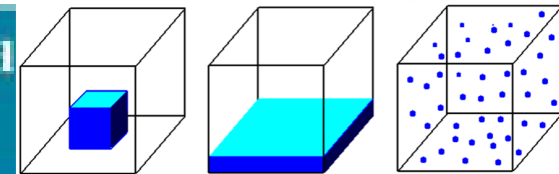
$$\rho = \frac{M}{V} = \frac{\text{mass}}{\text{volume}}$$



**Warning:**  $\rho$  is not  $p = m v$  !

- The values of density for a substance vary slightly with temperature since volume is temperature dependent. Otherwise ice would not float in water
- The various densities indicate the average molecular spacing in a gas is much greater than that in a solid or liquid

Densities of Some Common Substances at Standard Temperature (0°C) and Pressure (Atmospheric)

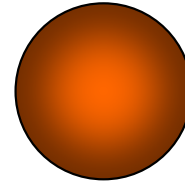


Substance	$\rho$ (kg/m <sup>3</sup> )	Substance	$\rho$ (kg/m <sup>3</sup> )
Air	1.29	Ice	$0.917 \times 10^3$
Aluminum	$2.70 \times 10^3$	Iron	$7.86 \times 10^3$
Benzene	$0.879 \times 10^3$	Lead	$11.3 \times 10^3$
Copper	$8.92 \times 10^3$	Mercury	$13.6 \times 10^3$
Ethyl alcohol	$0.806 \times 10^3$	Oak	$0.710 \times 10^3$
Fresh water	$1.00 \times 10^3$	Oxygen gas	1.43
Glycerin	$1.26 \times 10^3$	Pine	$0.373 \times 10^3$
Gold	$19.3 \times 10^3$	Platinum	$21.4 \times 10^3$
Helium gas	$1.79 \times 10^{-1}$	Seawater	$1.03 \times 10^3$
Hydrogen gas	$8.99 \times 10^{-2}$	Silver	$10.5 \times 10^3$

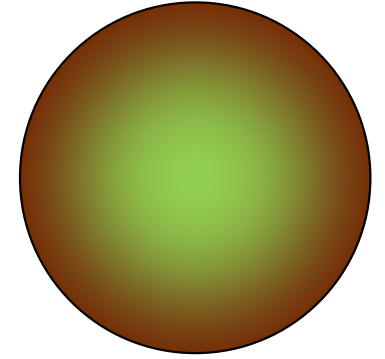
The sphere on the right has **twice the mass** and **twice the radius** of the sphere on the left.

Compared to the sphere on the left, the larger sphere on the right has

Not necessarily made of same material.



mass  $m$   
radius  $R$



mass  $2m$   
radius  $2R$

$$V_{\text{sphere}} \propto R^3$$

- A. twice the density.
- B. the same density.
- C. 1/2 the density.
- D. 1/4 the density.
- E. 1/8 the density.

$$\rho = \frac{M}{V} = \frac{\text{mass}}{\text{volume}}$$



**Q123**



250 LB  
2008

250 LB  
2013

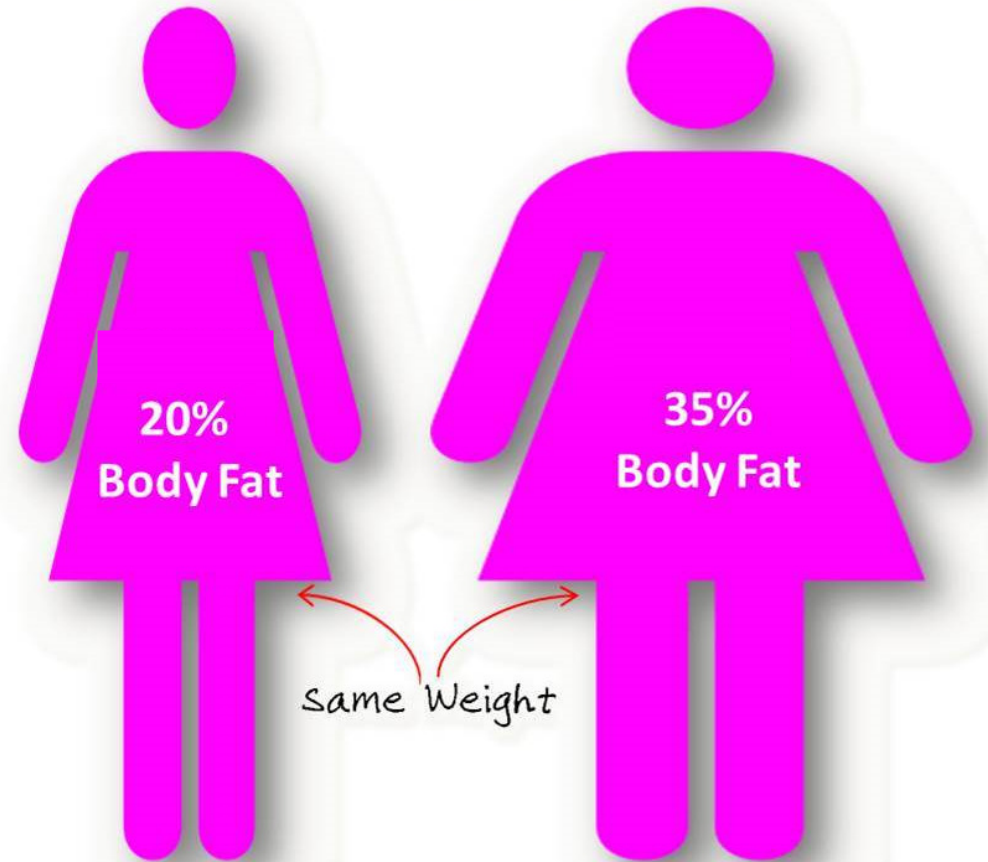
Older and fitter

Muscle is more dense  
than fat.

So while it sounds a  
little funny, your fitness  
goal might be to get  
more dense!

(Funny because of the other definition  
of *dense* in common language.)

THINK FAT LOSS  
NOT WEIGHT LOSS



The more **muscle** you have,  
the more fat you burn,  
the slimmer you look

MOTIVEWEIGHT

Muscle helps you burn slightly more  
calories and lessens the  
likelihood/severity of injuries.

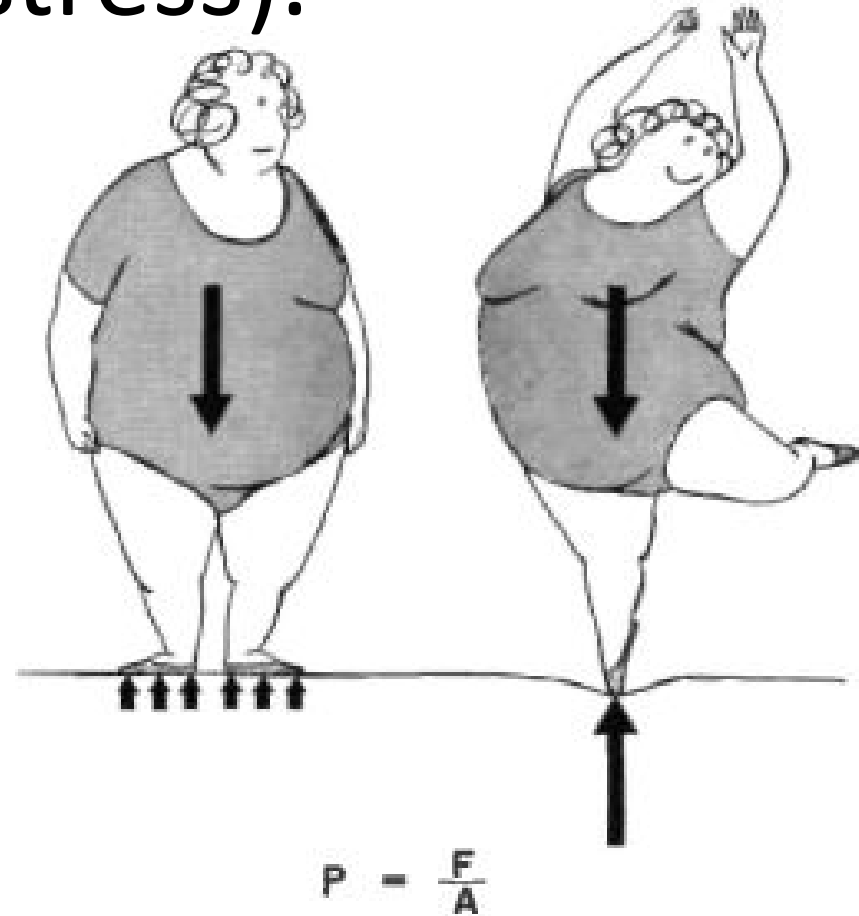


When a dense object (or any object) pushes against you, it applies pressure (or stress).

**Pressure = Force / Area**

Unit of pressure is pascal (Pa)

1 Pa = 1 N/m<sup>2</sup>



**Pressure depends on the area over which the force is spread  
(Also known as stress in solid materials.)**

**Pressure always pushes perpendicular to the surface.**

# Man on a Chair

A man sits on a four-legged chair with his feet off the floor. The combined mass of the man and chair is 95 kg. If the chair legs are circular and have a radius of 0.50 cm at the bottom, what pressure does each leg exert on the floor?

**What could you do to reduce pressure and chance of scratching?**



# Main Ideas in Class Today

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After today, you should be able to:

- Briefly explain differences between the 3 well-known states of matter
- Be able to make small talk about dark matter/energy and plasma
- Calculate density and pressure

Extra Practice: 9.1, 9.3, 9.5

# Clicker Answers

117=D, 118=A, 119=C, 123=D, 124=B