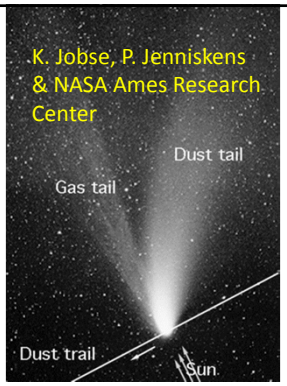
Comet tails—14 Feb

- For Friday: Read about Kuiper belt and Oort Cloud

- Radiation pressure
- Magnetic fields
- Solar wind

Comet Hale-Bopp (1997)

- A comet has two tails.
  - Bluer one points away from the sun.
  - Redder one trails the comet.

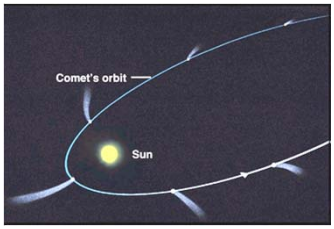


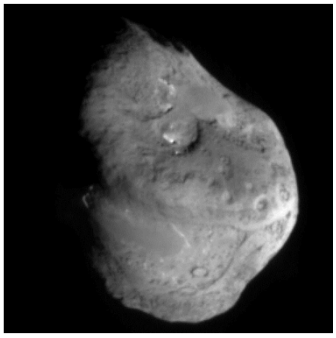
Comet Hale Bopp (1995 o1)
april 9, 1997

Forces on a comet tail

- Sunlight shines on the comet nucleus and sublimates gas. Larger particles are released when the solids holding them sublimate.

1. Assume gravity is the only force. Because of ___, the released material should be ___.
   A. Conservation of energy
   B. Conservation of momentum
   C. Conservation of angular momentum
   D. Galileo's experiment on the Leaning Tower of Pisa.
2. .
   A. In a cloud
   B. In a tail pointing away from the sun
   C. In a tail pointing toward the sun.





Comet Tempel 1. NASA Deep Impact

Force of gravity

- The comet releases a particle with mass density ρ. The force of gravity is

$$F = -GM\rho V/R^2$$

  – Negative sign means force is toward the sun.
  – What is V?

Radiation pressure

- Sunlight carries energy E.
- You learned in Electricity and Magnetism or in Special Relativity that sunlight carries momentum

$$p = E/c$$

1. A particle released from the comet nucleus absorbs some sunlight. The energy warms up the particle. What does the momentum do?

Radiation pressure

- The force of radiation

$$F_R = \frac{dp}{dt} = \frac{1}{c}\frac{dE}{dt}$$

- Write in term of the cross sectional area $A = \pi r^2$ and the luminosity of the sun L (watt). $\frac{dE}{dt} = LA/(4\pi R^2)$

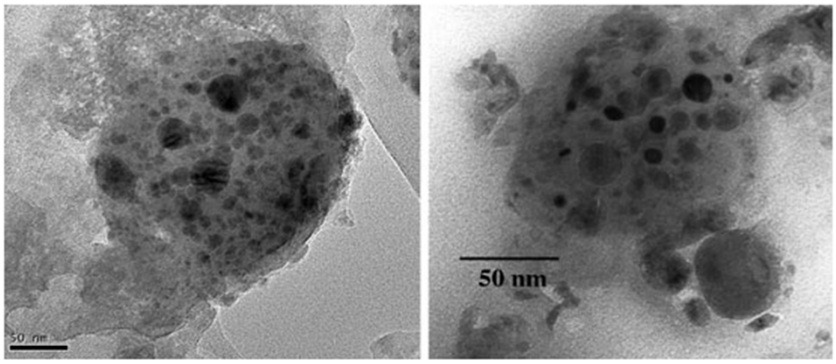
$$F_R = LA/(4\pi c R^2)$$

- The forces of gravity and radiation are equal, if the radius of the particle $r = 0.58\mu\text{m}(1\text{gm cm}^{-3})/\rho$.

1. A particle of radius r=1μm is __ the sun.
   1. Pulled toward
   2. Pushed away from

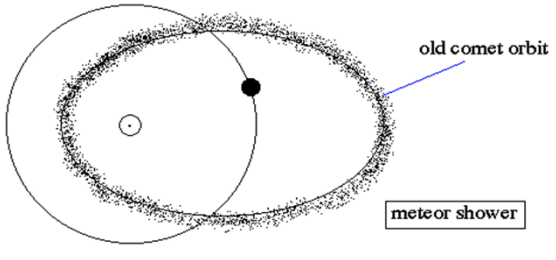
Dust

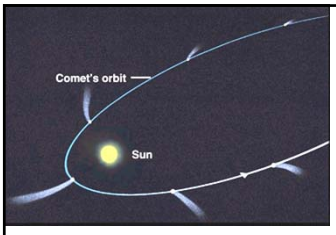
- Stardust mission to comet Wild 2



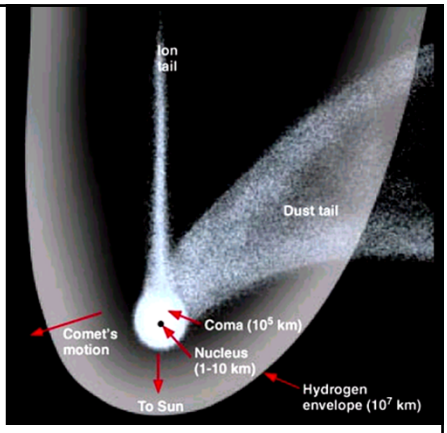
Larger particles

- Larger particles feel the same force as the comet nucleus. Their orbits approximately follow the comets.
  - If the radius is smaller, the orbital period is smaller.
  - They may get a kick before leaving the nucleus.
- Earth passes through comet orbits. Meteor showers
- Orionids (peak around Oct. 20-22; 20 meteors per hour) associated with Halley's comet
- Perseids (peak around August 12/13; 50-100 meteors/hour at peak) associated with comet Swift-Tuttle





Tails



- dust tail
  - up to 10 million km long
  - smoke-sized dust particles
  - driven off nucleus by escaping gases
  - pushed outwards by Sun's radiation
  - competing force of Sun's gravity ➔ curve in tail.
- ion tail
  - Up to 100's of millions km long
  - small charged particles, pushed out by charged particles from Sun (solar wind).

Motion in a magnetic field

- Force of a particle with charge e moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$
- $\vec{F} = e\vec{v} \times \vec{B}$

1. Assume $\vec{v}$ and $\vec{B}$ are parallel. What is the path of the particle?
2. Assume $\vec{v}$ and $\vec{B}$ are perpendicular. What is the path of the particle?