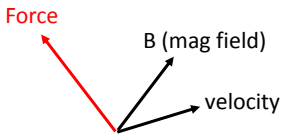
Comet tails—18 Feb

- Mike Velbel, *The geology of comets: An early look at results from the Stardust-NExT mission's encounter with comet 9P/Tempel 1*
  - Today, 4:00 PM, 204 Nat Sci Building.
- Finish comet tails
- Pluto & relation to objects beyond Neptune
- Next week: Read about derivation of Kepler's Laws (Textbook §4.4 & Carroll & Ostlie §2.1-2.3) Needed for understanding Kuiper Belt.

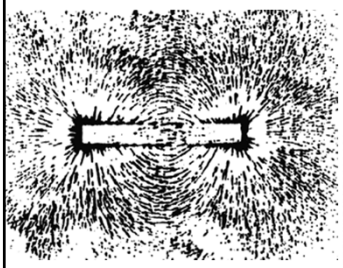
Motion in a magnetic field

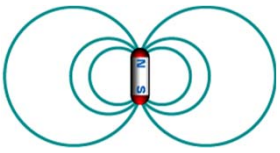
- Force of a particle with charge e moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$
- $\vec{F} = e\vec{v} \times \vec{B}$

1. Assume $\vec{v}$ and $\vec{B}$ are parallel. What is the path of the particle?
2. In a magnetic field, does the speed of the particle change?
   A. Yes
   B. No
3. Assume $\vec{v}$ and $\vec{B}$ are perpendicular. What is the path of the particle?

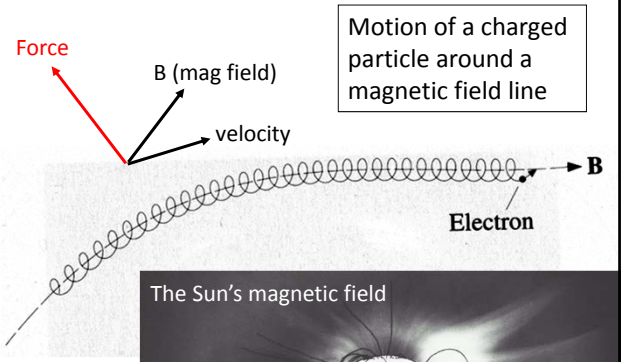


Magnetic Field Lines

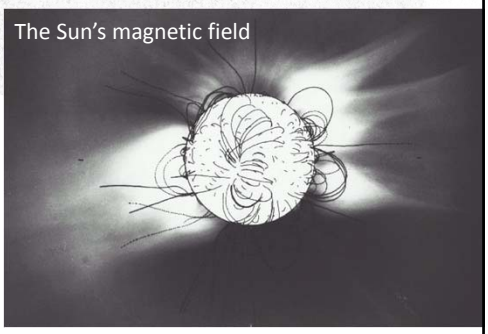




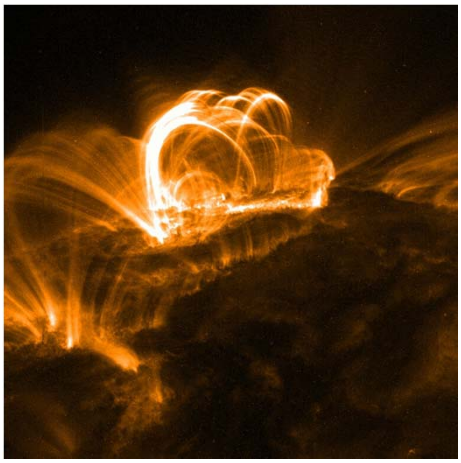
Magnetic field lines of force



Motion of a charged particle around a magnetic field line



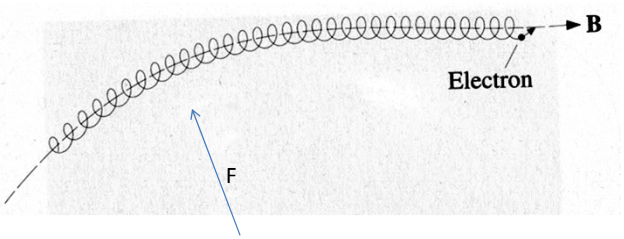
- Solar flares produce ionized gas. Why is the ionized gas in arcs?



NASA/LMSAL TRACE Satellite

Magnetic field is "frozen in"

- If I push on the electrons, the magnetic field lines move.
  - The electrons can move parallel to magnetic field.
  - They cannot move perpendicular to it. They circle a magnetic field line with the Larmor radius. Typical Larmor radius in the solar wind is 300km. $r = mv/(qB)$.
- Magnetic field is "frozen in" ionized matter.

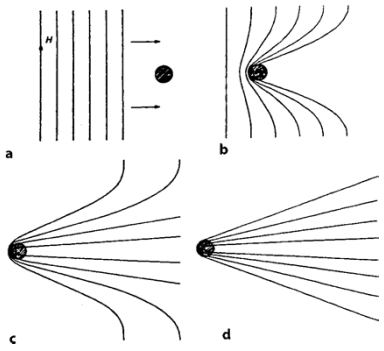


Solar wind & comets' ion tail

- Biermann (early 1950s): The sun's ultraviolet radiation ionized gas from the comet. Suppose there is a stream of charged particles from the sun. The collisions with the stream of particles accelerate the ions away from the sun.
- Chapman (1950s): temperature of sun's corona is very high $\Rightarrow$ conductivity is high.
- Parker (1950s): Since pressure is nearly constant & gravity falls as $1/R^2$, particles can escape the sun's gravity as a wind.

Solar wind & comet's ion tail

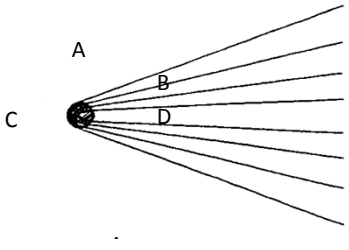
- Magnetic fields amplifies effect of solar wind.
- The sun's ultraviolet radiation ionized gas from the comet. Suppose there is a solar wind, a stream of charged particles from the sun.
  - The solar wind carries the magnetic field with it. (a)
  - The magnetic field wraps around the ionized gas from the comet. (b)
  - The ionized gas can move only into the region without magnetic fields.

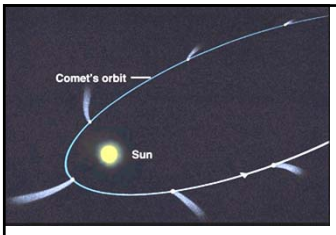


Alfven, H. (1957)
On the theory of comet tails,
Tellus, 9, 92

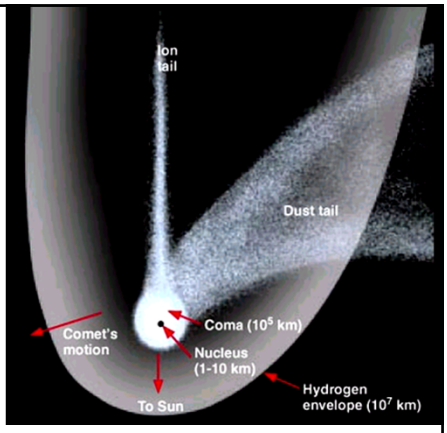
Comet

1. Where are ions that the comet emits?
   E. More than one location is correct.
2. Where are hydrogen atoms? Assume they come off the comet in all directions. (Hydrogen <u>atoms</u> do not absorb the sun's radiation.)





Tails



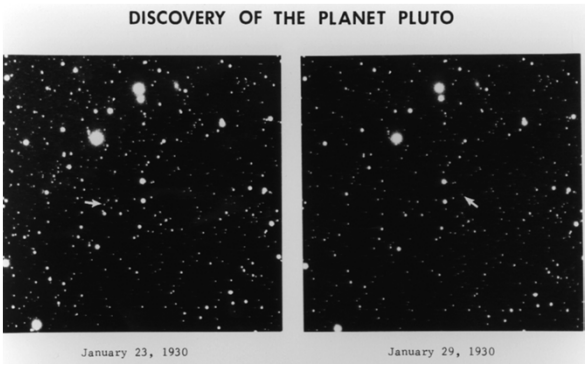
- dust tail
  - up to 10 million km long
  - smoke-sized dust particles
  - driven off nucleus by escaping gases
  - pushed outwards by Sun's radiation
  - competing force of Sun's gravity ➔ curve in tail.
- ion tail
  - Up to 100's of millions km long
  - Ions, pushed out by charged particles from Sun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

Pluto

- Outline
  - The ninth planet
  - Pluto and Neptune are in a 2:3 resonance
  - Pluto's orbit is tilted 17° relative to the ecliptic.
  - Pluto has same orbits as the Kuiper Belt objects.
  - Other objects in the Kuiper Belt are comets and large bodies similar to Pluto.

Discovery of Pluto

- Tombaugh discovered Pluto in a dedicated search in 1930s.

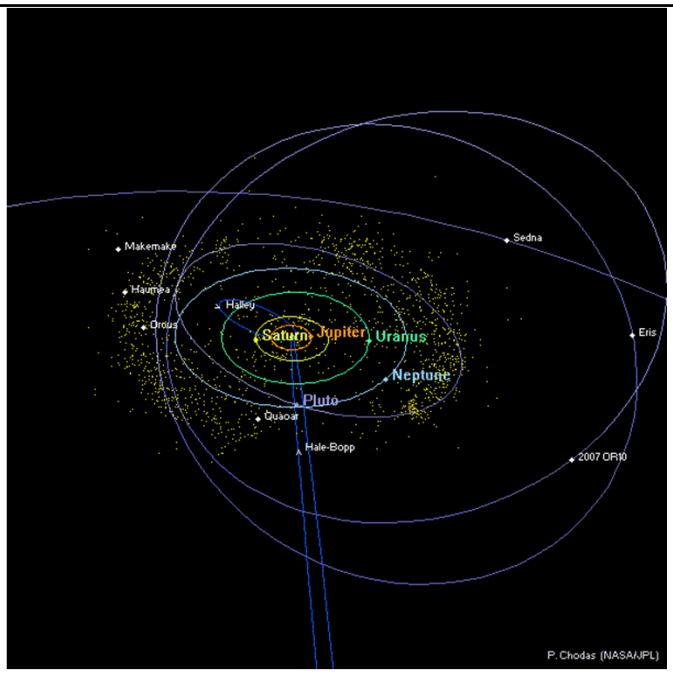


Lowell Observatory Archives

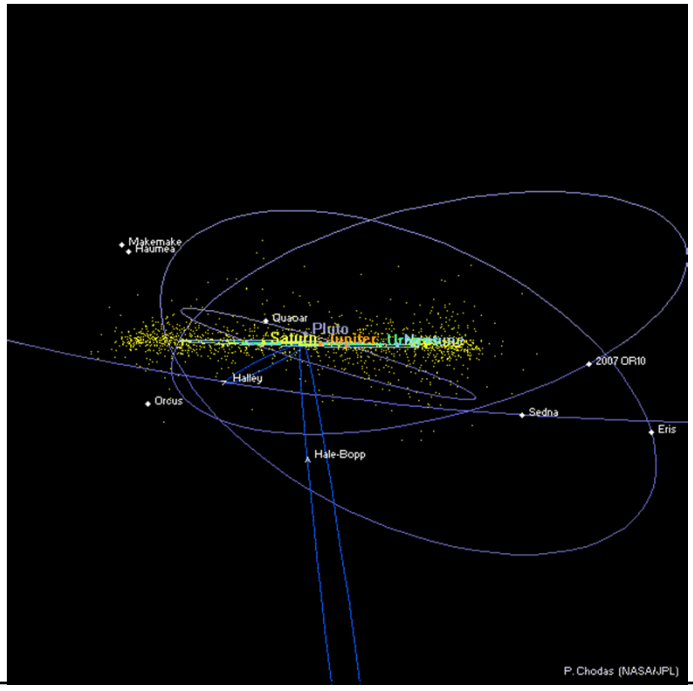
Orbit of Pluto

- Semi major axis
- High eccentricity
- Tilted
- $P_{Pluto}/P_{Neptune}=248/165=3/2$

Planet	ecc	A [AU]	P[yr]
Earth	0.0167	1	1
Mars	0.0934	1.52	1.88
Jupiter	0.0483	5.20	11.9
Saturn	0.0560	9.54	29.4
Uranus	0.0461	19.2	84.0
Neptune	0.0097	30.1	165
Pluto	0.249	39.5	248

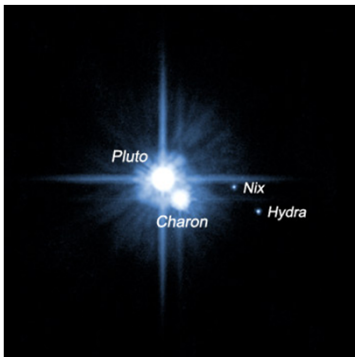


http://ssd.jpl.nasa.gov/?ss_distant



Pluto has 3 moons

- Charon discovered in 1978.
  - Used to determine the mass of Pluto
- Pluto
  - Diameter 1200km ($0.18R_{Earth}$)
  - Density 2.0gm/cm^3
  - Mass $1.30\times10^{22}kg=0.0024M_{Earth}$
- Pluto & Charon both in synchronous rotation
  - always show same faces to each other
- Pluto's inclination = 118° (i.e. tipped on its side)
  - but Charon orbits in Pluto's equatorial plane.



NASA, ESA, H. Weaver (JHU/APL), A. Stern (SwRI), HST Pluto Companion Search Team