

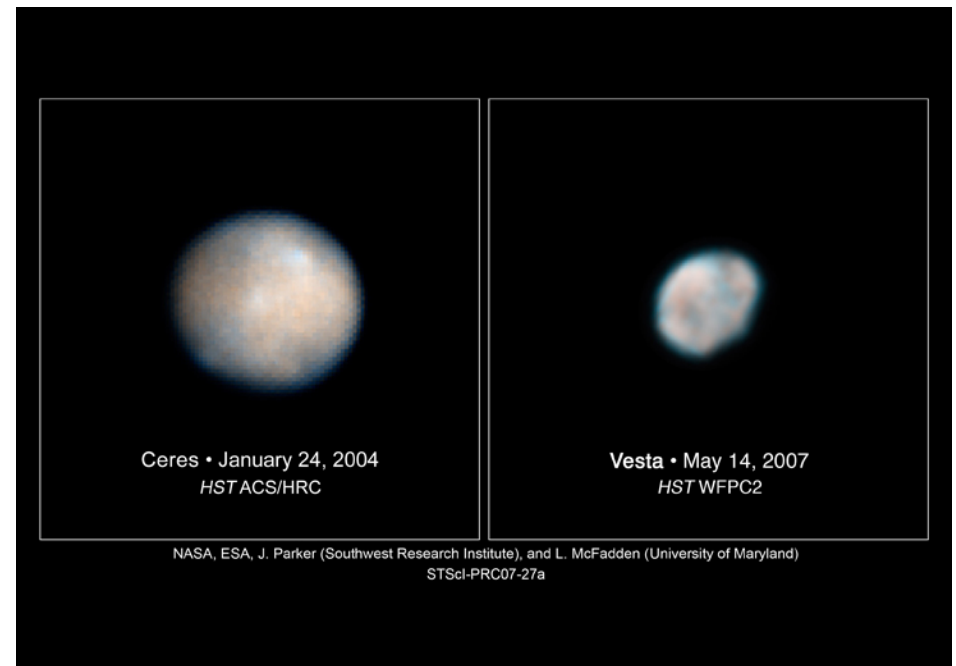
# Introductory Astronomy

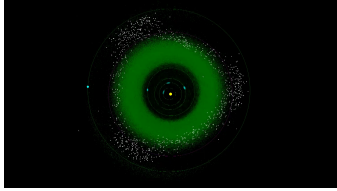
Week 3: Solar System(s)

Clip 10: Asteroids and Comets

# Asteroids

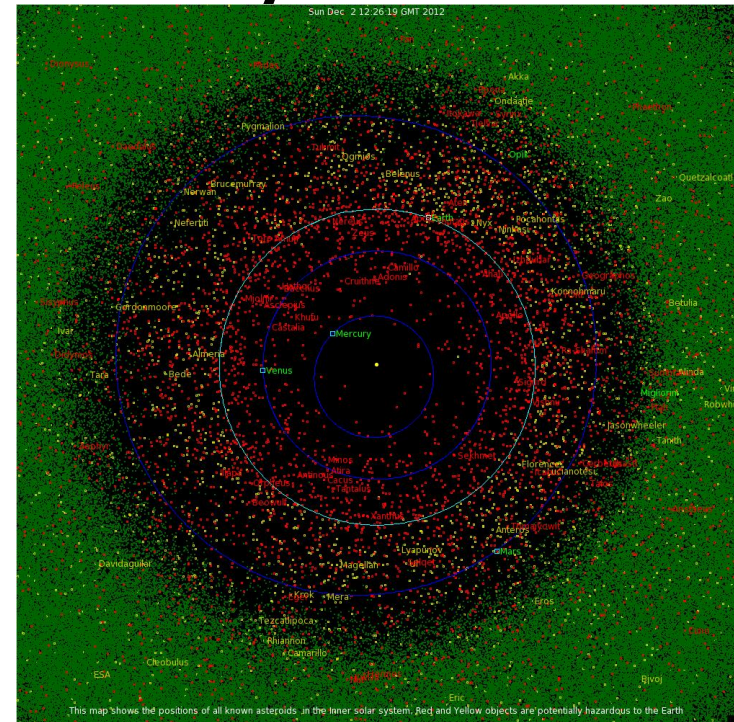
- Asteroids are planetesimals that never accreted to planets
- Most – but not all – never melted and differentiated so preserve chemistry of nebula on surface
- Some are debris of late collisions
- Some melted and are **dwarf planets**: in Solar orbit, big enough to melt, did not clear it's orbit





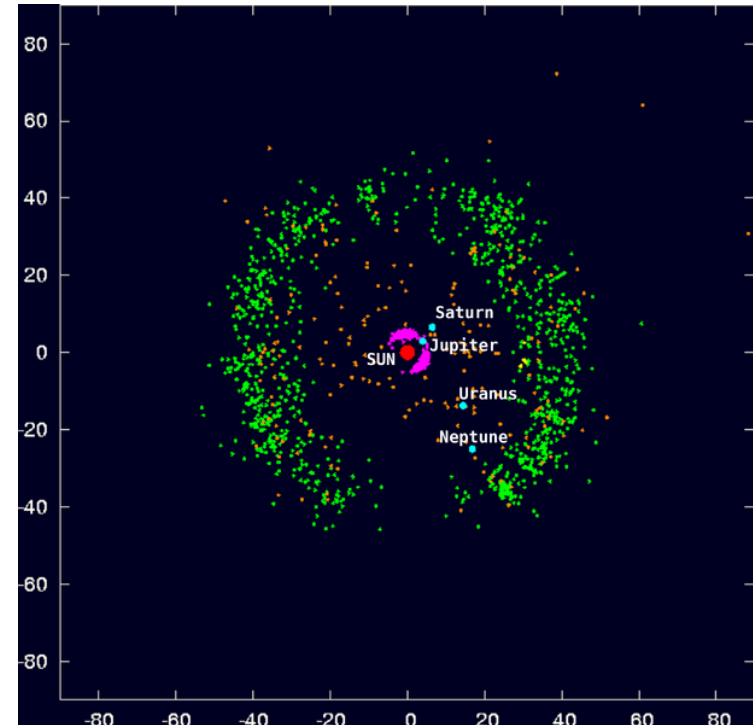
# Where Are They?

- Most – in **belt** at **2-3.5AU**
- Some in **resonance** with **Jupiter**
- Minor planets orbiting between **Jupiter** and **Neptune** are **centaurs**
- Some in **Near Earth** orbits or deflected near Earth
- Most **meteors** burn in atmosphere as **shooting stars**
- Surviving to ground makes a **meteorite**



# Farther Out

- Trans-Neptunian objects include Kuiper belt (Quaoar, Pluto, Makemake) at 30-50AU and moderate inclination
- Rich in Ices
- Over 1000 found
- From prevalence of short-period comets over  $10^5$  over 100km
- Long-period comets predict Oort cloud





# Comets

- Collisions or effect of **Neptune** can slow these down into **eccentric** orbits taking them into **inner Solar system**
- Interaction with sunlight and Solar wind creates a **comet**
- **Coma**, **Ion tail**, **Dust tail**



# Anatomy of a Comet

- **Nucleus**: original planetesimal. **Dirty snowball??**
- **Sublimating** volatiles carry away dust in **jets**
- Tenuous dusty atmosphere – **coma** – can be size of **Sun** and visible in Sunlight



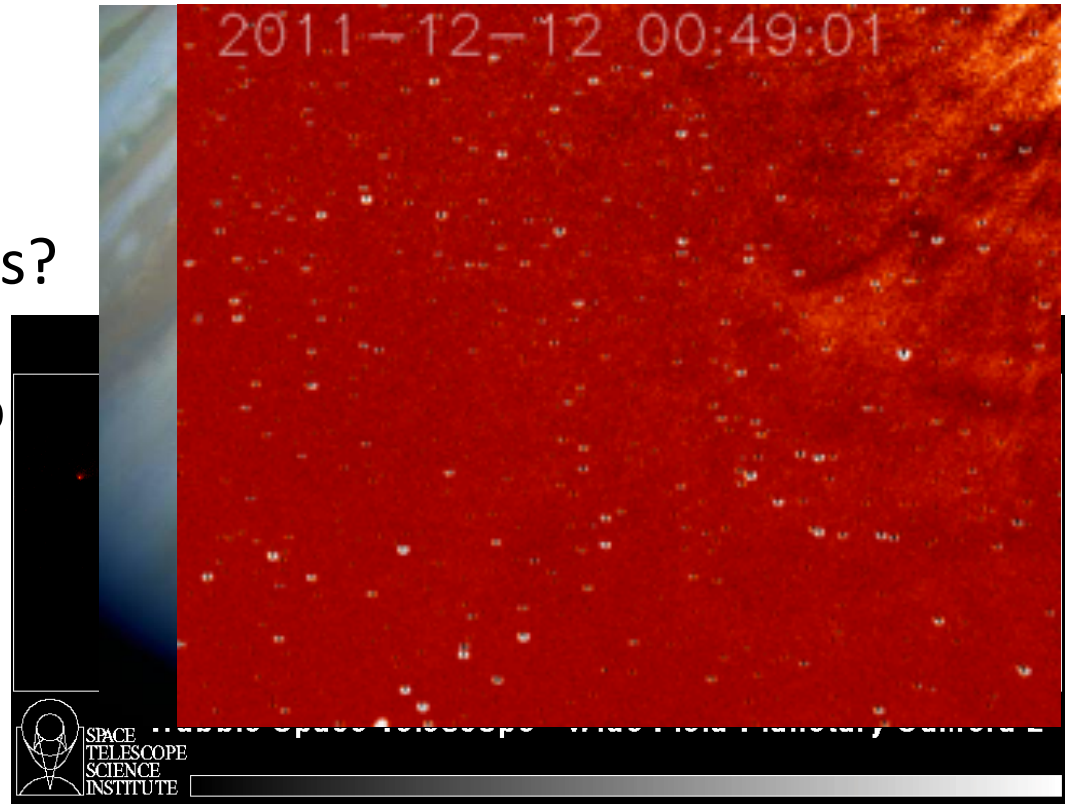
# Tale of Two Tails

- Dust and gas pushed by **radiation pressure** and **Solar wind** into tail pointing **away from Sun**
- Can be over **2AU** long!
- **Dust** tail lags – **arched** – white in **reflected** Sunlight
- **Ion** tail governed by **magnetic** interaction with Solar wind – **straight** – glows **blue**



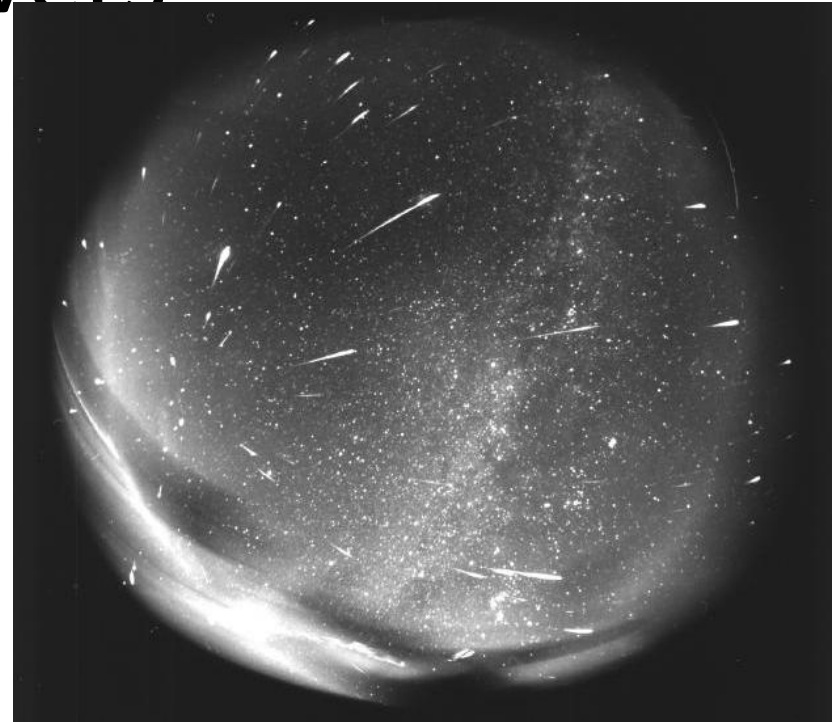
# Comet's End?

- Ejection
- Extinction by loss of volatiles. Are some asteroids extinct comets?
- Disintegration with loss icy glue under recoil from jets or tidal forces
- Collision with planet or Sun



# Leftovers

- Every pass leaves debris in orbit
- Radial dispersion spreads debris along orbit
- If Earth encounters orbit – meter shower





# Credits

- Asteroid PA8: NASA/JPL-Caltech [http://solarsystem.nasa.gov/multimedia/display.cfm?Category=Planets&IM\\_ID=15204](http://solarsystem.nasa.gov/multimedia/display.cfm?Category=Planets&IM_ID=15204)
- Ceres and Vesta: NASA/European Space Agency [http://solarsystem.nasa.gov/multimedia/display.cfm?Category=Planets&IM\\_ID=9885](http://solarsystem.nasa.gov/multimedia/display.cfm?Category=Planets&IM_ID=9885)
- Asteroid Map and Animations: S. Manley <http://www.arm.ac.uk/neos/JupiterResonance/>
- Comet West: Akira Fujii/DMI [http://www.davidmalin.com/fujii/source/af12-04\\_72.html](http://www.davidmalin.com/fujii/source/af12-04_72.html)
- Comet Temple: NASA/JPS/UMD [http://solarsystem.nasa.gov/multimedia/display.cfm?Category=Planets&IM\\_ID=4043](http://solarsystem.nasa.gov/multimedia/display.cfm?Category=Planets&IM_ID=4043)
- Deep Impact: NASA/JPL-Caltech/UMD [http://solarsystem.nasa.gov/multimedia/display.cfm?Category=Planets&IM\\_ID=9367](http://solarsystem.nasa.gov/multimedia/display.cfm?Category=Planets&IM_ID=9367)
- Hartley 2: NASA/JPL-Caltech/UMD [http://solarsystem.nasa.gov/multimedia/display.cfm?Category=Planets&IM\\_ID=11263](http://solarsystem.nasa.gov/multimedia/display.cfm?Category=Planets&IM_ID=11263)
- Comet McNaught 2006: Akira Fujii/DMI <http://www.davidmalin.com/fujii/source/af12-34.html>
- Comet Hale-Bopp 1996: Akira Fujii/DMI [http://www.davidmalin.com/fujii/source/af12-19\\_72.html](http://www.davidmalin.com/fujii/source/af12-19_72.html)
- Comet 73P: NASA, ESA, H. Weaver (JHU/APL), M. Mutchler and Z. Levay (STScI)/G. Rhemann and M. Jager <http://hubblesite.org/newscenter/archive/releases/2006/18/image/a/>
- Comet SL9: H.A. Weaver, T. E. Smith (Space Telescope Science Institute), and NASA <http://www2.jpl.nasa.gov/sl9/image2.html>
- Jupiter after SL9 Collision: Hubble Space Telescope Comet Team and NASA <http://www.nasa.gov/centers/goddard/multimedia/largest/EduImageGallery.html>
- Comet Lovejoy Encounter: NASA/STEREO/
- 2001 Leonid meteors: Juraj Toth (Comenius U. Bratislava), Modra Observatory <http://apod.nasa.gov/apod/ap011104.html>