Introductions

- Me
  Prof. Eric M. Wilcots
  5534B Sterling ("The Big Office")
  262-2364
  ewilcots@astro.wisc.edu

- You
  Majors?
  Library access?
  Programming experience?
Course Details

- **Text:** *Planetary Sciences* (de Pater & Lissauer)
- Supplementary readings: will be either handed out in class (with a copy kept on reserve) or listed on the “Lectures” web page.
- Lectures: some powerpoint, some not – powerpoint lectures will be posted on the “Lectures” web page
- Grading: see web page – more details about the project/paper to follow.
- Homework: handed out on Thurs and due Tues 12 days later – we’ll end up with 5 or 6 – don’t procrastinate (too much)!
- Exams: will be like the homework
  - Midterm – Thursday, October 25 in class
  - Final – Tuesday, December 18 10:05am
- Office hours – 2:15-3:30 Tuesdays or by appointment
Course Goals

- Mine
  - Fundamental astrophysics
    - Gravity
    - Radiative transfer
    - Observational techniques
  - Planetary science is alive and well
  - This stuff is cool!

- Yours
  - ????
Tools of the Trade

- Nothing like being there…
  - “flybys” – Voyager 1, Voyager 2
  - Orbiters – Magellan, Galileo, Cassini
  - Rovers – Mars
  - Landers – Mars, Venus
  - Crashes – Jupiter, Titan, comet

- “Remote Sensing”
  - Spectroscopy
    - UV – atmospheric, magnetospheric ions
    - NIR – surface mineralogy, molecules
    - Radio – atmospheric physics
      - Radar – surface features
  - Polarimetry
    - Physics of particulate matter (atmospheres/surfaces)
  - Photometry
    - Variations in brightness (temporal and spatial)
    - Colors → surface morphology/composition
Notable Missions

- Apollo missions (1960s, 1970s) to moon
- Mariner 9 – Mars orbiter (US; 1971)
- Venera 7 – Venus landing (USSR; 1970)
- Pioneer 10 – Jupiter flyby (US; 1973)
- Mariner 10 – Mercury flyby (US; 1973)
- Viking 1,2 – Mars lander (US; 1976)
- Voyager 1,2 – Jupiter, Saturn flyby (US; 1979, 1980)
- Voyager 2 – Jupiter, Saturn, Uranus, Neptune flyby (US; 1970s, 1980s)
- Vega – Halley’s Comet encounter (EUR; 1985)
- Magellan – Venus orbiter (US; 1990s)
- Galileo – Jupiter orbiter (US; 1995)
- Pathfinder – Mars rover (US; 1997)
- Cassini – Saturn orbiter (US+EUR; 2005)
- Spirit, Opportunity – Mars rovers (US; 2004)
- Stardust – comet (US; 2004)
- New Horizons – Pluto/Kuiper Belt (US; launched 2005)
Missions

- Mercury – Mariner 10 (1974), MESSENGER (ongoing)
- Venus – Venera (1972), Magellan (1989-92)
- Mars – Mariner 9 (1971), Viking (1976), Rover (current), Surveyor (current)
- Saturn – Pioneer 11 (1977), Voyager 1,2 (1970s), Cassini (current)
- Uranus – Voyager 2
- Neptune – Voyager 2
- Pluto – New Horizons (current)
Notable Ground-Based and Orbiting Observatories

- Hubble Space Telescope
- Keck I, II (Hawaii)
- VLT (Chile)
- SALT (South Africa)
- Very Large Array (New Mexico)
- Green Bank Telescope (West Virginia)
- Atacama Large Millimeter Array (Chile; coming soon)
What’s Going on Now?

- Extrasolar Planets
  - Ground-based optical/NIR
  - Planned space missions (e.g. TPF)

- Solar System Origins
  - Water, life on Mars?
  - Methane on Titan

- Formation/Frequency of Planetary Systems
  - Theory/Simulation
    - Disk formation, orbit migration, planet formation
  - Radio, NIR (ground+space) observations
    - Molecules have most of their transitions in the IR and radio parts of the spectrum

- Surveys
  - TNOs/Kuiper Belt objects and dwarf planets
  - Near Earth Asteroids
Contents of our “Solar System”

- 1 star ($L \sim 10^{33} \text{ erg s}^{-1}, \ T_{\text{eff}} \sim 6000 \ K$)
- Four “terrestrial” planets
  - Very few moons, small, rocky, atmospheres
- Four “gas giants”
  - Large numbers of moons
- Pluto and the Dwarf Planets
- Countless small bodies
  - Asteroids
  - Comets
  - Kuiper Belt, TNOs
Overview - Contents

- **Sun**
  - Radiation – surface temp of everything in solar system depends on the solar luminosity
  - Gravity – Sun dominates, but there are lots of 3-body problems
  - Solar system “weather”

- **Terrestrial Planets**
  - Rocky with mean density ~ 2.5 g cm$^{-3}$
  - Mostly silicates w/ varying amounts of iron
  - Atmospheres produced by geological activity

- **Debris**
  - Small, rocky bits $\rightarrow$ asteroids
  - Small icy bits $\rightarrow$ comets/KBOs/TNOs

- **Giant Planets**
  - Mostly gaseous with mean density ~ 1.0 g cm$^{-3}$
  - Nearly solar composition but with complex C+H+N compounds
  - Lots of natural satellites, ring systems $\rightarrow$ mini-solar systems?
Common Properties and Questions

- **Orbits**
  - Keplerian
  - Mostly prograde → “everything spins in the same direction”
  - Conservation of angular momentum
  - 3-body problems → tides, Lagrange points, resonances
  - Questions: what accounts for the common orbital properties? What puts things in retrograde orbits? How much orbital migration has occurred?

- **Composition**
  - Mostly solar composition and/or ratios
  - Questions: what causes deviations from solar composition?

- **Temperature**
  - Surface temperatures all depend on solar luminosity and distance
  - Questions: what are the sources of internal heating

- **Magnetic Fields**
  - Very common, but vary in strength
  - Questions: what is the origin of planetary magnetic fields?
“BIG” questions we want to ask (and try to answer):

- What are the forces that shape the surface/atmosphere/interiors of the planets?
- What is the origin of our solar system and its contents?
- How prevalent are other “solar systems” and is our configuration common?
- What determines the configuration of planetary systems?
- What is a planet?
What is a planet?

- **Stars and Brown Dwarfs**
  - stars $\rightarrow$ stable luminosity via H burning and 100% of luminosity from fusion
  - Brown dwarfs $\rightarrow$ not stable, some luminosity from gravitational contraction
  - BDs tend to be fully convective (contrast with higher mass stars and giant planets)

- **Fusion**
  - H burning above $75 \ M_J$ ; D burning about $13 \ M_J$
  - $H^1 + D^2 \rightarrow Be \ (unstable) \rightarrow He + He$
  - Not a good long term source of luminosity