Honors Seminar 259 — cheat sheet for 12/8/2008 — Andrew Baker

Kalas et al. (2008)

You should read the whole article, although don't kill yourself trying to understand the details of the "Dynamical models of planet-belt interaction" section. Key questions:

1. Was there any reason before this work was undertaken to suspect that Fomalhaut might have a planet orbiting it?
2. How do the authors know that the object they're claiming is a planet is not just an unrelated background object?
3. The authors use a couple of different methods to estimate the mass of the putative planet. What (qualitatively) are they?
4. In Figure 3, the brightness of Fomalhaut b at several different wavelengths (i.e., photometry) is plotted as discreet points on top of several theoretical models of what the spectrum of such a planet might look like. How would you assess the agreements and disagreements with the models (keep in mind that some of the points are detections, and some are only upper limits)?
5. What do the authors suggest about possible formation mechanisms for Fomalhaut b?

Key terms:

- **abundance** = fraction of a star's, planet's, or gas cloud's mass that is in the form of one or more heavy elements (relative to hydrogen)
- **apsidal orientation** = the angle on the sky at which the long axis of an orbital ellipse falls in projection
- **bolometric** = refers to a sum over all wavelengths
- **chromosphere** = hot outer layer of a stellar or planetary atmosphere
- **condensation temperature** = temperature at which vapor turns to liquid (this will be different for different materials)
- **conjunction** = moment in an object's orbit when it is aligned with another
- **cooling track** = predicted decline of temperature with time for a young star or planet
- **H band** = a standard near-infrared filter centered at $1.6\,\mu$m
- **Keplerian motion** = the orbit that one object follows when it moves around a single, large mass (e.g., a planet moving around its star; the motions of stars around the center of a galaxy are *not* Keplerian, since the galaxy's mass is extended)
- **optical depth** = a number that expresses (roughly speaking) how transparent a medium is; media with $\tau < 1$ are optically thin (i.e., transparent) at a particular wavelength, while media with $\tau > 1$ are optically thick (i.e., opaque)

- **pc** = parsec = 3.1×10^{15} km
- **periastron** = closest approach to a star
- **Poynting-Robertson drag** = a process in which a dust grain in orbit around a star can actually lose angular momentum and drop to a smaller orbit, thanks to absorption and reradiation of photons
- **proper motion** = the apparent motion of an astronomical object in the plane of the sky, expressed as an angular displacement per unit time
- **radiation pressure** = the push imparted to dust grains by photons (i.e., light)
- **resonance** = in orbital mechanics, a region of parameter space in which a small gravitation perturbation can lead to an extremely large response in the motion of an orbiting particle
- **secular forcing** = any process in orbital dynamics in which the influence of one body causes slow changes in the parameters of the orbit of another body (here "slow" means on a timescale longer than that second body's orbital period)
- **shot noise** = statistical fluctuations in a result due to the small number of particles involved
- **thermal emission** = radiation that an object produces because of its own heat (an alternative would be radiation from another source that is scattered or reflected)
- **vibrational band** = an absorption-line feature in a spectrum produced by the superposition of many narrower individual absorption lines, all due to the same type of molecule

Marois et al. (2008)

You should read the whole article. Key questions:

1. What are the advantages and disadvantages of trying to find planets that are far from their central stars?
2. What are the advantages and disadvantages of looking for planets around A stars (a type of star more massive than our Sun)?
3. Why do the authors make such a big deal about estimating the age of the *star* in this system?
4. Is there any significance to the fact that the planets in this system are all revolving counter-clockwise about the central star?

Key terms:

- **accretion shock** = boundary between an accreting gas envelope and the body onto which it is accreting

- **altitude/azimuth telescope** = a telescope mounted in such a way that its two axes of motion allow it (respectively) to rotate around the sky parallel to the ground, and to rotate between horizon and zenith
- **adaptive optics** = a technique used to obtain very sharp images from a ground-based telescope by correcting in real time for the blurring induced by atmospheric turbulence above the telescope
- **black-body** = adjective describing an object that radiates because it is hot, and whose spectrum is the universal "Planck function" that depends *only* on its temperature
- **brown dwarf** = a low-mass "star" that is capable of extracting energy by burning deuterium but is not massive enough to fuse ordinary hydrogen
- **color-magnitude diagram** = a plot that can be used to indicate the evolutionary state of a star or a set of stars (an example is Figure 3, which plots the "magnitude" at $1.6\,\mu$m with brighter stars higher, vs. the "color" ratio of $2.2\,\mu\mathrm{m}/1.6\,\mu$m emission with redder stars to the right)
- **core-accretion model** = a scenario for the formation of a planet in which the initial buildup of a solid core from planetesimals is followed by the capture of a gaseous envelope
- **field brown dwarf** = a brown dwarf that is not in orbit around another, more massive star
- **Hertzsprung-Russell diagram** = color-magnitude diagram
- **insolation** = incident radiation from a central star
- **near-IR** = the range of wavelengths ($1 - 2.2\,\mu$m) just longer than the range to which our eyes are sensitive
- **photometric** = adjective referring to properties of images (often through multiple filters) only
- **telescope pupil** = image of a telescope's primary aperture (e.g., main mirror) as seen by a detector
- **quasistatic** = nearly constant
- **resolve** = image with sufficient angular resolution that an object doesn't just look like a dot
- **speckle** = a blob in an image that is not a real source, but instead is an artifact of surface errors in the optical path or (for a ground-based telescope) atmospheric turbulence
- **spectroscopic** = adjective referring to properties of spectra

- **unsaturated** = an image in which the number of counts is proportional to the number of incident photons (if one exposes too long, the number of counts will hit a limit and no longer increase even though the photons keep arriving, a condition known as "saturation")
- **UVW** = three coordinates to describe the motions of stars relative to the Sun and solar system