Honors Seminar 256 — cheat sheet for 10/13/2011 — Andrew Baker

Endl & Kürster (2008)

You should read the whole article. Key questions:

1. What's *unique* about Proxima Centauri from our point of view?

2. What property or properties of Proxima Centauri make it a good target for a radial velocity planet search? What property or properties might make it not such an interesting target for seeking life?

3. Why are the authors so concerned about the Hα line index measurements in Proxima Centauri?

4. What explains the principal features of the authors' Figure 4 (i.e., the "HZ" box, the "1-year window" gap, and the various lines sloping upward from left to right)?

5. The authors' main conclusion is a negative result (these are important to publish too!): they see no evidence for a planet around Proxima Centauri. Are there any scenarios in which one or more planets could still be present but undetected in their data?

Key terms:

- **AU** = astronomical unit = mean distance of the Earth from the Sun ($\sim 1.50 \times 10^8$ km)

- **barycentric correction** = correction for the motion of the Earth around the barycenter (i.e., the center of mass of the Solar system), which must be applied to radial velocity measurements

- **bootstrap** = a statistical technique used to estimate the uncertainty in a given measurement, which relies on resampling the data one already has and seeing how much one's results change

- **Ca I** = neutral calcium atom(s)

- **convective redshift** = an effect in the atmospheres of certain stars in which the different temperatures of material rising and falling within convective cells lead to an apparent redshift of a given spectral line; this can be suppressed in regions of high magnetic activity

- **ESO** = European Southern Observatory, which operates telescopes in the Chilean Andes

- Hα = the transition from the $n = 3$ to the $n = 2$ electronic state in a hydrogen atom; this can produce a very strong emission line in an optical spectrum

- Hα **line index** = a measurement of the strength of an Hα line relative to the emission at wavelengths on either side

- **Hipparcos** = a space mission that measured the positions and motions of the nearest stars to very high precision

- **HST** = Hubble Space Telescope

- **image slicer** = a piece of hardware that can help take incident light and produce a spectrum

- **K band** = a filter whose central wavelength is in the redmost end of the of near-infrared atmospheric window ($\lambda \sim 2.2\,\mu$m)

- **M dwarf** = a star on the main sequence that has spectral type M (i.e., has a mass lower than that of the Sun, which is a G dwarf, in the OBAFGKM classification scheme)

- **microlensing event** = sudden increase in brightness when the light from a background object is gravitationally lensed by a foreground object that passes in front of it along our line of sight

- **null hypothesis** = the hypothesis about a given dataset that some statistical analysis is (in principle) capable of rejecting

- **parallax** = the angular displacement that a nearby star exhibits relative to more distant background stars on opposite sides of the earth's orbit (a bit like putting a finger in front of your nose and closing first one eye and then the other)

- **pc** = parsec = 3.09×10^{13} km (about three light years)

- **periodogram** = a manipulation of a time series of measurements (e.g., of radial velocities) that reveals how much "power" there is at different frequencies

- **phase angle** = angle describing where in a planet's orbit it is

- **pulsar** = the rapidly rotating, radio-beam-producing neutron star (i.e., a "star" so dense that all protons and electrons have been compressed together into neutrons!) that can be the collapsed remnant left after a supernova

- **resolving power** = $R \equiv \lambda/\Delta\lambda$ = a measure of how finely a spectrum has been sampled in wavelength

- **secular** = adjective describing any process that is slow relative to some main timescale of interest

- **slit width** = dimension of the slit used to pick off light so that it can be split into a spectrum; the narrower the slit, the higher the resolution of the spectrum

- **TPF** = Terrestrial Planet Finder, a possible future NASA mission

- **UVES** = Ultraviolet and Visual Echelle Spectrograph, an instrument on the VLT that takes very high-resolution spectra

- **V band** = a filter whose central wavelength is in the green part of the optical band ($\lambda \sim 5500\,\text{Å}$)

- **VLT** = Very Large Telescope, a set of four $8\,\text{m}$ diameter telescopes in northern Chile

- **window function** = a function of frequency that reflects how much power will end up in the periodogram of a given time series simply as a result of when the observations were made

Lineweaver et al. (2004)

You should read the whole article. Key questions:

1. What are the three key considerations that determine when and whether a planet is "habitable" by complex multicellular life?

2. Why isn't the Sun exactly at the center of the green zone in Figures 3 and 4? Would we expect it to be?

Key terms:

- **accretion** = process by which gas from some external reservoir flows onto or into a massive structure (e.g., a star, a black hole, or a galaxy)

- **active galactic nucleus** = a supermassive black hole at the center of a galaxy that is converting the potential energy of inflowing matter into lots of radiative and mechanical/kinetic energy

- **corotation** = a dynamical resonance in a rotating disk, close to which stellar orbits are unstable

- **cumulative integral** = the total area enclosed under a curve to the left of some value of x

- **kiloparsec** = a distance of about 3000 light-years (the Sun is about 8 kiloparsecs from the center of the Milky Way)

- **molecular clouds** = large clouds of gas that is sufficiently cold and dense that most of the hydrogen content is in the form of diatomic molecules

- **normal distribution** = Gaussian = bell curve distribution

- **starburst** = an event in which a galaxy (or a part thereof) undergoes an unusually vigorous episode of star formation

- **stellar initial mass function** = a mathematical description of the relative numbers of stars of different masses that are formed when a parcel of gas is converted into stars