Formation and Detectability of Earth-Size Planets Around Alpha Centauri B

J. Guedes, E. Rivera, E. Davis, G. Laughlin, E. Quintana[2], & D. Fischer[3]

[1]Department of Astronomy and Astrophysics, University of California, Santa Cruz, CA

[2] SETI Institute, Mountain View, CA

[3] Department of Physics and Astronomy, San Francisco State University, San Francisco, CA

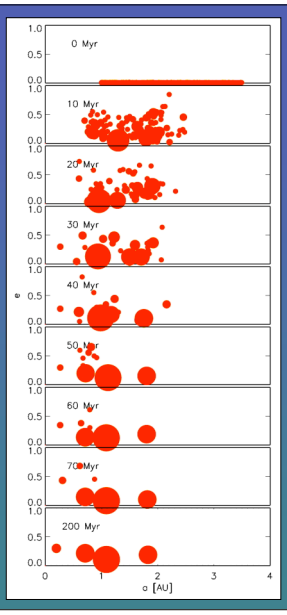

Fig. 1 -- Evolution of a circumstellar disk initially populated by moon-mass oligarchs in circular orbits around Alpha Centauri B. The radius of each circle is proportional to $m^{1/3}$.

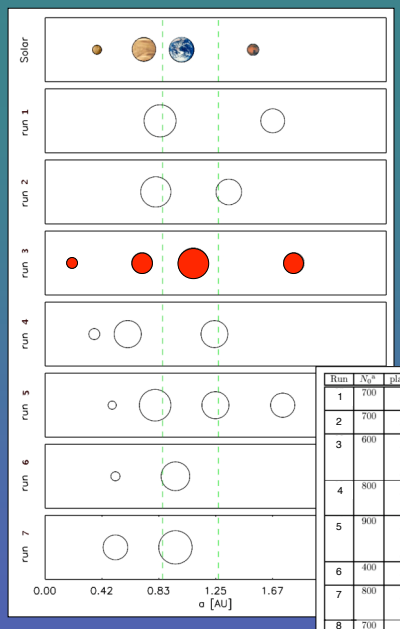

Fig. 2 -- Resulting planetary systems around Alpha Centauri B for 8 runs of simulated disk evolution. Green lines indicate the habitable zone.

We simulate the formation of planetary systems around Alpha Centauri B and examine the detectability of the resulting simulated planetary systems by generating synthetic radial velocity observations.

Analysis of one of the simulated systems indicates that we can reliably detect a 1.4 earth mass planet around Alpha Centauri B within 2 years and detect multiple planet systems within 4.7 years.

Using a modified version of the MERCURY symplectic hybrid integrator, we evolve 8 protoplanetary disks around Alpha Centauri B for 200Myr, taking into account gravitational effects of Alpha Centauri A. Fig. 1 depicts the evolution of the disk for simulation run 3.

Initial conditions mimic the chaotic growth phase of terrestrial planet formation in which collisions of isolated oligarchs (approximately moon-mass protoplanets) dominate the evolution of the disk.

For each of the 8 simulations, multiple planet systems were formed, many with planets in or near the habitable zone (Fig. 2 & Table 1).

Run 3 (shown in red) was chosen for detectability analysis since it would be one of the more difficult systems to detect.

Synthetic radial velocity data were generated for the planetary system with a 5 year period of observations (Fig. 3).

The radial velocity data assumes high cadence observation of Alpha Centauri B with the signal from the 4 planets and added white noise of $3ms^{-1}$.

Observations are assumed to take place with a modest 1m dedicated telescope at the location of the Las Campanas observatory.

Evolution of the periodogram over the 5 years of simulated observations shows a reliable detection of the 1.4 earth mass planet in only 2 years and a reliable detection of 3 planets by the end of the 5 year period (Fig. 4).

Our results indicate that radial velocity detection of earthlike planets (possibly in the habitable zone) around Centauri B is feasible within a 2-5 year time period using a modest 1m telescope.

This leaves us with the unique opportunity not only to find "earths" in our own neighborhood but also to test the limits of the radial velocity technique.

Run	N_0*	planet	M [$M_\odot$]	Period [yr]	a [AU]	e	I [°]
1	700	a	0.897	2.262	1.669	0.198	4.965
		b	2.165	0.812	0.843	0.142	4.516
2	700	a	1.820	0.767	0.811	0.016	1.846
		b	1.107	1.640	1.346	0.032	3.064
3	600	a	0.565	2.585	1.831	0.181	3.979
		b	0.578	0.628	0.710	0.242	6.827
		c	0.073	0.091	0.196	0.286	7.590
		d	1.771	1.189	1.086	0.031	3.124
4	800	a	0.086	0.227	0.361	0.244	19.135
		b	1.316	0.495	0.606	0.105	1.639
		c	1.279	1.453	1.242	0.168	2.042
5	900	a	2.054	0.760	0.806	0.052	1.585
		b	0.922	2.412	1.734	0.051	5.784
		c	0.036	0.361	0.491	0.094	18.108
		d	1.291	1.464	1.248	0.145	5.391
6	400	a	1.549	0.981	0.956	0.095	4.777
		b	0.049	0.388	0.515	0.345	15.378
7	800	a	0.996	1.769	1.419	0.169	6.034
		b	0.098	0.441	0.663	0.325	8.259
		c	2.435	0.835	0.858	0.024	3.759
8	700	a	2.755	0.944	0.931	0.217	4.391

*Initial number of oligarchs.

Table 1 -- Initial conditions and resulting orbital parameters for runs 1 through 8.

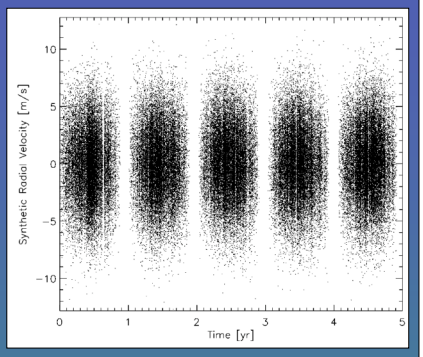

Fig. 1 -- Synthetic radial velocities over a 5 year period for the run 3 planetary system.

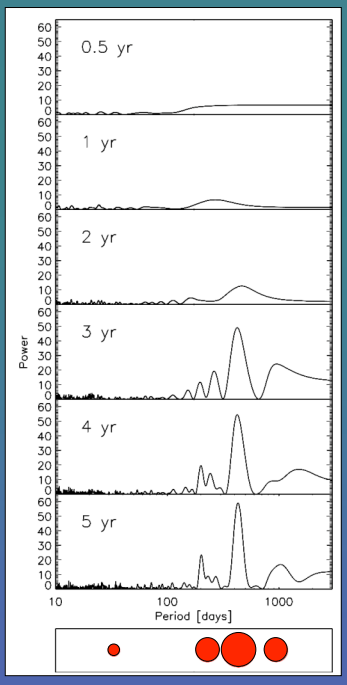

Fig. 4 -- Evolution of the periodogram over 4.7 years for the run 3 planetary system. One planet can be reliably detected after the first 2 years of observations, and 3 planets can be detected within 4.7 years.

edavis@ucolick.org

http://www.ucolick.org/~javiera/AlphaCen/