Observational Constraints on Planets in the Alpha Centauri Star System

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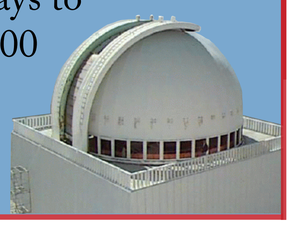
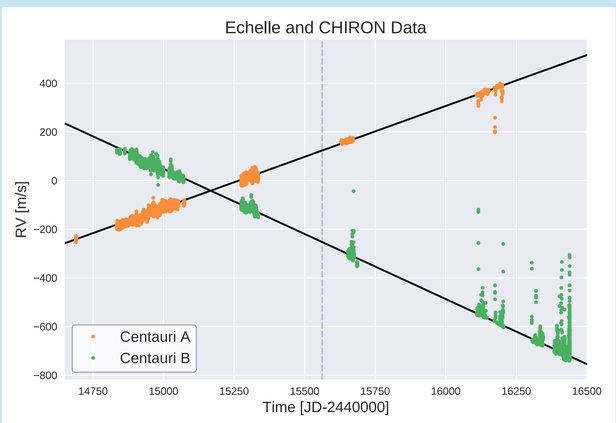
Abstract: Using observations of α Centauri A and B with CHIRON, α Centauri B with HARPS, and Proxima Centauri with HARPS and UVES, we place **constraints on the extent to which undetected planetary companions may still exist** around these stars. Orbital periods of two days to nearly three years are investigated. Existing observations are sufficient to rule out planets with masses down to at least 15 M_{Earth} at short (<100 days) periods. While more massive planets are excluded, **the parameter space remains wide open for the discovery of more potentially habitable, Earth-like planets**. As the projected separation of α Centauri A and B increases beginning in 2019, high-precision, radial velocity measurements may well detect analogs to our Earth around α Centauri A and B in addition to Proxima Centauri b.

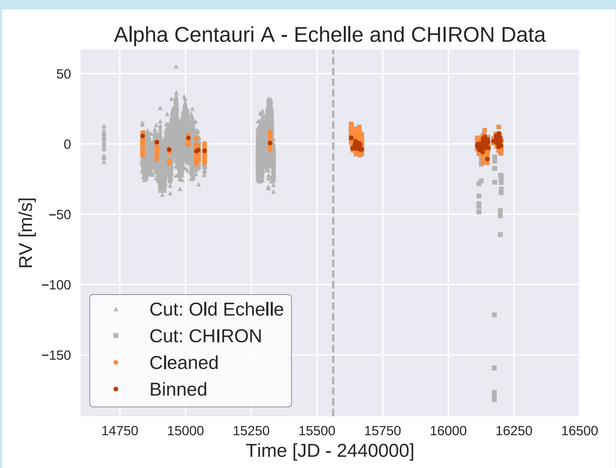


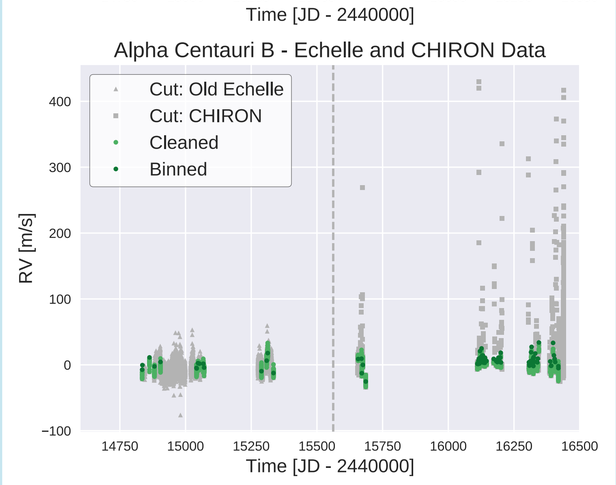
Data:

Data from CHIRON, HARPS, and UVES were used in this analysis[1,2,3]. The binary trend was fit to a low-or and subtracted.



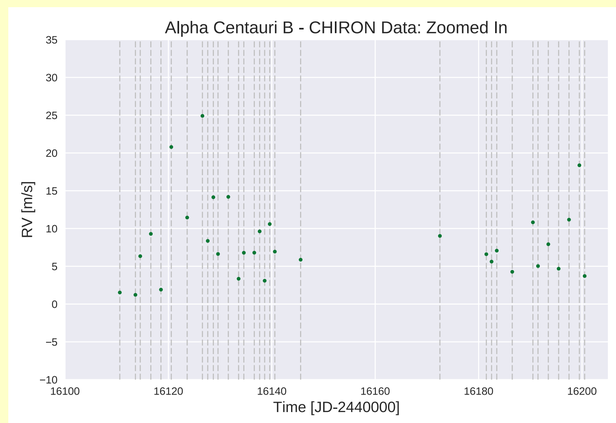
Observations were vetted for particularly bad scatter based on the nightly standard deviation. They were then binned by night.



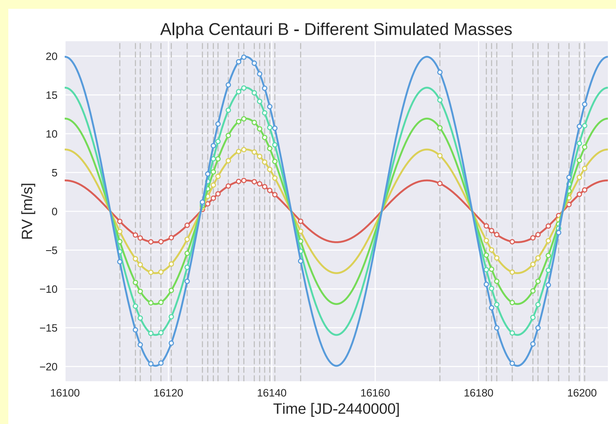


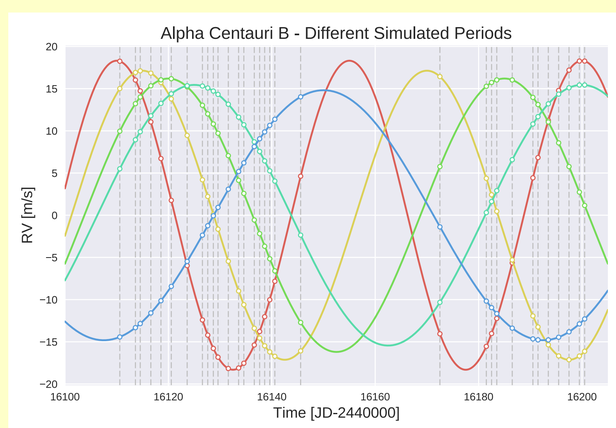
Simulations:

We maintain the time of observations to retain any periodicities that could have arisen due to the observing cadence.



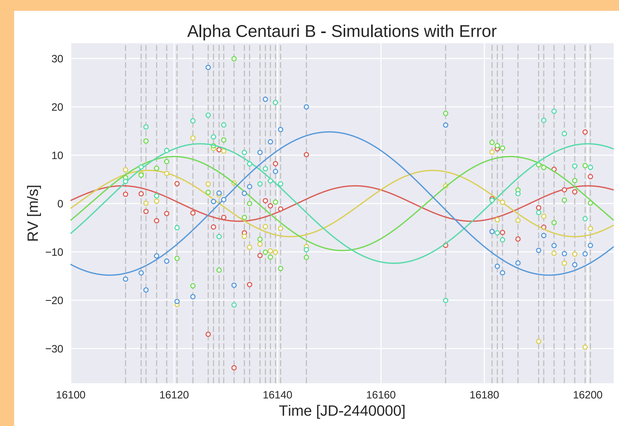
We simulate radial velocity measurements for planets with different masses and periods. Masses ranged from 0.1 to 1000 Earth masses; periods ranged from 2 to 1000 days.



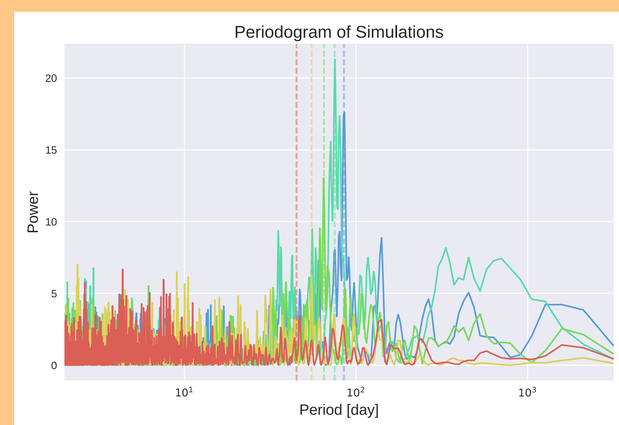


Significance:

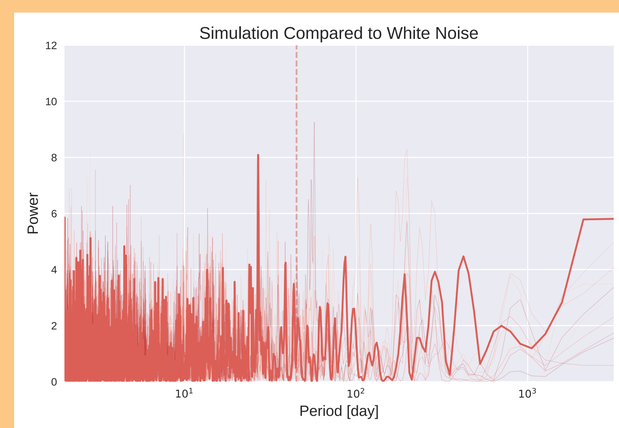
Using the residuals from fitting out the binary trend, we introduce error to our simulated data.



This simulated data with errors is run through a periodogram to identify periodicities.



Simulated data is compared to periodograms of pure white noise to establish the significance of the signal



Results:

A p-value of less than 0.01 is set as sufficient to detect planets. Our analysis shows that **Earth-mass planets** at all periods may still exist undetected around the α Centauri Stars.

We fit the border of detection to a white noise detectability threshold (WNDT) curve,

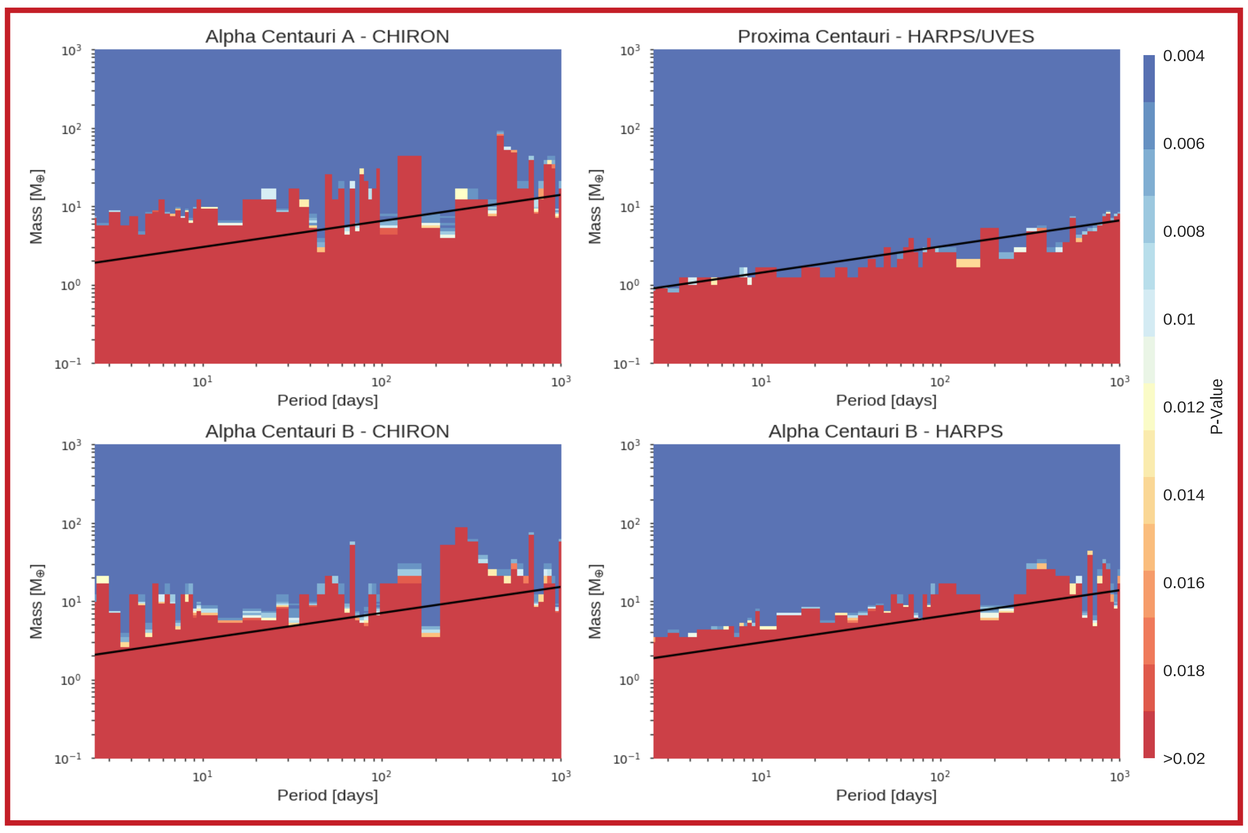
$$WNDT = K\sqrt{\frac{N}{\sigma}}$$

where K is the semi-major amplitude of the radial velocities, N is the number of observations and σ is the error.

$$K = \frac{28.4329\ m\ s^{-1}}{\sqrt{1-e^2}} \frac{m_P\ sin(i)}{M_{Jup}} \left(\frac{m_S + m_P}{M_{Sun}}\right)^{-2/3} \left(\frac{P}{1\ yr}\right)^{-1/3}$$

Earth's orbit around the Sun gives a K value of 0.1m s^{-1}.

Data Set	WNDT	K [m s^{-1}]	σ [m s^{-1}]	N
Cen A - CHIRON	2.942	0.822	6.085	78
Cen B - CHIRON	3.240	0.991	7.298	78
Cen B - HARPS	6.809	0.897	3.787	218
Proxima - HARPS/UVES	45.466	1.729	0.308	213



Citations: [1] Tokovinin, A. et al. (2013) PASP, 125, 1336. | [2] Dumusque, X. et al. (2012) Nature, 491, 207. | [3] Anglada-Escudé, G. et al. (2016) Nature, 536, 437.