Understanding the Parent Stars

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Abstract / Motivation: Practically all astrophysical parameters of extrasolar planets are actually functions of stellar parameters. Consequently, understanding extrasolar planets requires "understanding the parent stars". One option of directly determining fundamental astrophysical parameters of stars is long-baseline interferometry. We use the CHARA array for an ongoing survey of nearby exoplanet host stars' angular diameters. Coupled with trigonometric parallax values and literature photometry, we obtain direct estimates of the stellar physical sizes and surface temperatures, i.e., their luminosities and location / extent of their habitable zones. Furthermore, for transiting planets, a knowledge of the stellar size provides a direct determination of the planetary diameter.

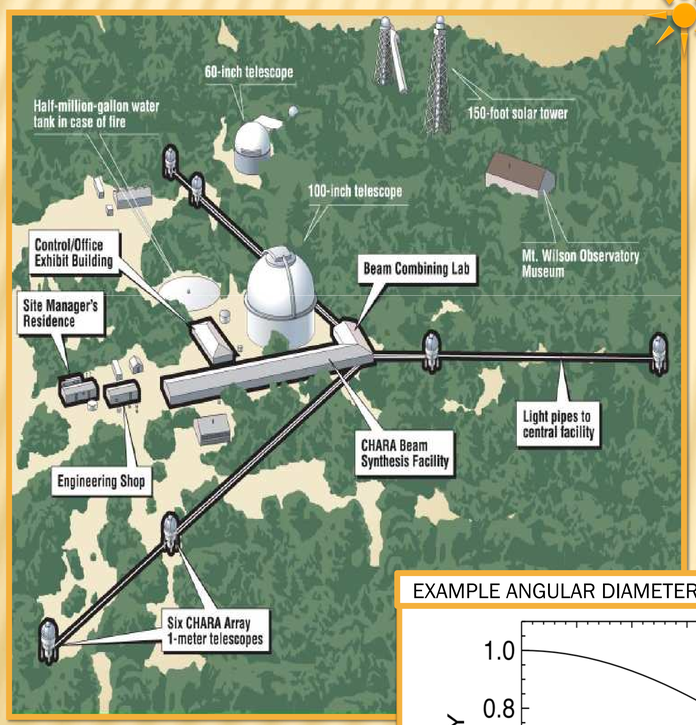
Methods

◆ Stellar angular diameter, θ, is directly measured from interferometry using the CHARA array in *H*-band (single baseline). Combined with trigonometric parallax values (π), we obtain the stellar physical radius R.

◆ Literature photometry and Pickles (1998) spectral templates provide F_{BOL} and A_V.

◆ The luminosity (L=f[F_{BOL}, π]), temperature (T=f[θ,F_{BOL}]), and radius (R=f[θ,π]) are determined to precisions of σR/R~3% and σT/T~1-2%.

◆ Habitable zone boundaries are functions of L, T.

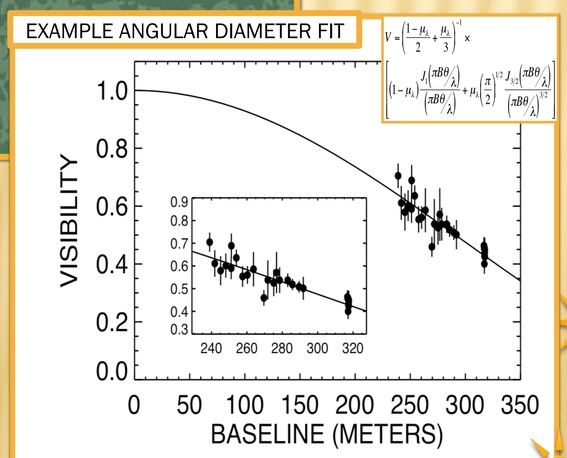


INTERFEROMETRY

◆ Above: Georgia State University's CHARA Array on Mt. Wilson, California.

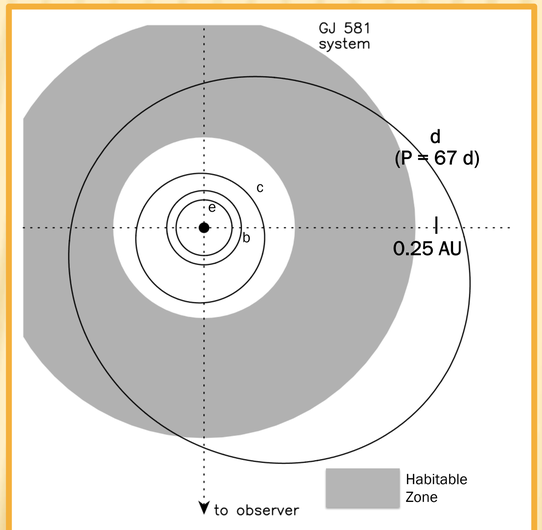
◆ Right: A typical data set and associated fit to the interferometric visibility.

EXAMPLE ANGULAR DIAMETER FIT

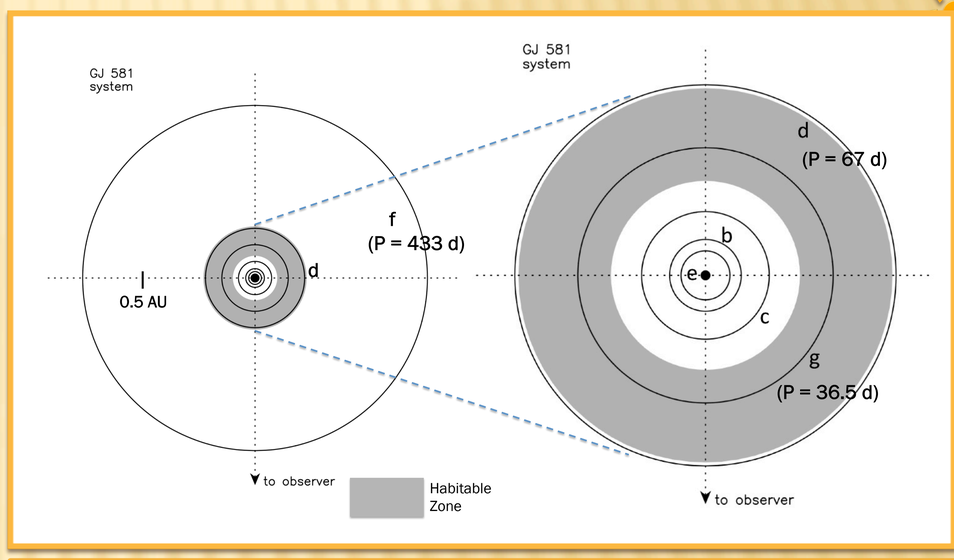


GJ 581 – Stellar Parameters

Parameter	Value (Uncertainty)
θ_{UD}(mas)	0.433(14)
θ_{LD}(mas)	0.446(14)
F_{BOL}(10^{-8} erg/s/cm^2)	0.992(1)
Radius (solar)	0.299(10)
Luminosity (solar)	0.0121(2)
T_{EFF}(K)	3498(56)
HZ boundaries (AU)	0.11—0.21



GJ 581



GJ 581 – Results

◆ The planet hosting star GJ 581 is an M2.5 dwarf (distance ~ 6.3 pc).

◆ Our directly determined stellar parameters, plus the boundaries of the HZ, are shown above.

◆ Left panel: GJ 581's HZ (planets & orbits from Mayor et al. 2009).

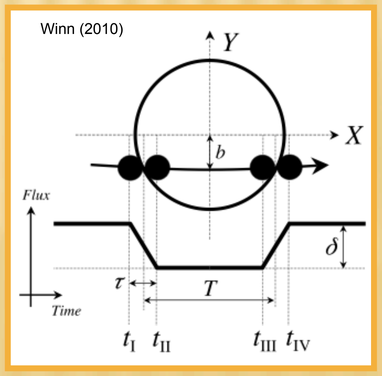
◆ Top panel: GJ 581's HZ (planets & orbits from Vogt et al. 2010).

◆ Results published in von Braun et al. (2011).

GJ 436

GJ 436 – Stellar Parameters

Parameter	Value (Uncertainty)
θ_{UD}(mas)	0.405(13)
θ_{LD}(mas)	0.414(13)
F_{BOL}(10^{-8} erg/s/cm^2)	0.788(1)
Radius (solar)	0.452(18)
Luminosity (solar)	0.0257(1)
T_{EFF}(K)	3427(54)



GJ 436 – Results

◆ The star GJ 436 is an M3 dwarf at a distance of 10.2 pc that hosts a transiting planet.

◆ Our directly determined stellar parameters are shown on the left.

◆ Using literature values for flux decrement δ (average δ ~0.0065), we obtain:

R (GJ 436b) = (4.09 +- 0.19) R_{earth}

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More details: