Characterizing Exoplanet Host Giant Stars

Ellyn Baines
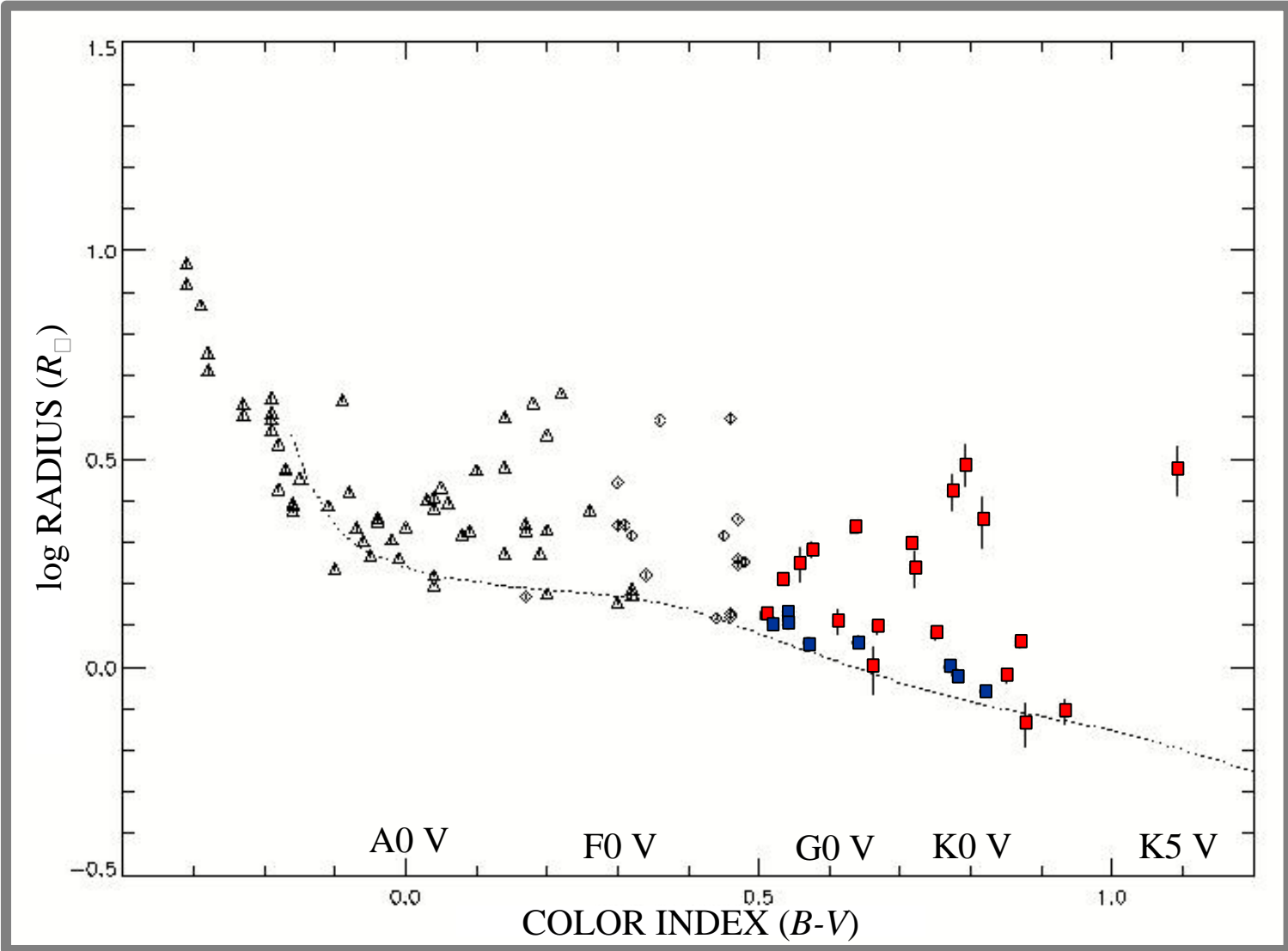
Charoid #27

Naval Research Laboratory

CHARA + Andersen 1991

Tale of two projects…

Exoplanet Host Stars

- 11 targets
  - 6 giants
  - 4 subgiants
  - 1 dwarf
- Measured θ_{LD}
- Calculated T_{EFF}
- Estimated R, M, age

Giant Stars

- 15 giants
- Measured θ_{LD}
- Calculated T_{EFF}
- Estimated R, M, age

- Future oscillation studies combined with $\theta \rightarrow$ mass

Collaborators

Exoplanet Host Stars

- Hal McAlister
- Theo ten Brummelaar
- Judit Sturmann
- Laszlo Sturmann
- Nils Turner
- Stephen Ridgway
- PJ Goldfinger
- Chris Farrington

Giant Stars

- Folks on left plus:
- ESO:
  - Michaela Döllinger

- Thüringer Landessternwarte:
  - Felice Cusano
  - Eike Guenther
  - Artie Hatzes

Exoplanet Host Diameters

HD	Spectral Type	μ_λ	π (mas)	θ_{SED} (mas)	θ_{UD} (mas)	θ_{LD} (mas)	σ_{LD} (%)	R_L ($R_\odot$)	σ_R (%)
16141	G5 IV	0.27	25.67±0.66	0.381±0.012[†]	0.480±0.048	0.490±0.049	10	2.05±0.21	10
17092	K0 III	0.33	N/A	0.531±0.029[†]	0.586±0.039	0.601±0.041	7	N/A	N/A
45410	K0 III-IV	0.31	17.92±0.47	0.867±0.066	0.946±0.034	0.970±0.035	4	5.82±0.26	4
154345	G8 V	0.28	53.80±0.32	0.452±0.008[†]	0.490±0.026	0.502±0.026	5	1.00±0.05	5
185269	G0 IV	0.25	19.89±0.56	0.359±0.012[†]	0.471±0.032	0.480±0.033	7	2.59±0.19	7
188310	G9 III	0.32	17.77±0.29	1.712±0.053	1.671±0.008	1.726±0.008	0.4	10.45±0.18	2
199665	G6 III	0.31	13.28±0.31	0.985±0.028	1.083±0.027	1.111±0.028	3	9.00±0.31	3
210702	K1 III	0.31	18.20±0.39	0.879±0.049[†]	0.854±0.017	0.875±0.018	2	5.17±0.15	3
217107	G8 IV	0.28	50.36±0.38	0.534±0.016[†]	0.688±0.013	0.704±0.013	2	1.50±0.03	2
221345	G8 III	0.32	12.63±0.27	1.380±0.164	1.297±0.008	1.336±0.009	1	11.38±0.26	2
222404	K1 IV	0.32	70.91±0.40	3.130±0.211	3.331±0.022	3.302±0.029	1	5.01±0.05	1

$T_{\rm EFF}, F_{\rm BOL}, L$

Star HD	A_V (mag)	BC	$F_{\rm BOL}$ $(10^{-8}$ erg s^{-1} cm$^{-2})$	Calculated $T_{\rm eff}$ (K)	$\sigma_{T\rm eff}$ (%)	Range of $T_{\rm eff}$ from other sources (K)	$\log(L)$ $(L_\odot)$
16141	0.00[a]	0.06 ± 0.04	5.2 ± 0.2	5040 ± 257	5	4900-5888	2.4 ± 0.1
45410	0.03[b]	0.29 ± 0.03	15.0 ± 0.5	4679 ± 92	2	4750-4898	14.6 ± 0.4
154345	0.20[a]	0.40 ± 0.04	8.8 ± 0.4	5691 ± 159	3	5436-5570	1.0 ± 0.0
185269	0.13[a]	0.01 ± 0.03	6.1 ± 0.2	5307 ± 187	4	5850-6166	4.8 ± 0.1
188310	0.10[b]	0.35 ± 0.02	49.3 ± 1.0	4720 ± 26	1	4635-4786	48.8 ± 0.9
199665	0.00[b]	0.28 ± 0.04	25.9 ± 1.0	5008 ± 80	2	4750-5012	45.9 ± 1.7
210702	0.10[a]	0.32 ± 0.03	14.3 ± 0.4	4870 ± 62	1	4600-4898	13.5 ± 0.4
217107	0.10[a]	0.09 ± 0.03	9.3 ± 0.3	4872 ± 57	1	4900-5704	1.1 ± 0.0
221345	0.13[b]	0.36 ± 0.03	32.3 ± 1.0	4826 ± 40	1	4582-4900	63.3 ± 1.8
222404	0.01[b]	0.36 ± 0.00	180.6 ± 0.5	4722 ± 21	0.4	4566-4916	11.2 ± 0.0

Note. — [a]van Belle & von Braun (2009); [b]Famaey et al. (2005). All BC values from Allende Prieto & Lambert (1999) except for HD 154345, which is from Cox (2000) with an assigned error of 10%.

PARAM Stellar Model

- Based on evolutionary tracks (Giardi et al. 2000)

- Modified by da Silva et al. (2006)
  - Use theoretical isochrones and a Bayesian estimation method

- Inputs: T_{EFF}, [Fe/H], V mag, parallax

- Outputs: age, mass, $\log g^*$, R_{linear}^*, $\theta_{\mathrm{LD}}^{(*)}$, $(B\text{-}V)^*$

Model Results

Star HD	Average [Fe/H]	R_{model} ($R_\odot$)	Mass ($M_\odot$)	Age (Gyr)	Approx. M-S Spectral Type
16141	0.11 ± 0.07	2.2 ± 0.1	1.1 ± 0.0	6.7 ± 0.9	G0 V
45410	0.17 ± 0.05	6.1 ± 0.3	1.3 ± 0.1	4.2 ± 1.4	F6 V
185269	0.11 ± 0.05	2.6 ± 0.1	1.4 ± 0.0	3.4 ± 0.2	F5 V
188310	-0.27 ± 0.10	10.0 ± 0.4	1.0 ± 0.2	6.8 ± 3.5	G2 V
199665	-0.10 ± 0.12	7.9 ± 0.3	2.0 ± 0.1	1.2 ± 0.1	A5 V
210702	0.00 ± 0.05	5.0 ± 0.2	1.4 ± 0.1	2.6 ± 1.0	F5 V
221345	-0.32 ± 0.05	10.3 ± 0.3	1.1 ± 0.2	4.6 ± 1.9	G0 V
222404	0.08 ± 0.11	5.0 ± 0.2	1.2 ± 0.1	5.7 ± 2.2	F8 V

θ, *R* Comparison
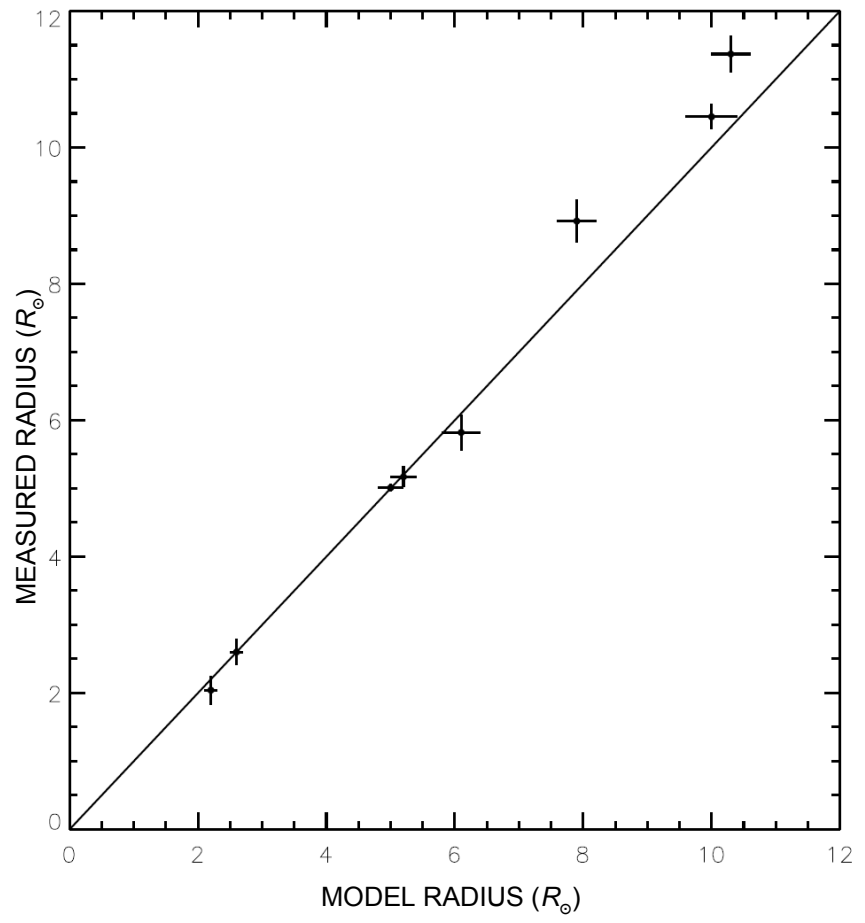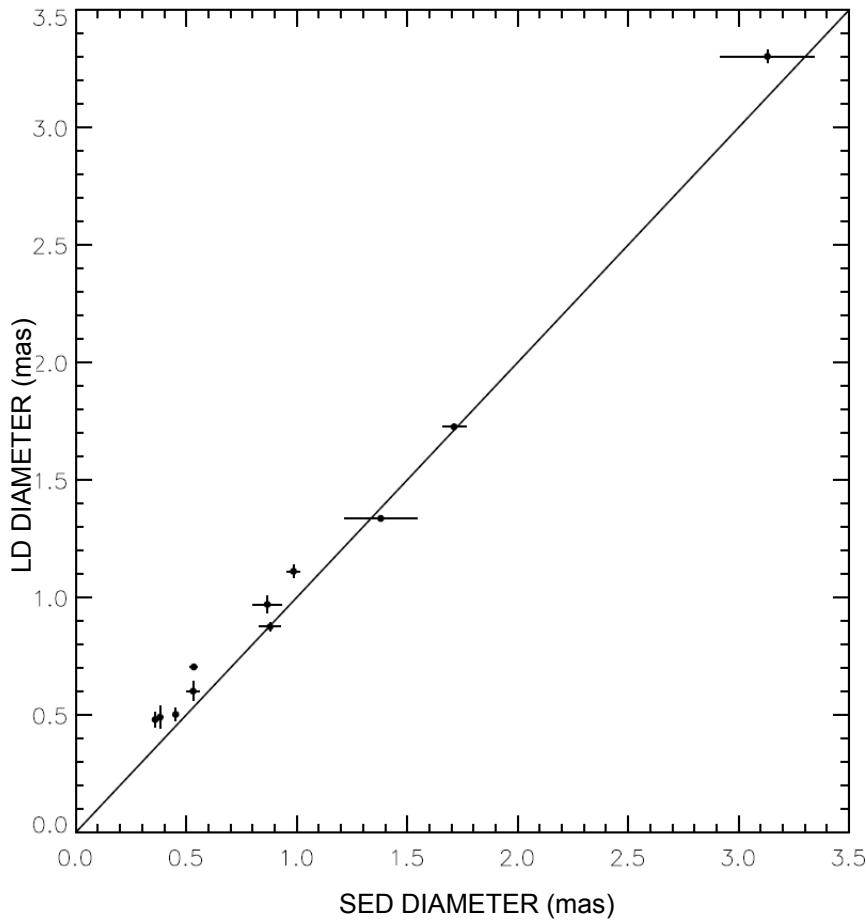
K III Diameters, $T_{\rm EFF}$, $F_{\rm BOL}$

Target HD	$\theta_{\rm UD,measured}$ (mas)	$\theta_{\rm LD,measured}$ (mas)	$\sigma_{\rm LD}$ (%)	$R_{\rm linear}$ ($R_\odot$)	$F_{\rm BOL}$ (10^{-8} erg s^{-1} cm^{-2})	$T_{\rm eff}$ (K)	$\sigma_{\rm Teff}$ %
32518	0.828 ± 0.022	0.851 ± 0.022	3	11.04 ± 0.77	11.1 ± 0.7	4630 ± 94	2
73108	2.161 ± 0.019	2.225 ± 0.020	1	18.79 ± 0.38	60.4 ± 3.5	4374 ± 66	2
106574	1.458 ± 0.027	1.498 ± 0.028	2	23.02 ± 0.92	22.5 ± 1.4	4166 ± 75	2
118904	1.842 ± 0.031	1.871 ± 0.032	2	25.38 ± 0.88	27.8 ± 1.7	3931 ± 68	2
136726	2.264 ± 0.020	2.293 ± 0.020	1	30.12 ± 0.70	59.3 ± 5.5	4289 ± 101	2
137443	1.638 ± 0.030	1.690 ± 0.031	2	20.51 ± 0.62	30.8 ± 2.8	4242 ± 105	2
138265	1.998 ± 0.037	2.062 ± 0.038	2	43.40 ± 2.75	27.6 ± 2.8	3736 ± 102	3
139357	1.040 ± 0.012	1.073 ± 0.013	1	13.63 ± 0.51	24.5 ± 2.3	5026 ± 121	2
150010	0.995 ± 0.028	1.024 ± 0.029	3	15.84 ± 1.08	13.5 ± 0.9	4430 ± 95	2
157681	1.600 ± 0.009	1.664 ± 0.009	1	34.19 ± 1.77	33.8 ± 3.4	4375 ± 112	3
167042	0.898 ± 0.017	0.922 ± 0.018	2	4.98 ± 0.07	17.4 ± 1.0	4979 ± 86	2
170693	1.981 ± 0.041	2.041 ± 0.043	2	21.19 ± 0.60	49.7 ± 2.7	4351 ± 75	2
195820	0.840 ± 0.040	0.863 ± 0.041	5	10.69 ± 0.62	13.0 ± 0.6	4781 ± 128	3
200205	1.963 ± 0.043	2.032 ± 0.045	2	41.23 ± 2.08	36.4 ± 3.4	4032 ± 105	3
214868	2.721 ± 0.015	2.731 ± 0.035	1	29.97 ± 0.88	69.3 ± 4.0	4086 ± 65	2

Question for the audience

- T_{EFF} measured spectroscopically by Döllinger et al.

- T_{EFF} measured using θ_{LD} by us

- Why the odd spread?