20 Years of Precise Radial Velocities at Keck and Lick Observatories

Jason T Wright

4 October 2015
20 Years of Giant Exoplanets
Observatoire de Haute-Provence
France
Lick Observatory Planet Search
1987–2011

Shane 3–meter

0.6–meter Coude Auxiliary Telescope

Siderostat
Lick Observatory Planet Search
1987–2011

0.6-meter Coude Auxiliary Telescope Siderostat
Hamilton Spectrograph
Built by Steve Vogt
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Fig. 3—Hamilton spectrum of the V = 12.3 magnitude globular cluster star M71-A4. The spectrum runs from 4530 Å at the bottom to 7320 Å at the top. The atmospheric B-band is visible near row 80. Hα is the prominent absorption feature near row 135. The strong pair of lines at row 285 are the sodium D lines. The strong line to the left at row 495 is part of the Mg b feature.
Method follows Bruce Campbell and Gordon Walker’s HF cell, inspired by Roger Griffin’s use of telluric lines. Iodine suggested by Robert Howard (CIW).

Lick Observatory Planet Search 1987–2011

- Discovered 9 of the first 10 exoplanets
- Exoplanet Mass Distribution: Rises toward low masses & BD Desert
- Eccentric Orbits common!
- Discovered the first multi-planet system around normal star.
Lick Observatory Planet Search
1987–2011
Lick Observatory Planet Search
1987–2011

386 stars observed
14,000 precise Doppler velocities published:
Fischer, Marcy, & Spronck (2013)
Keck Observatory
Planet Search
1994–present
Mylan: We need two pyrex, cylindrical cells, one with 4-in. diam windows, and other with 2-in. These windows are optically flat so please try to minimize distortion.

Both cells must have a length of 4-in, between inner surfaces of windows.

Dr. Geoff Marcy
Physics and Astronomy
x 2955
HD 37605

Wang et al. (2012)
Jupiter analogs are emerging

Feng et al (2015)
Jupiter analogs are emerging

Feng et al (2015)

(a) GJ 849 system

(b) Residuals

(c) GJ 849 b

(d) GJ 849 c

Feng et al (2015)
Some hot Jupiters’ “friends” are cold — they keep their distance.
sufficiently strong cycles that we can confirm their continued coherence since the end of the published Mount Wilson data from our own activity measurements.

None of these four stars shows RV variations similar to HD 154345, or any correlation of $S$-index with RV. In fact, all of these stars show rms RV variations of less than 5 m s$^{-1}$, and one, HD 185144, is among the most RV-stable stars in our entire sample.

Wright et al. (2009)
The diagram shows the variation of $R_{\text{HK}}$ (black dots) and RV (blue dots) for HD 9986 over the years from 1995 to 2015. The $R_{\text{HK}}$ values range from approximately -4.86 to -4.98, while the RV values range from -30 m/s to 10 m/s.
15 YEARS OF GIANT EXOPLANETS AT MCDONALD OBSERVATORY

PAUL ROBERTSON
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PENN STATE UNIVERSITY, USA
McDonald Observatory

HET 10 meter

2.7 meter
THE MCDONALD OBS. TULL SPECTROGRAPH SURVEY

- Tull Spectrograph located at coude focus of 2.7m Harlan J. Smith Telescope
- White pupil, iodine-calibrated, typical observations at R~60K.
- Wavelength range ~375-1000 nm
- 200 (mostly) FGK targets, ~1 observing run/month 1998 -> now
- Primary science goal: Jupiter analogs at 4-5 AU

Survey support from NASA and NSF
NEW RESULTS: NEW LONG-PERIOD GIANT PLANETS!

HD 95872: $4.6 M_J @ 5.2$ AU

psi1 Dra B: $1.5 M_J @ 4.4$ AU

NEW RESULTS: ACTIVITY CYCLES IN RV

- Solar-type activity cycles are quite common, and frequently print through to RV.

- Broad wavelength coverage of Tull spectrograph provides activity tracers, thus avoiding false positives.

\[ \beta \text{ Vir: } P = 5.6 \text{ yr, RV amplitude } 9 \text{ m/s} \]
\[ \text{HD 10086: } P = 7.7 \text{ yr, RV amplitude } 11 \text{ m/s} \]

Regular telescope access over long baseline yields great coverage of both planets and activity cycles.

HD 219134: complete coverage of 11-year activity cycle. Confirms planetary nature of long-period RV signal.

Johnson et al. 2015, in prep.
SUMMARY AND CONCLUSIONS

• The combination of baseline and precision of the Tull survey is a rare and valuable resource for giant exoplanet science.

• The addition of HET/HRS extends the survey to M dwarfs, for which very few Jupiter analogs are known.

• Long-period giant planets and activity cycles appear to be common for FGK stars!
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20 Years of Giant Exoplanets
Observatoire de Haute-Provence
France
Approaching the Stellar Astrophysical Limits of Exoplanet Detection: Getting to 10 cm/s

August 28 – September 18, 2016
Aspen, Colorado, USA

Organizers: Fabienne Bastien, Jason Wright, Xavier Dumusque, Gibor Basri (tentative)