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Radial Velocity Detection of Extra-Solar Planetary Systems

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Strategy

The goal of this program is to detect planetary systems in orbit around other stars through the ultra-high precision measurement of the orbital motion of the star around the star-planet barycenter. Our survey of 33 nearby solar-type stars is the essential first step in understanding the overall problem of planet formation. The McDonald Observatory Planetary Search (MOPS) program will accumulate the necessary statistics to determine the frequency of planet formation as a function of stellar mass, age, and composition.

Progress and Accomplishments

The MOPS has made significant progress in 1990. In particular, we have completed the installation of the stabilized I₂ cell to serve as the velocity reference system. Starlight from the telescope passes through a permanently sealed temperature stabilized I₂ cell before the light enters the spectrograph. Relative radial velocity variations are then measured by determination of the Doppler shift of the stellar photospheric lines with respect to the stabilized I₂ reference lines. Our experience with the I₂ cell demonstrates that we can now achieve rms radial velocity precision of better than 5 m s⁻¹ on most stars. In our monthly observing runs, we are now doing simultaneous observations with the I₂ cell and with the former telluric O₂ line technique, in order to determine the relative zero-points of the two systems. All future observations will be made with the I₂ cell. We have obtained spectra of all available program stars during each of our monthly observing runs. We have completed our data reduction software, and installed it on our new workstations (obtained under State of Texas funding). Our most exciting results to date concern the IAU radial velocity standard star HD114762. In 1988, David Latham discovered periodic radial velocity variations and calculated an orbital solution from his low precision (200 m s⁻¹) data. Our independent orbital solution for the HD114762 confirms Latham's 84 day orbital period, but derives a higher eccentricity for the orbit of 0.38. The mass function for this system indicates a companion with $M \sin i = 0.011 M_{\odot}$. The problem is now to determine if we are viewing a planetary system edge on, or a binary star system pole-on. We have analyzed the profiles of the stellar photospheric absorption lines (which we obtained as an automatic by-product of our radial velocity data) and we have determined that the line profile shapes are purely the result of stellar macroturbulence; the best fit stellar rotational contribution ($V \sin i$) is 0.0 km s⁻¹, with an upper limit of 1.0 km s⁻¹. This corresponds to an upper limit on $\sin i$, the sine of the inclination angle of 0.20. Thus, we determine that the companion object mass is at least 0.055 M_⊙. This means that the companion object is not a planet, but instead is a

either a brown dwarf or a low mass star in a system viewed nearly pole-on. Unfortunately, the HD114762 system is a false alarm for planet detection!

Projected Accomplishments

We will continue regular observations of the 33 stars on the MOPS list. We intend to obtain concentrated time-series observations on selected stars which show possibly periodic short-term radial velocity variations. These variations are possibly due to intrinsic pulsation modes of the star. We need to fully understand the intrinsic stellar variability in order to sort out extrinsic (orbital) from intrinsic (pulsational) radial velocity variations.

Publications

1. "A Search for Eclipses of HD114762 by a Low-Mass Companion" (E. L. Robinson, A. L. Cochran, W. D. Cochran, A. W. Shafter, and E. H. Zhang) *Astron. J.* **99**, 672-674, 1990.
2. "High Precision Measurement of Stellar Radial Velocity Variations" (W. D. Cochran and A. P. Hatzes) in *Optical Spectroscopic Instrumentation and Techniques for the 1990s: Applications in Astronomy, Chemistry and Physics*, B. J. McNamara and J. M. Lerner Eds. *Proc. SPIE* **1318** 148-157, 1990.
3. "Gravitational Instabilities in a Protoplanetary Disk" (H.-R. Noh, E. T. Vishniac, and W. D. Cochran) *Ap. J.* submitted, 1991.
4. "Constraints on the Companion Object to HD114762" (W. D. Cochran, A. P. Hatzes, and T. Hancock) *Ap. J. (Letters)* submitted, 1991.
5. "Radial Velocity Variations of K Giants" (W. D. Cochran and A. P. Hatzes) *Bull. Amer. Astron. Soc.* **21**, 1114, 1989.
6. "The McDonald Observatory Planetary Search" (W. D. Cochran and A. P. Hatzes) *Bull. Amer. Astron. Soc.* **22**, 1082, 1990.