A SEARCH FOR PLANETARY-MASS COMPANIONS TO NEARBY STARS

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ABSTRACT. Nine of 18 stars observed with a high precision radial velocity technique show long term, low level variations which imply the presence of companions in the range of 1 to 10 Jupiter masses. These companions could represent the tip of the planetary-mass spectrum.

1. INTRODUCTION

High precision radial velocities have been measured for a sample of solar-type stars at the Canada-France-Hawaii telescope since 1981. Precise velocities are obtained by using an absorption cell containing HF gas to impose reference absorption lines on the stellar spectrum. This eliminates the systematic errors which limit the precision of conventional velocity measurements. Random errors are minimized by obtaining very high signal-to-noise ratio spectra, typically 1000:1. Details of this technique may be found in Campbell et al. (1986) and Campbell, Walker, and Yang (1988; hereafter Paper I).

2. ANALYSIS OF THE RADIAL VELOCITIES

To assess whether there are significant long-term trends present in the velocities, we fit the data for each star with alternately a straight line, and a parabola. This yields the first and second derivatives of the velocities, as well as the formal 1 sigma uncertainties in each of these quantities. We conclude that a significant velocity variation is present if either the slope or curvature differ from zero at more than the 3 sigma level.

Of 17 stars analyzed by this procedure, 8 are significant velocity variables. The slope or curvature significance values are shown for these stars in Table 1. We attribute these low level velocity variations to the presence of low mass companions.

The eighteenth star in our sample, which cannot be analyzed in the same way, is γ Cep. This star shows an obvious change in velocity over the past seven years of about 2000 m s^{-1}, probably due to a stellar

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companion. However, on top of this gross trend there is a small, oscillatory variation. A simultaneous fit of a parabola and a sine-wave to the data yields a best-fitting sine-wave of period 3.1 years, and amplitude 22.5 m s^{-1}. We ascribe this variation to a third body in the system.

TABLE 1. Velocity variables

Star	Significance (sigmas)	M_c sin i (Jupiters) Lower Lim.	Upper Lim.
ε Eri	4.5	1.0	4.5
36 UMa	4.8	1.6	12.7
β Vir	3.3	0.9	9.6
β Com	3.6	1.0	9.0
61 Vir	3.8	0.8	7.2
β Aql A	4.1	1.0	12.7
η Cep	3.0	1.1	19.4
61 Cyg A	3.0	0.7	4.0
γ Cep	M_c sin i = 1.6 Jupiters		

3. LIMITS TO COMPANION MASSES

Even though we do not know orbital periods in most cases, it is possible to place upper limits on the masses of companions by combining our radial velocity results with astrometric information. Most of our program stars have been observed astrometrically, and none shows a convincing perturbation. Combining this with limits to the velocity variations (see Paper I for details) yields the upper limits to the companion masses shown in Table 1. These show a large range because they depend on the parallax, but average around 10 Jupiter masses.

Lower limits to the companion masses can be derived from the observed range in velocities. The lower limits are all about 1 Jupiter mass. For γ Cep, the third body has M_c sin i of 1.6 Jupiter masses.

In summary, nine of 18 stars observed show significant low level velocity variations which imply companions of 1 to 10 Jupiter masses. Companions in the traditional brown dwarf range of 10 to 80 Jupiter masses are conspicuously absent, which implies that those we have detected could represent the tip of the planetary mass spectrum. If so, then $\gtrsim$50% of the stars in the Galaxy could have planetary companions.

REFERENCES

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