51 Pegasi and Tau Boötes: Planets or Pulsations?

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Abstract. Using data from the AFOE and simulations of pulsating stars, we are able to rule out pulsations as the cause of the radial velocity (RV) variations seen in τ Boo and conclude that it is unlikely that pulsations are the cause of RV variations seen in 51 Peg. Orbital companions are still the most probable causes of the RV variations observed in these systems.

1. Introduction

It has recently been suggested (Gray 1997) that the RV variations observed in the spectra of 51 Peg are the result of stellar pulsations as opposed to the reflex motion due to an orbital companion. We briefly discuss the results of a search for evidence of pulsations in the AFOE data for 51 Peg and τ Boo. A more detailed discussion of this work can be found in Brown et al. (1998A & B).

2. Observations and Simulations

Observations confirming the RV variation of 51 Peg and τ Boo have been made with the Advanced Fiber Optic Echelle² (AFOE; cf. Brown et al. 1994). The resolution of the AFOE is \( \frac{\Delta V}{V} \approx 50000 \), which is inadequate for measuring line bisectors as Gray did. Instead, we represent the absorption line profile as an expansion of Hermite polynomials. \( H_1 \) is absorbed into the line center position and \( H_2 \) is absorbed into the line width, leaving \( H_3 \) as the lowest order non-zero term in the expansion describing changes in the line shape.

To interpret observed line profiles in a quantitative fashion, and to relate the line bisector span and curvature observed by Gray to the Hermite coefficients

\[^1\text{http://www.astro.psu.edu/users/horner/}\]
\[^2\text{http://cfa-www.harvard.edu/afoe/}\]
determined in our observations, we must perform numerical simulations of the shape of the line profile during pulsation. These simulations were run for all values of $m$, inclinations of 15, 45, and 75 degrees, and for values of $k = 0$ and 100.

In Figure 1, filled circles are data points covering one cycle of the RV variation; open circles are the same data covering a wider phase range, plotted for clarity of the phase relations. In the case of 51 Peg, the solid curve is a least-squares fit to the observations with amplitude 0.147%. The other curves are the typical $h_3$ signals expected from pulsation models yielding a RV signal (dashed line) with $V_{dop} = 56$ m s$^{-1}$ and a line bisector curvature signal (dot-dashed line) of 45 m s$^{-1}$. For $\tau$ Boo, the least-squares fit has amplitude 0.270% and $V_{dop} = 468$ m s$^{-1}$. Since there is no bisector curvature information available for $\tau$ Boo, the corresponding (dot-dashed) curve is not shown.

3. Conclusions

Our results rule out the possibility of pulsations causing the RV variations seen in $\tau$ Boo, leaving an orbiting companion as the most plausible conclusion. While not conclusive, our results indicate that it is unlikely that pulsations are the cause of the RV variations seen in 51 Peg. We believe that an orbiting companion is still the most likely cause of the RV variations in 51 Peg, but further observations and analysis are required to definitively resolve this question.

References