TITLE
ASP Conference Series, Vol. **VOLUME***, **YEAR OF PUBLICATION**
NAMES OF EDITORS

Recent Results from the Wide Angle Search for Planets (WASP) Prototype

Stephen R. Kane[1], Keith Horne[1], Rachel A. Street[2], Don L. Pollacco[2], David James[3], Yiannis Tsapras[1], Andrew Collier Cameron[1]

[1] *School of Physics & Astronomy, University of St Andrews, North Haugh, St Andrews, Fife KY16 9SS, Scotland*
[2] *APS Division, School of Physics, Queen's University of Belfast, University Road, Belfast, BT7 1NN, Northern Ireland*
[3] *Laboratoire d'Astrophysique, Observatoire de Grenoble, BP 53, F-38041, Grenoble, Cedex 9, France*

Abstract. WASP0 is a prototype for what is intended to become a collection of WASPs whose primary aim is to detect transiting extrasolar planets across the face of their parent star. The WASP0 instrument is a wide-field (9-degree) 6.3 cm aperture F/2.8 Apogee 10 CCD camera (2Kx2K chip, 16-arcsec pixels). The camera is mounted piggy-back on a commercial 10-inch Meade telescope. We present some recent results from the WASP camera, including observations from La Palma of the known transiting planet around HD 209458 and preliminary analysis of other stars located in the same field. We also outline further problems which restrict the ability to achieve photon limited precision with a wide-field commercial CCD.

1. Introduction

Of the indirect methods, the use of transits is rapidly developing into a strong and viable means to detect extrasolar planets. A transit occurs when the apparent brightness of a star decreases temporarily due to an orbiting planet passing between the observer and the stellar disk. Since this can only be observed when the orbital plane is approximately aligned with the line of sight, this transit method favors large planets orbiting their parent stars at small orbital radii ("hot Jupiters"). Hence, a large sample of stars must be monitored in order to detect transiting planets.

In this report, we briefly describe the data reduction methods and initial results from WASP0, a prototype wide-angle CCD camera currently being used to search for transiting extrasolar planet signatures.

2. Overview of WASP

WASP0 is a prototype for what is intended to become a "swarm" of WASPs whose primary aim is to detect transiting extrasolar planets. The WASP0 instrument is a wide-field (9-degree) 6.3 cm aperture F/2.8 Nikon camera lens,

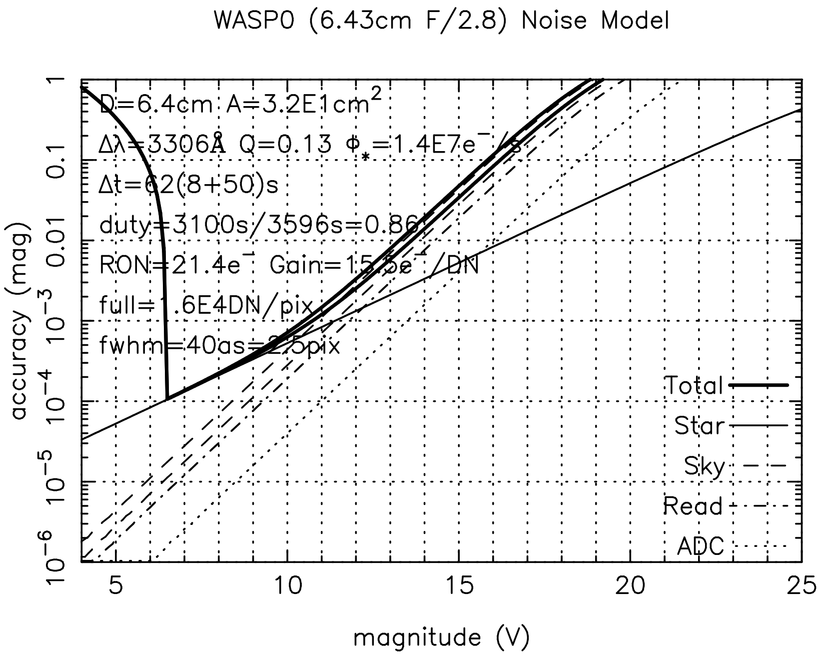

Figure 1. Noise model for the WASP0 camera.

Apogee 10 CCD detector (2Kx2K chip, 16-arcsec pixels) which was built by Don Pollaco at Queen's University, Belfast. The camera was mounted piggy-back on a commercial 8-inch Celestron telescope during its observing run at La Palma, Canary Islands from 20th June until 20th August, 2000. It is currently mounted on a 10-inch Meade at Kryoneri, Greece.

3. Observations and Data Reduction

In order to monitor a sufficient number of stars for a successful planetary transit detection, a wide field needs to be combined with reasonably crowded star fields. Field stars towards Draco were regularly monitored for two months during the observations from La Palma in 2000. More recent observations from Greece have targeted the Hyades open cluster. During the first two months of WASP0 observations, nearly 150 Gbytes of data were obtained.

The data reduction pipeline currently being developed to reduce this dataset uses a modified version of the photometry program DoPHOT (Schechter, Mateo, & Saha 1993). The positions of the stars on each frame are "fixed" using a template image which reduces the number of PSF fit parameters from 7 to 5, thus decreasing processing time and increasing the quality of the photometry.

A transiting planet with $R \sim R_J$ and $M_\star < M_\odot$ may cause a 1-10% decrease in brightness of the star. WASP0 aims to achieve milli-mag photometry to unambiguously detect such effects. Signal-to-noise calculations (see Figure 1) suggest that WASP0 will achieve 1% rms accuracy in 60 minutes for 13th-14th magnitude stars. This of course depends upon the sky background, particularly associated with moonlight.

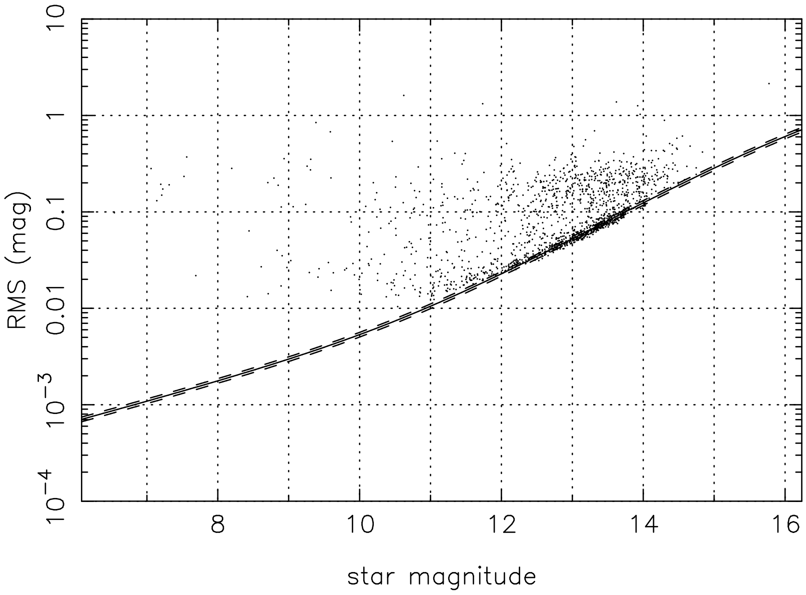

Figure 2. Photometric accuracy vs star magnitude for 1500 stars in comparison with theoretical accuracy predicted based on the CCD noise model.

4. Preliminary Results

Figure 2 shows an RMS vs mag diagram for a single night of WASP0 data. The solid line indicates the theoretical noise limit with the $\pm 1\sigma$ range being shown by the dashed lines either side. The diagram contains 1500 stars from a 500×500 sub-frame of 320 images with exposure times of 50 seconds. It can be seen that our present analysis of WASP0 images achieves the theoretical sky noise limited performance for differential photometry, reaching 1% rms accuracy at 11th magnitude.

A known transiting extrasolar planet around HD 209458 (Charbonneau et al. 2000; Henry et al. 2000) was observed using WASP0 at the predicted transit time of 8th August, 2000. The top-left panel of Figure 3 clearly shows the characteristic dip in the HD 209458 light curve due to the planetary transit. The WASP0 data also contains a large collection of variable star light curves. Shown in Figure 3 are three variables stars from the same data.

5. Further Calibrations

Cheap commercial CCD cameras may be used to detect extrasolar planetary transits as long as systematic errors are treated with care. By using thousands of light curves of constant stars available in the fields, the systematic errors may be pushed below a milli-magnitude.

The adequate addressing of wide-field issues such as position dependent airmass and vignetting is vital to achieve the required photometric precision. Many of these factors are yet to be dealt with in this data, including the con-

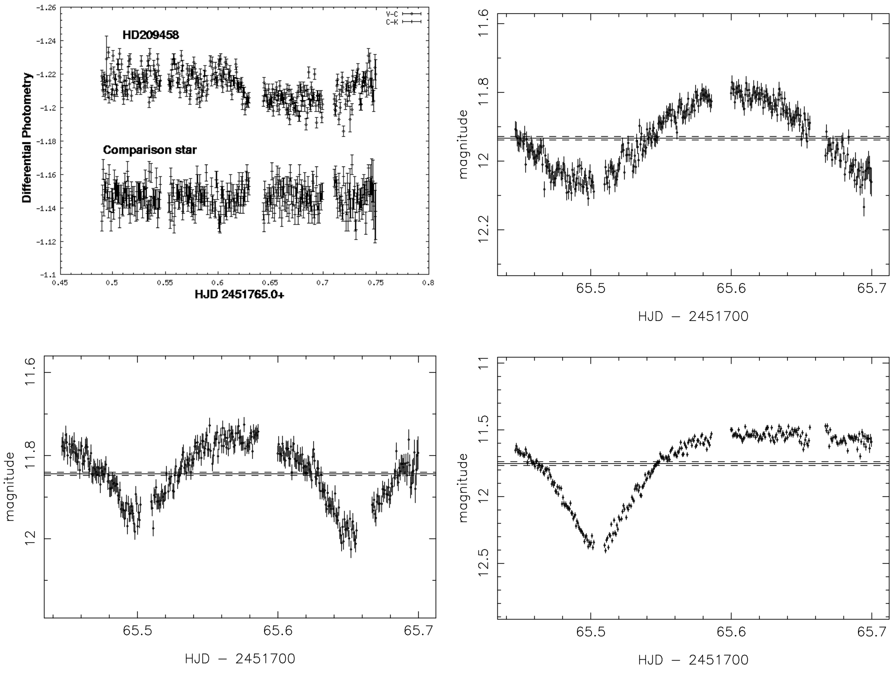

Figure 3. Transit of HD 209458 and comparison star (top-left) along with three variable stars from the the HD 209458 field.

struction of a PSF model which better matches the undersampled stellar profiles. Star images with 1.7-pixel FWHM appear 4% brighter when centred on a CCD pixel than when centred at the corner between 4 pixels. The inclusion of an astrometric fit to fix star positions and correct for field distortions is also being implemented.

6. Summary and Future Work

The preliminary analysis of WASP0 data presented here demonstrates that this instrument is able to achieve the necessary precision required to detect transit events due to extrasolar planets. Further calibrations and refinement of the PSF model are needed to determine if WASP0 is able to detect even smaller photometric deviations. This prototype has successfully served as a proof-of-concept for SuperWASP. Further details on the SuperWASP project are available in a separate paper by Street et al. (2002) in this volume.

References

Charbonneau, D., et al., 2000, ApJ, 529, L45

Henry, G.W., et al., 2000, ApJ, 529, L41

Schechter, P.L., Mateo, M., Saha, A., 1993, PASP, 105, 1342

Street, R.A., et al., 2003, these proceedings