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SuperWASP: Wide Angle Search for Planets

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Abstract.
SuperWASP is a fully robotic, ultra-wide angle survey for planetary transits. Currently under construction, it will consist of 5 cameras, each monitoring a $9.5^\circ \times 9.5^\circ$ field of view. The *Torus* mount and enclosure will be fully automated and linked to a built-in weather station. We aim to begin observations at the beginning of 2003.

1. Introduction

The observations of the planetary transits of HD 209458 by Charbonneau et al. (2000) and Henry et al. (2000) highlighted the role which can be played by small aperture/ultra-wide field surveys in detecting transits by hot Jupiter-type planets. These surveys have the great advantage of requiring only relatively inexpensive, off-the-shelf equipment, which is then dedicated to the project. The wide field of view allows many thousands of ∼7–13 mag stars to be photometrically monitored simultaneously. As radial velocity surveys indicate $\sim 1\%$ of these stars have hot Jupiters, we should, in theory, be able to discover statistically significant numbers of these planets within a reasonably short timescale. Such a sample is necessary to answer questions about the formation and evolution of these planets, and how it is related to factors such as stellar metallicity, age, type, etc. The magnitude range matches that of the radial velocity programs, allowing detailed follow-up observations.

The *SuperWASP* project has developed from our experience in building and operating the prototype *WASP0*. This instrument is the subject of separate papers by Kane et al. (this volume) and Street et al. (2000). Having proven that we can achieve the required high-precision photometry from this single, manually-operated camera, we are now building a fully robotic, multi-camera instrument supported by a custom-built mount. *SuperWASP*, which is primarily funded by Queen's University, will initially be able to monitor 5 separate fields simultaneously, with the potential for up to 10. This will provide precise photometry on ∼25,000 – 50,000 stars at a time, data which will form an important resource for bright star astronomy. With this in mind, we will be making use of the data to search for a number of phenomena, including Near Earth Asteroids and optical transients in addition to the primary goal of planet-hunting. Here we present our science goals followed by the equipment design, a discussion of the data we expect to gather and our plans for its analysis and dissemination.

2. Science Goals

2.1. Planetary Transits

From our *WASP0* dataset we estimate that *SuperWASP* will be able to monitor between 5,000 and 10,000 stars per $9.5^\circ \times 9.5^\circ$ field. We therefore expect to have simultaneous photometry for up to 50,000 stars. We plan to observe a set of 5 selected fields continuously for 1–2 months at a time before moving on to the next set. In order to estimate the expected yield of transit detections from this data, we turn to the radial velocity surveys which indicate that ∼1% of Solar neighbourhood stars harbour hot Jupiter companions. Geometric arguments show that ∼10% of these planets should transit their parent stars. Given the approximate numbers of stars within *SuperWASP*'s magnitude range (7–13 mag), we can estimate the expected number of planets detected per field. Table 1 compares the yield from *SuperWASP* to those from other similar projects, e.g. VULCAN (Borucki et al. 2001).

Table 1. The expected yield of transit detections depends on the number of stars monitored and hence the area of sky and the magnitude depth covered by the survey. *SuperWASP* will cover a $5 \times 9.5^\circ \times 9.5^\circ$ field of view with 5 cameras, while a number of similar projects cover fields of $\sim 6^\circ \times 6^\circ$.

Area	7 mag	8 mag	9 mag	10 mag	11 mag	12 mag	13 mag
All sky	0.5	2	8	32	128	512	2000
$5 \times 9.5^\circ \times 9.5^\circ$		0.02	0.1	0.4	1.5	6.1	24
$6^\circ \times 6^\circ$			0.01	0.04	0.15	0.6	2.4

SuperWASP is designed to operate continuously round the year. It will therefore be able to monitor a maximum of 6 sets of 5, $9.5^\circ \times 9.5^\circ$ fields per year; in reality this will be less due to poor weather, technical problems, etc. Table 1 indicates that we can expect over one hundred transit detections per year. This would enable us to rapidly provide a large sample of planets for further analysis.

Figure 1. (Left) The robotic *Torus* fork mount which can operate with upto 10 cameras. (Right) An example of a *SuperWASP* CCD camera plus associated electronics.

2.2. Near Earth Asteriods and Optical Transients

A dataset of continous, highly sampled photometry will be a extremely useful in a number of areas of astronomy beyond planetary detection. In particular, the dense sampling will enable us to detect and closely examine the lightcurves of a range of transient phenomena. Consequentially, our reduction procedures aim to measure all objects present in each frame. Near Earth Asteriods and optical transients are of special interest to our collaboration. We expect that *SuperWASP* will set constraints on the number of 10 – 100m asteroids in near-Earth space, and discover around $1/\Box^\circ$/year optical transient events, depending on γ-ray burst collimation models.

3. *SuperWASP*: The Design

Figure 1 shows the *Torus* fork mount on which will be mounted the 5 CCD cameras (as shown on the right). Each camera will consists of a 2048×2048 pixel thinned Marconi CCD and a Canon 200mm f/1.8 lens. This combination will give each camera a $9.5^\circ \times 9.5^\circ$ field of view while a pixel size of 13.5 μm means that the plate scale is expected to be 16.7 arcsec/pixel. The cameras will have an operating temperature of -60° C maintained by 3-stage Peltier cooling mechanisms. The readout time is expected to be 4s. Five cameras will be mounted such that each will be targeted individually, although the mounting is capable of supporting up to 10 such cameras. The *Torus* robotically-operated fork mount has a reported pointing error over the whole sky of 30 arcsec and a tracking error of less than 0.01 arcsec per second. A Global Positioning System receiver will give UTC with less than 1s error. The whole experiment will be housed inside an automated enclosure which will be linked to a weather station. The observatory will open robotically at dusk and observe pre-determined target fields until automatic closure at dawn or if bad weather intervenes.

4. *SuperWASP*: The Data

With the advent of *SuperWASP* and projects like it, we are entering the era of multi-terabyte astronomical datasets. From our *WASP0* experience, we expect to take exposures of $\sim$30s, each of which will be 8.4MB in size. With a 4s-readout speed and perhaps $\sim$ 8+ hours of observations per night, we expect to obtain at least $\sim$ 7 GB of data per camera, every clear night. With 5 cameras, the expected data rate will be $\leq$ 12.5 TB per year. To handle such a large dataset, the data will be compressed and written to DLT tape at the observatory. These DLTs will be collected about once a month and posted to Queen's University where backup copies will be made and distributed to collaborators. The reduction of the data will happen via an automated pipeline as soon as the data is obtained, in order to avoid the build-up of an insurmountable back-log. This reduction will provide a catalogue of photometric, positional and quality control data on every object detected in every frame. In this way, we will also be able to detect and monitor transient events in great detail. This catalogue will then be mined and analysed according to the aims of each project. We aim to make this catalogue publically available, probably via a web-based interface, as the data will provide an invaluable resource for a large number of projects.

5. Summary

We present our plans for a multi-camera, robotic search for planetary transits. *SuperWASP* will have a greater field of view than other similar projects, and a higher expected yield of planetary transits. It will provide a very large catalogue of densely sampled lightcurves of hundreds of thousands of stars which could result in more than 100 planets being detected per year. We aim to make this data publically available. *SuperWASP* is currently under construction, and is on schedule to begin observations from La Palma in early 2003.

References

Borucki, W. J. et a., 2001, PASP, 113, 439–451.

Charbonneau, D. et al., 2000, ApJ, 529, L45–L48.

Henry, G. W. et al., 2000, ApJ, 529, L41–L44.

Kane, S. et al, 2002, these proceedings.

R.A. Street et al., 2000, Disks, Planetesimals and Planets, ASP Conf. Series, 219,eds. F. Garzon, C. Eiroa, D. de Winter and T.J. Mahoney, p.621 - 625.