ASTEP South: An Antarctic Search for Transiting Planets around the celestial South pole

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Abstract : ASTEP South is the first phase of the ASTEP project that aims to determine the quality of Dome C as a site for future photometric searches for transiting exoplanets and discover extrasolar planets from the Concordia base in Antarctica. ASTEP South consists of a front-illuminated 4k x 4k CCD camera, a 10 cm refractor, and a simple mount in a thermalized enclosure. A double-glass window is used to reduce temperature variations and its accompanying turbulence on the optical path. The telescope is fixed and observes a 4° x 4° field centered on the celestial South pole. With this design, A STEP South should be very stable and observes with low and constant airmass, both being important issues for photometric precision. We present the project, the noise budget, an analysis of test observations around the celestial North pole done in Calern as well as first observations from Concordia.

1) ASTEP South : aim and setup

ASTEP South aims to detect transisting planets from Dome C, Antarctica. The 3 month continuous night as well as a very dry atmosphere should yield to an improvement of the photometric precision when compared to other sites. The instrument is completely fixed and points towards the celestial South pole continuously, so that stars turn around the CCD every ~24hours. The instrument was set up at the Concordia base in January-February 2008. ASTEP South is now observing and delivering its first data.

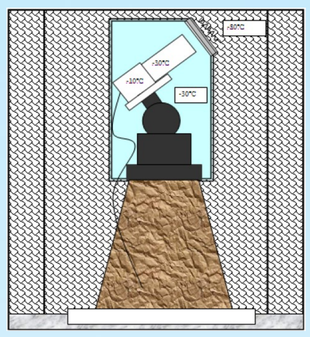

Fig. 1: ASTEP South at the Concordia base. The instrument is composed of a 10 cm refractor, a front-illuminated 4kx4k CCD camera, and a simple mount in a thermalized enclosure. A double glass window is used to reduce temperature variations and its accompanying turbulence on the optical path. The instrument is completely fixed.

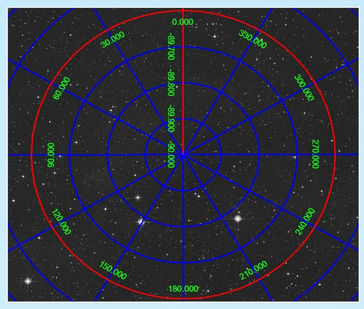

Fig. 2: ASTEP South points towards the celestial South pole during the 3 month-continuous night. The observed field is 3.88° x 3.88° and contains around 8000 stars up to Mv=15.

Fig. 3: First image from Dome C ! This 1000x1000 pixels image corresponds to the central part of the CCD. The exposure is 30 seconds and the brightest star in this zone is V=7.

2) Simple model

We perform an analytical model to evaluate the planet radius that can be detected with ASTEP South. Simulated field at the celestial South pole from the Besançon model are used. We consider that a planet is detected if the flux variation is at least 3 times the photon noise. From the star radius, we obtain the minimum planet radius that can be detected. As shown in fig. 4, in a 1°x1° field, a planet with a radius of 1.5 Rjup can be detected for roughly 500 stars. For our 3.8°x3.8°, this number grows to 7000 and implies that enough stars are present to allow the detection of one to a few transiting giant planets.

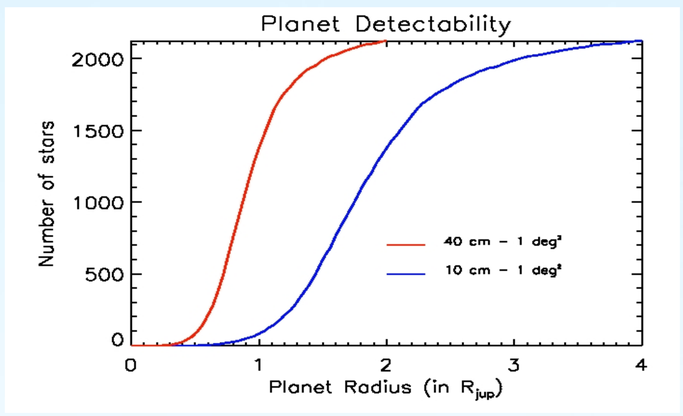

Fig. 4: Number of stars for which a planet equal to or larger than a given radius can be detected, for a 1°x1° field of view around the South Pole. The two curves are for a 10cm refractor (blue) and a 40cm telescope (red). For comparison, the number of F,G,K dwarfs per **transiting giant** planet is estimated to be about 1100 to 1 (Fressin et al. 2007).

3) Numerical study

Simphot is a photometric simulator that aims to reproduce each step of a survey, from the observation to the final lightcurves. The starting point is the flux from target and background stars. Atmospheric elements such a seeing variations and sky background are added. A CCD transmission matrix is then simulated as well as instrumental noise including jitter and Point Spread Function variations onto the CCD. Aperture photometry and comparison with a reference star are then performed on simulated images. Lightcurves and photometric precision for each target star are then obtained.

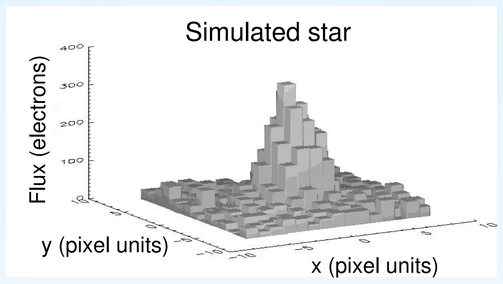

Fig. 5: Simulated magnitude 15 star for a 40cm telescope and a 30 seconds exposure. After passing trough the atmosphere and the instrument, the simulated signal is processed with aperture photometry.

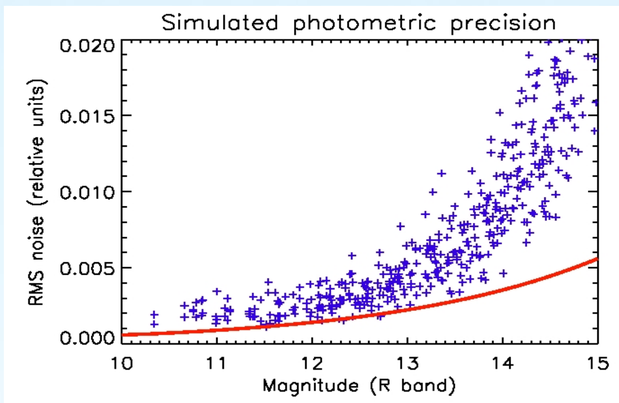

Fig. 6: Simulated rsm noise vs magnitude with Simphot using the ASTEP South parameters, for 450 target stars on the 1000x1000 pixels (1°x1°) central part of the CCD. A few mmag precision should be reached for stars brighter than magnitude 12, and the noise level is better than 10 mmag for stars of magnitude 14 or less. The red line shows the photon noise limit.

Conclusion : ASTEP South is the first transit survey from Dome C, Antarctica. The instrument inside its thermalized box is currently observing towards the celestial South pole. A simple analytical model shew that the observed field contains enough star to allow transit detection with our 10 cm refractor. Simulation made with Simphot show a rms noise close to the photon noise for stars of magnitude 12 or less, and a noise level better than 10 mmag for stars of magnitude 14 or less. This first campaign should allow us to test this new observing method, to qualify the Dome C for photometric precision and possibly to detect planets.

References:

- Crouzet et al., *Astron. Nachr.*, **328**, 2007
- Fressin et al. *EAS* **14**, 2005
- Fressin, Guillot, Morello & Pont, *A&A,* 2007