

Simulations for the Permanent All Sky Survey (PASS) Experiment

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Abstract. Simulations for PASS (Permanent All Sky Survey) are shown, which include the generation of artificial CCD images and photometric extraction of the stellar sources. First results indicate that PASS can obtain photometry with sufficient precision to pursue its principal goal, the detection of giant planet transits for all stars up to 11th mag.

1. The PASS experiment

PASS is intended to perform a permanent all-sky survey, for time-series photometry from *all* bright stars visible in one or more observing locations, with the major aim to detect all giant planets transiting bright stars, with sufficient coverage for periodicities up to several months. PASS would also obtain information on any other astronomical phenomena which display variability in time, therefore being potentially interesting to wide range of investigations. For more information on objectives of PASS, see Deeg (2002) and the PASS web-site¹. Physically, PASS would consist of 15 CCD cameras with short focal lengths, which image the entire sky that is visible from one (or more) observing locations. The CCD cameras would be mounted fixed, without any guiding. This way, excellent stability should be achieved, but stars will appear as traces in CCD images. Since there exists very little experience on the photometry of such stellar traces, simulations are being performed to evaluate the potential of PASS.

2. Simulations of PASS and first results

A software emulator for one camera of PASS has been created, which contains the following elements: simulations of the *CCD detector*, considering pixel-size and count, quantum efficiency including inter-pixel sensitivity variations (Kavaldjiev & Ninkov 1998), read-noise, digitalization noise, maximum well depth, and CCD read-time. The *optical system*, represented by $f=50\text{mm}$ lens with $f/1.2$ - $f/2.0$ apertures, projecting a *psf* of $24\ \mu\text{m}$ FWHM into the focal plane; *atmospheric*

¹<http://www.iac.es/proyect/pass/>

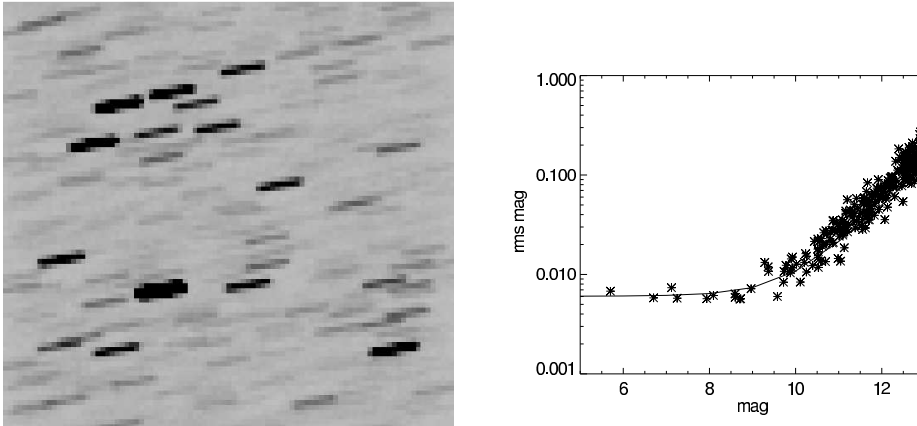


Figure 1. (left): Simulated PASS CCD image of a low latitude stellar field with an exposure time of 60s, and dark night conditions. The field size is about $2^\circ \times 2^\circ$, with visible stars ranging from 5-11 mag, though stars up to 15.5mag were included in the simulation. **Figure 2** (right): rms error in measured magnitudes from 10 simulations, as shown in Fig. 1. The solid line indicates the average expected rms, based on theoretical S/N calculations, for equal conditions than the simulated images.

effects given by scintillation, seeing, standard extinction, and sky brightness under varying lunar phases, and lastly, *astronomical sources*, which are stellar distributions at different declinations and densities corresponding to different galactic latitudes, including stars up to 15 mag to obtain realistic estimates for the confusion by background sources (Fig. 1). In order to evaluate if stellar brightnesses can be recovered from these images with sufficient precision, a program *tracephot* for trace-shaped aperture photometry was developed. Fig. 2 shows the rms errors from photometry on 10 simulated images, corresponding to data that are taken over 10 nights at the same sidereal time, when stars move over exactly the same CCD pixels. For the set-up used (60s exposure time, $f = 50\text{mm}/1.8$ lens, no moon, $\delta = 0^\circ$, 1.4 airmasses), scintillation dominates for $\text{mag} < 10$, and background photon noise for fainter stars. Stellar photon noise is relevant only for 9-11 mag. The recovered magnitudes up to 10th mag are precise within 1%, as is required for giant planet detection. Since all relevant noises diminish with $(\text{integration time})^{1/2}$, and brightness varies during transits on time-scales of 10 minutes, we expect limiting magnitudes beyond 11. A more detailed description of PASS, with further simulations under varying conditions will be the subject of a forthcoming publication.

References

- Deeg, H.J. 2002, in Proc. of the first Eddington Workshop "Stellar Structure and Habitable Planet Finding", eds. F. Favata et al., ESA publ. SP-485, 273
 Kavaldjiev, D. & Ninkov, Z. 1998, Opt. Eng. 37(3), 948