MIOSOTYS, a multi-object high-rate photometer designed for TNO serendipitous occultations

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Abstract

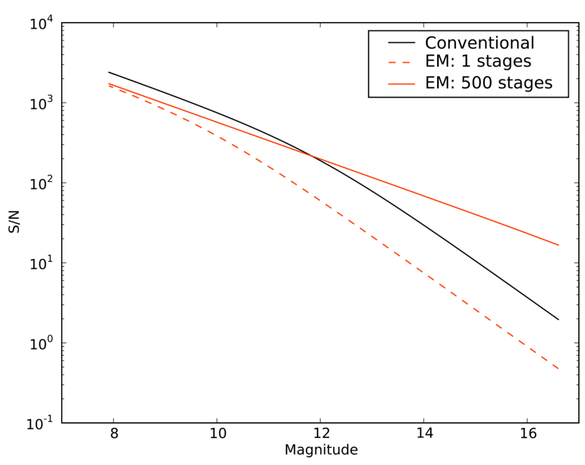
MIOSOTYS (Multi-object Instrument for Occultation in the SOlar system and TransitorY Systems) is a multiple-object, high-speed photometer primarily designed for the observation of serendipitous stellar occultations by small (100m) trans-neptunian objects. The instrument can also be used for other high time resolution astrophysics.

Instrument

MIOSOTYS is based on MEFOS (Meudon ESO Fibre Optical System) which is a multiple-fibre positioner first designed for multi-objects spectroscopy on the 3.6-m ESO telescope at La Silla, Chile in the 90s'. It remains in excellent shape and, recently, has been re-commisioned by LESIA, Paris Observatory to conduct high time resolution photometry. The instrument consists of a multi-objects fibre system and a high speed EMCCD camera. It has be implemented at the cassegrain focus of the 193 cm telescope at the Observatoire de Haute-Provence (OHP), France. The fibre positioner moves 29 arms to the targets within a field of view of 25 arc-minute. Each arm is equipped with an individual viewing system for accurate setting and carries one individual fibre that intercept 12 arc-sec on the sky. All the 29 fibre images are projected onto an EMCCD camera for fast photometry acquisition.

EMCCD Camera

We chose the ProEM™ camera manufactured by Princeton Instruments as the imaging sensor for the instrument. The sensor of e2v CCD201B is a back-illuminated, frame-transfer EMCCD with 1024X1024 image pixels (or active area 13.3X13.3 mm). The large image area can cover all of 29 fibre images. The peak Q.E. at 530 nm is 95%. The air cooling system maintains the operating temperature at -55ºC or lower. At the temperature the typical dark current is ~ 0.008 electron/pixel/second. The readout noise then depends on the readout modes: electron-multiplying or low-noise.



Comparison of CCD S/N to readout modes.

Conventional: traditional readout register.
EM: 1 stage: the readout goes through EM register, but no gain is applied, thereby readout noise is not suppressed, and its S/N is even worse.
EM: 500 stages: 500 stage gain is applied in the register. The S/N begins to improve as source becomes fainter.

The magnitude scale is based on an OHP observation.

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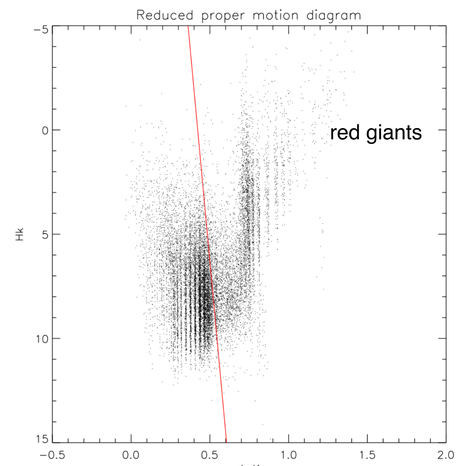
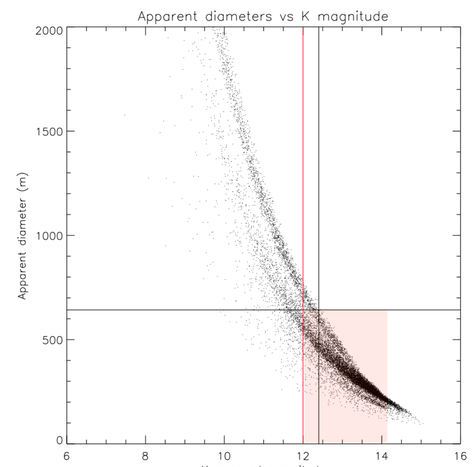
Trans-Neptunian Objects

Serendipitous stellar occultations by small TNOs requires right background stars to increase the probability of detection, namely stars on the ecliptic plane and located near the anti-solar direction. The star must have an apparent diameter, projected at the distance of the hypothetical TNO, smaller than the Fresnel scale **Fs**. In this case the event profile follows the Fresnel-Fraunhofer diffraction laws, and both distance and size of the responsible TNO can be retrieved with some analysis (Roques et al. 2000).

The selection of stars is based on several factors: such as distance, temperature, spectral class, interstellar extinction as well as a model of the galaxy (Robin et al. 2003). A combination of criteria on J, K and Hk (reduced proper motion), defined with the model, allows to ensure the selected stars in the NOMAD catalog have a certain maximum apparent diameter.



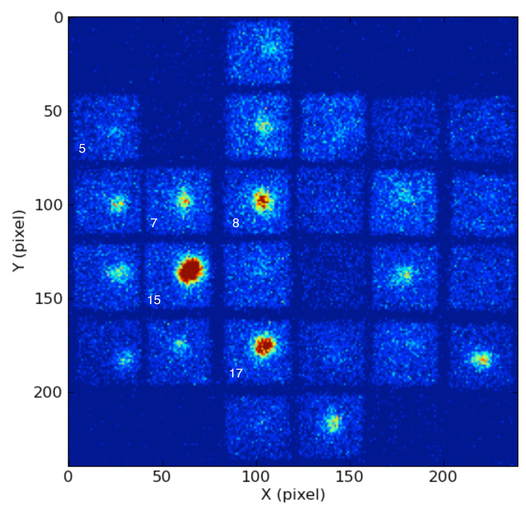
Reduced proper motion diagram. The red line separates red giants which have mostly too big apparent diameters. This is also used to estimate the interstellar extinction.



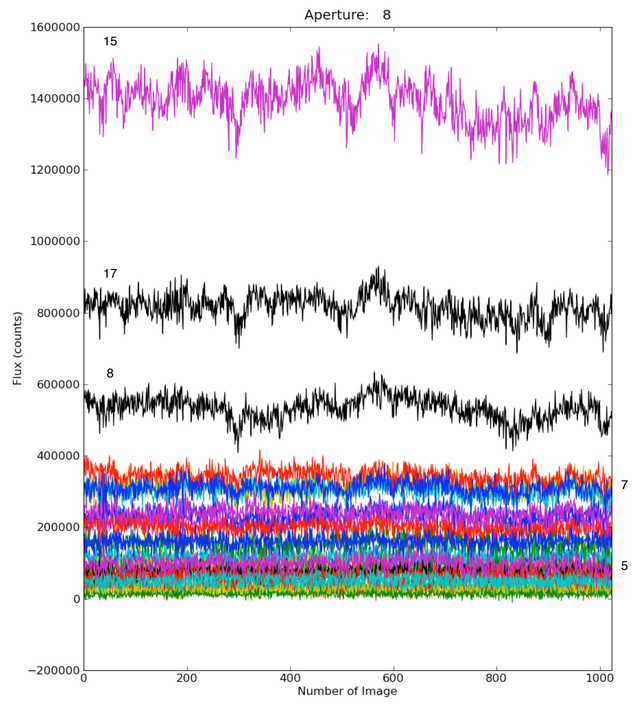
Change in apparent diameter with K band. The black line shows the K magnitude limit over which the stars are small enough for our search. The red line brings this limit down by 0.5-1 mag. The red area indicates the stars whose conditions are suitable for MIOSOTYS.

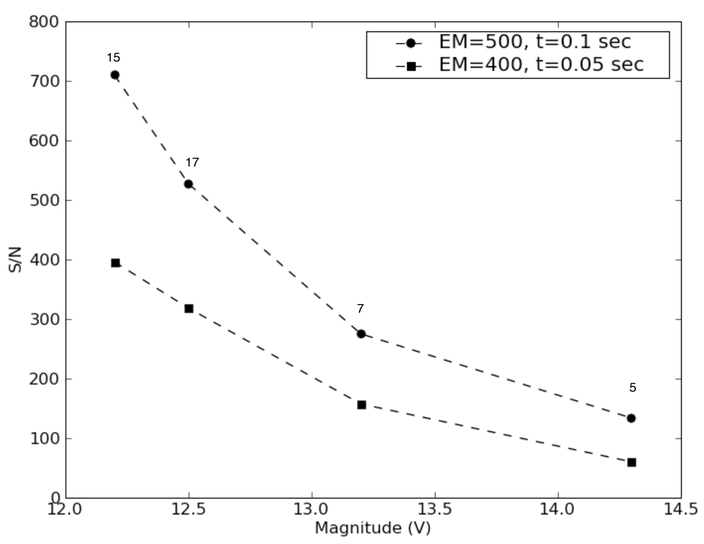
First Light Result

In March 2010 MIOSOTYS had its first light observing a TNO field. 26 of 29 fibres were used.



R.A. (centre)	07:10:15.3
Dec. (centre)	+22:44:12.8
Exposure time	0.1 sec
EM gain stage	500
V Magnitude (NOMAD)	12.2 - 14.5





Comparison of S/N to different configurations of EM gain and exposure time. The results were derived from the same group of stars and the same fibres were used. The magnitudes are quoted from the NOMAD catalogue. Observation date: (circle) 01 March 2010; (square) 28 Februarv 2010.