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Mining the Kilo-Degree Survey for Solar System Objects

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The search for minor bodies in the Solar System promises insights into the history of our Solar System. Wide imaging surveys offer the opportunity to serendipitously discover and identify these traces of planetary formation and evolution [1].

We present a method to acquire position, photometry, and proper motion measurements in surveys using dithered image sequences, as described in [2]. The application of this method on the Kilo-Degree Survey to search for Solar System objects is demonstrated.

Optical images of 346 square degree fields of the sky are searched in up to four filters using the Astr*O*matic software suite to reduce the pixel to catalogue data. The Solar System objects within the acquired sources are selected based on a set of criteria based on their motion and size. A cross-match with known SSOs is performed with the Virtual Observatory SkyBoT tool.

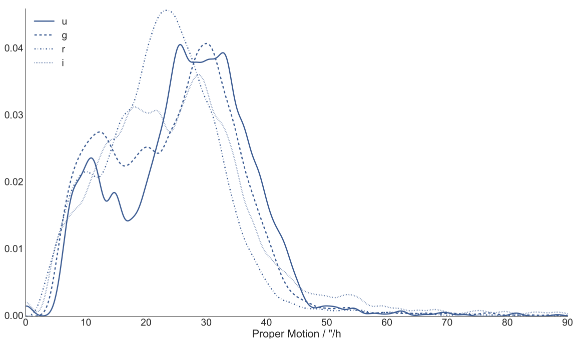

Fig 1: Normalized proper motion distribution of the recovered Solar System objects in the different bands they were observed in.

We observed 28.290 SSO candidates, with an estimated false-positive content of 7%. The proper motion distribution of the recovered SSOs is shown in Fig.1, split up into the bands the candidates were observed in. 47.2% of these SSOs are cross-matched with a known SSO by SkyBoT.

KiDS can detect previously unknown SSOs because of its depth and coverage at high ecliptic latitude, including parts of the Southern Hemisphere. Thus we expect the large fraction of the 52.8% of unidentified objects to be truly new SSOs. A comparison of the number of SSOs per degree of ecliptic latitude recovered in KiDS and given by SkyBoT is shown in Fig. 2.

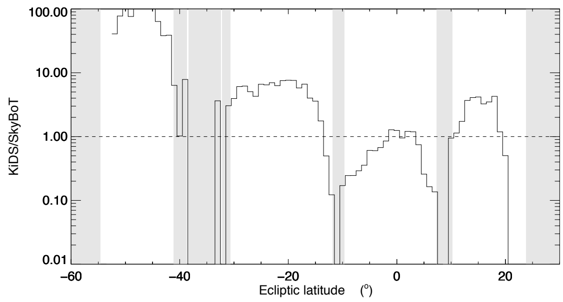

Fig 2: The ratio of number of SSOs per ecliptic latitude per square degree for KiDS and for known SSOs. The black dashed line marks the ratio equal to one. The observed areas in the sky span from −51.6° to 20.6° ecliptic latitude. Grey shaded areas mark ecliptic latitudes which were not covered by the survey. The KiDS sample has a much higher content of SSOs per square degree at high inclinations than the known SSOs in the SkyBot database.

Using the cross-match with SkyBoT, we determine the distribution of the known SSOs in our sample across different SSO populations, shown in Tab. 1.

MBA	JTA	MC	NEO	KBO	Cen	Com
13.034	177	98	18	4	2	2

Table 1: The distribution of identified SSOs in our sample over different SSO populations. Most identified SSOs are main-belt asteroids (MBAs), the remaining objects are made up of Jupiter's Trojan asteroids (JTAs), Mars-crosser (MCs), near-Earth objects (NEOs), Kuiper-belt objects (KBOs), Centaurs (Cen), and Comets (Com).

Our method is applicable to a variety of dithered surveys such as DES, LSST, and Euclid. It offers a quick and easy to implement search for Solar System objects. SkyBoT can then be used to estimate the completeness of the recovered sample.

[1] Popescu. M et al., (2016). Near-infrared colors of minor planets recovered from VISTA-VHS survey (MOVIS). A&A, 591:A115.

[2] Bouy, H. et al., (2013). Dynamical analysis of nearby clusters. Automated astrometry from the ground: precision proper motions over a wide field. A&A, 554:A101.