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The SkyMapper Southern Survey and its calibration

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Abstract. I discuss the photometric calibration of the SkyMapper Southern Survey, our adopted methods and what we learned from comparisons with external catalogues.

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SkyMapper observes the whole Southern hemisphere in approx. 4,000 overlapping tiles with a field-of-view of 5.7°. It spans a dynamic range of 13 mag by combining shallow exposures with a deeper Main Survey. Data Release 1 is based on the Shallow Survey and world-accessible since Dec 2017 (Wolf *et al.* 2018, PASA 35, 10). Its six passbands are similar to SDSS filters except that the SDSS u band is split into two SkyMapper filters, an u(ultraviolet) and a v(iolet) band. Science goals include searching for extremely metal-poor stars and luminous high-redshift QSOs, to provide colour maps of nearby Southern galaxies, serve as a parent sample for the spectroscopic Taipan Galaxy Survey and as an optical complement to the radio surveys of the Australian SKA Pathfinders.

Photometric calibration can be done in three ways: (i) using airmass regression, but SkyMapper has a modest fraction of photometric nights, (ii) via frame overlaps, which require sufficient survey completion, and (iii) via external authority, which we adopted for now. A few challenges remain: (i) we are at the mercy of the external authority's own reliability, (ii) our exposures which can be as short as 5 sec freeze weather-related atmospheric throughput patterns across the wide field, and (iii) external all-sky catalogues currently don't cover the uv filter range, forcing us to extrapolate the calibration. Extrapolation from gri to uv depends on stellar metallicity, which has gradients across the sky; and on dust reddening, which is known for the integrated column along the line-of-sight to a calibrator star, but not for the star itself given its limited distance.

For DR1 we used 2MASS and APASS DR9; the latter has discontinuities across the sky, with residuals reaching over 0.3 mag. Given the exact APASS bandpasses are unknown, we fit an empirical transformation from APASS gri to Pan-STARRS1 gri and then apply a second transformation from PS1 to SkyMapper $uvgriz$ using the Pickles (1998, PASP 110, 863) spectral atlas. Calibrator stars are restricted to a colour range where transformations are close to linear. Calibration residuals between SkyMapper $griz$ and PS1 $griz$ have an rms scatter of 2%, but can be off by up to 10% in fat tails. For DR2 we replace APASS by Gaia DR2 (2018) and thus inherit its all-sky homogeneity.

Still, reddening at very low levels is not described with a precision of 1% yet, and at higher levels bandpass extrapolation still causes offsets. For DR2, Gaia allows us to restrict calibrator stars to a distance of less than 1 kpc and limit the amount of reddening.

Comparing Gaia DR2 and PS1 while creating the ATLAS Reference Catalog (Tonry *et al.* 2018, ApJ, in press), we find offsets of up to 10%, which can be modelled as a strong function of local star density and thus be suppressed to below 1%.