APOP - Absolute Proper motions Outside the Plane

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Abstract

The astrometric calibration and removal of systematic errors for absolute proper motions (μ_α, μ_δ) from Digitized Sky Survey Schmidt plates is presented. This version is based on plate data outside the galactic plane, i.e. $|b| \geq 27^o$. The systematic errors of absolute proper motions related to the plate position, magnitude and color are removed using reductions with both stars and galaxies. The resulting zero point error is less than 0.6 mas/yr, and the precision better than 5.0 mas/yr for objects brighter than R_F = 19.0, rising to 10.0 mas/yr for objects with magnitude $19.0 < R_F < 20.0$. We present a proper motion catalogue with sky coverage of 22,525 square degrees, the total number of objects is 100,777,385 and the magnitude limit is $R_F \sim 20.8$. This catalogue is a step towards the production of proper motions for the Guide Star Catalog and the procedures will be useful in other reductions to dispel astrometric magnitude- and color-dependent systematic errors.

Data

The observational data come from the STScI Catalogue of Objects and Measured Parameters from All-Sky Surveys (COMPASS), containing the measured astrometric, photometric and geometric parameters for all detections on the digitized scans of 7000+ all-sky survey Schmidt photographic plates used to build the Guide Star catalogues and the Digitized Sky Survey. The derived absolute proper motions rely on a novel calibration method which iteratively uses the stellar and galaxy images on each plate in order to eliminate all the systematic errors in the rectification of the plates.

Construction of APOP

Under the hypothesis that objects (stars and galaxies) physically close on a photographic plate and with similar magnitudes/colors have similar systematic errors, and that the absolute proper motions of galaxies are always zero, i.e. not dependent on their plate position, magnitude or color, we can rely on the galaxies present on each plate for the calibration of magnitude- and color- dependent errors (MdE and CdE, respectively) in the plate-to-plate transformation. n synthesis, the principal calibration steps are:

1. Removing the position-dependent systematic errors (PdE) with a moving-mean filter using stellar objects with good image quality;
2. Selecting galaxies from non-point-like sources (non-stars) via their common null-motion characteristics;
3. Calibrating the MdE and CdE and the residual PdE of all objects with reference to the galaxies;
4. Calculating the absolute proper motions from all-epoch plate data.

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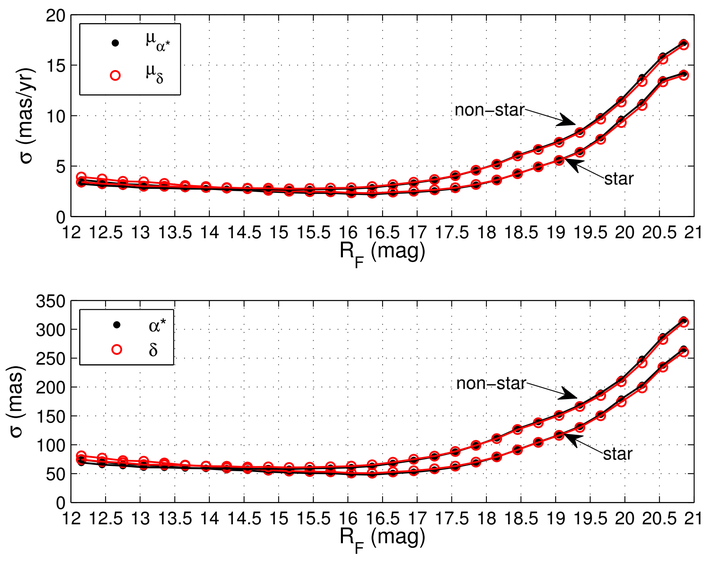
Internal accuracy

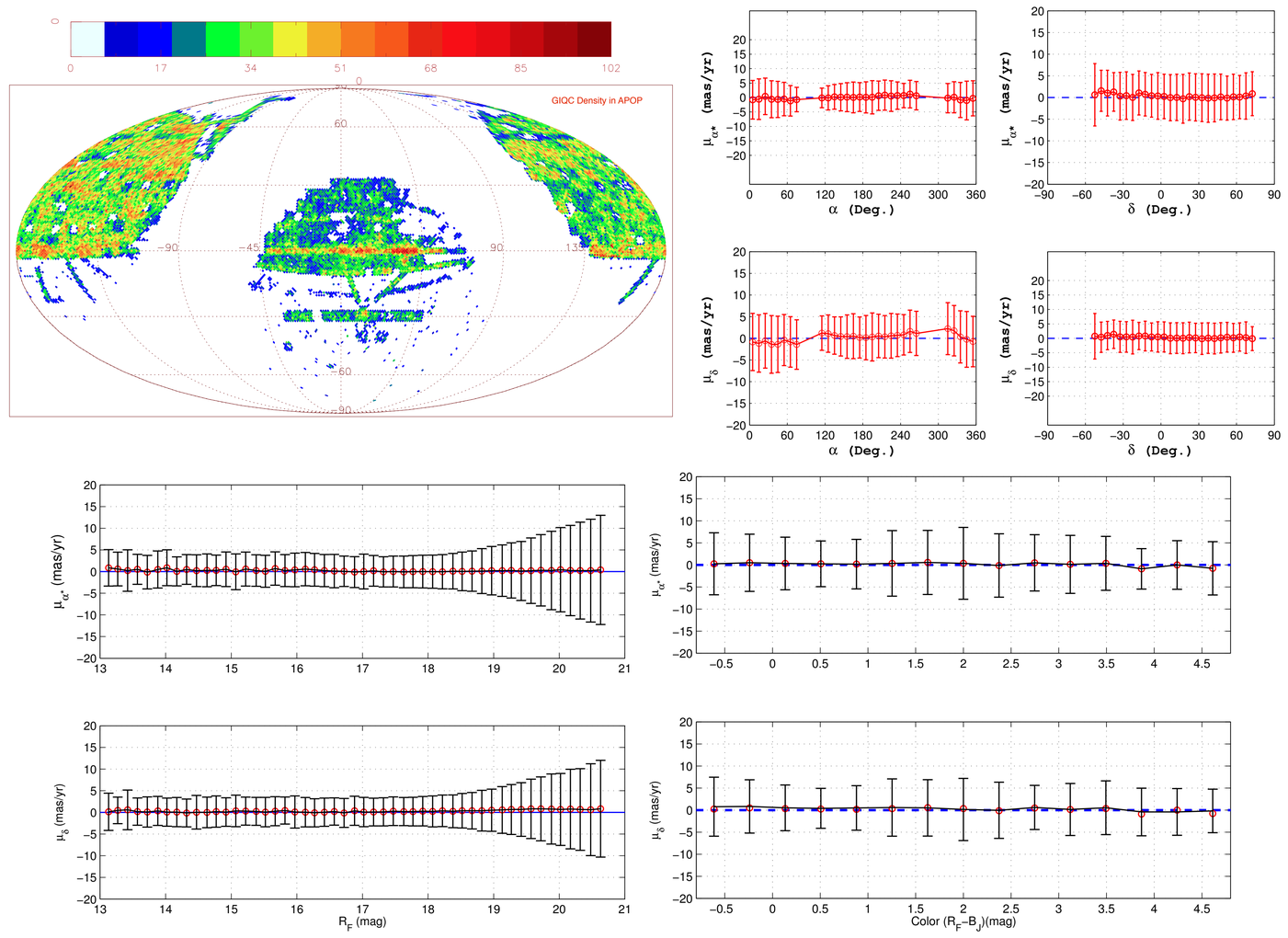
For each object, we could obtain the calibrated absolute proper motions and positions by fitting a equation with all its measures in different epochs. Meanwhile, we could also get the median standard errors of the calibrated parameters ($\mu_{\alpha*}$, μ_δ, α, δ), which could be as an internal check of the qualities of the catalogue APOP.



This figure shows the mean formal errors of the absolute proper motions ($\mu_{\alpha*}$,μ_δ) and positions (α,δ) of stars and non-stars as a function of R_F magnitude in catalogue APOP. The magnitude bin for this statistics is 0.3 mag, which make sure there are at lest 100,000 objects in each bin. The marker $*$ followed the μ_α and α means projecting them onto the the great circle direction (i.e times the cos δ). Top panel: the formal errors of absolute proper motions, the unit is milli-arcsec per year; bottom panel: the formal errors of positions, the unit is milli-arcsec.

External accuracy

Quasi-stellar objects (QSOs) have stellar-like images and since they are extragalactic, their proper motions could be considered as zero. Thus the dispersions of their measured proper motion will be a very good measure of the zero point and overall accuracy of absolute proper motions of the stellar objects. Here we use them as an independent and direct determination of the quality of this APOP catalogue. The Gaia Initial QSO Catalogue (GIQC) (Andrei et al. 2009) is chosen as the source list for known QSOs. The objects are broadly distributed within the SDSS region, though their density is not uniform.



The **top-left** panel shows the distribution of 376,490 QSOs found in the APOP . The rest panels show the systemic and random values of absolute proper motions ($\mu_{\alpha*}$, μ_δ) of QSOs as a function of their α and δ, magnitude, color. The dashed line indicates zero absolute proper motion. The circles indicate the mean of $\mu_{\alpha*}$,μ_δ in that bin and the error-bar shows their standard deviation, which following the assumption that QSOs should have zero proper motions are indicative of the proper motion random errors.

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