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Proper Motions from Schmidt Plate Scans at STScI

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Abstract. We describe a program of determining proper motions from digitized scans of Palomar Oschin Schmidt telescope plates at the Space Telescope Science Institute. Our method is most useful over $11 \lesssim V \lesssim 18$ and $0\farcs05/\mathrm{yr} \leq \mu \leq 0\farcs25/\mathrm{yr}$.

Introduction: Scans and Extractions

Using two PDS 2020G microdensitometers, scanning of the early 1950's–epoch POSS E plates north of $\delta = -18°$ was completed at the Space Telescope Science Institute about three years ago. The scan lines were separated by 25 μm so that 1 'pixel' = $1\farcs68$. These scans, together with those done of the Palomar Oschin Schmidt 'Quick V' plates taken for the HST Guide Star Catalogue (Lasker et al. 1990), give a baseline of about 30 years which makes it reasonable to consider using them for determination of proper motions. Indeed, the identity of the faint carbon star CLS 96 (Sanduleak & Pesch 1988) with the proper motion star LP 328–57 was made by comparing plots from the scans thus confirming it as the second dwarf carbon star (Green et al. 1991). It was that finding which gave rise to the current program.

Extractions from the scan database are typically done over small regions, no larger than $14'$ on a side, so that distortions are minimized, and we find that quadratic terms are sufficient to match images to the arcsec level. We run an in–house program which does an inventory of each extracted field and the output of which is a file containing positions in linear units and equatorial coordinates, rough magnitudes, and a star/non–star classification for each object. Images classified as stars in both frames are matched using a nearest–neighbour algorithm in both 'directions' eliminating those with residuals $\geq 2.25\sigma$ as potential proper motion stars but retaining in the solution those with $\mu \leq 0\farcs035/\mathrm{yr}$. A typical number of remaining reference stars is 25 to 30. After the matches are made and accepted, we compute a solution for an affine transformation from one frame to the other using the least-squares, singular value decomposition routines in Press et al. (1992). With our material, we have the most confidence in results for $11 \lesssim V \lesssim 18$ and $0\farcs05/\mathrm{yr} \leq \mu \leq 0\farcs25/\mathrm{yr}$. We work in either of two ways which we call the Selected–Target and Survey Modes.

Selected–Target Mode

In this mode, the position of a specific star is centered in the extraction 'window' for each epoch so the motion of that star may be determined. We have been obtaining proper motions of

- candidate nearby stars for H. Jahreiß verifying some having motions up to $0\farcs3$/yr which are not in the Luyten or Giclas catalogues
- hot DAs from the Palomar–Green survey for J. Liebert
- sdO stars in the P–G survey for R. Saffer
- faint, high–latitude carbon stars
- low–mass, post–AGB stars for M. Parthasarathy
- other collaborations are pending.

Survey Mode

We have also carried out a search over the full 6–degree field of POSS area 321 near the NGP using a 50% overlapping sub–plate technique. Our epoch difference is 31.92 yr compared with Luyten's 17.04 yr for neighboring area 322 and 12.98 yr for area 478 (Luyten 1973). The method is vulnerable to cosmetic defects, especially for faint objects, and the star/non–star classifier.

Of 123 Luyten p.m. stars in the common area, we find 44 certain and 2 possible correspondences; the faintest Luyten R mag of these is 19.8. Of 77 Luyten stars not found, 24 are too faint [$R(\mathrm{Luy}) \geq 19.9$] to appear on the 'Quick V' plate and two are too bright (8th mag). Of the 51 remaining, 34 have $\mu \lesssim 0\farcs06$/yr i.e. maybe too small for us. Of the remaining 17, six are near our faint or bright limit. The largest undetected Luyten p.m. is $0\farcs18$/yr for an $R = 18.9$ star. This and other cases of missing, known p.m. stars may be due to the star/non–star classifier being too conservative and hence eliminating real stars from one or both frames.

Our experience shows that one must be careful about claiming large numbers of stars having $\mu > 0\farcs2$/yr which are not in the NLTT. We find many spurious cases due to stellar variablility, plate defects, etc. Such a case is illustrated in Fig. 1 which is a computer plot showing the stars matched in the field of PG 2129+150; the target star, below the 't' in the figure, shows no motion, but two others, separated by about $9'$, seem to be a common proper motion pair with $\mu \simeq 0\farcs35$/yr at $\theta \simeq 156°$. However, upon inspecting the actual photograph, Fig. 2, we see that two stars of the right separation and position angle are present at each position. For these spurious motions to be computed, it must be the case that the star/non–star algorithm classified the northern member of each pair as a star and the southern members as non–stars in the early–epoch plate output file and reversed the classifications for the late–epoch plate file.

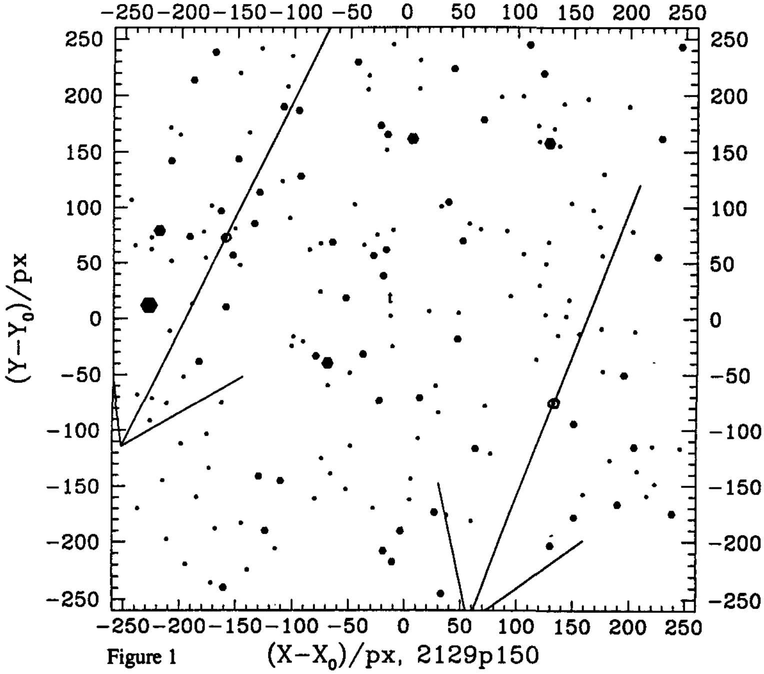

Figure 1

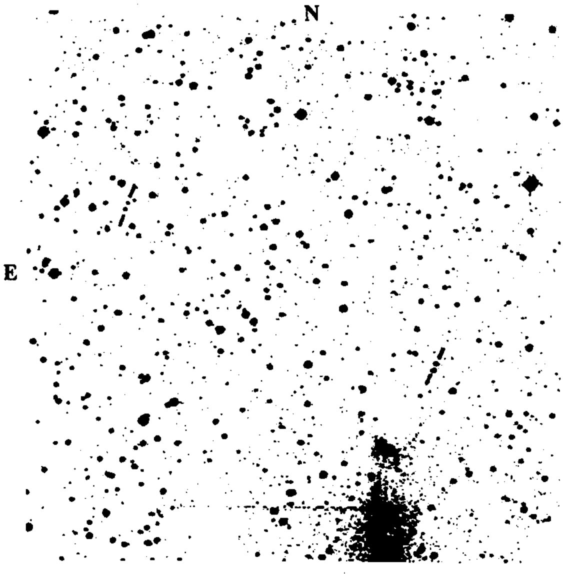

Figure 2

Comparison with "Standard Motions"

We compared our motions with those of 22 stars from Lists VII, VIII, and IX of the U.S. Naval Observatory Parallaxes of Faint Stars (Harrington et al. 1985, 1993, Dahn et al. 1988); V mags ranged from 9.8 to 16.5 and proper motions from $0\farcs0184$/yr to $0\farcs1727$/yr. We included four stars with USNO motions below $0\farcs03$/yr to check our detection limit; we find no motion for three and $0\farcs061$/yr for the fourth. The mean residuals on 18 stars in the sample are $0\farcs0107$/yr and $4\fdg06$.

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