Proper Motions from Schmidt Plate Scans at STScI

D. Jack MacConnell
Astronomy Programs, Computer Sciences Corporation,
Space Telescope Science Institute

Wm. James Roberts

Ramon L. Williamson II
Space Telescope Science Institute

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 $11 \leq V \leq 18$
and $0.05/\text{yr} \leq \mu \leq 0.25/\text{yr}$.

Introduction: Scans and Extractions

Using two PDS 2020G microdensitometers, scanning of the early 1950's–epoch
POSS E plates north of $\delta = -18^\circ$ was completed at the Space Telescope Science
Institute about three years ago. The scan lines were separated by 25 $\mu$m so that
1 'pixel' = 1'68. 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 algo-
rum in both 'directions' eliminating those with residuals $\geq 2.25\sigma$ as potential
proper motion stars but retaining in the solution those with $\mu \leq 0.035/\text{yr}$. 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 \(11 \leq V \leq 18\) and \(0''05/\text{yr} \leq \mu \leq 0''25/\text{yr}\). 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. Jahreiβ verifying some having motions up to \(0''3/\text{yr}\) 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 \([R(\text{Luy}) \geq 19.9]\) to appear on the ‘Quick V’ plate and two are too bright (8th mag). Of the 51 remaining, 34 have \(\mu \lesssim 0''06/\text{yr}\) 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 \(0''18/\text{yr}\) 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 \(\mu > 0''2/\text{yr}\) which are not in the NTT. We find many spurious cases due to stellar variability, 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 \(\mu \approx 0''35/\text{yr}\) at \(\theta \approx 156^\circ\). 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.
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"0184/yr to 0"1727/yr. We included four stars with USNO motions below 0"03/yr to check our detection limit; we find no motion for three and 0"061/yr for the fourth. The mean residuals on 18 stars in the sample are 0"0107/yr and 4"06.

Acknowledgements

We are pleased to acknowledge the support of the Space Telescope Science Institute and its Catalogues and Surveys Branch, and particularly, of Barry Lasker and Brian McLean.

References

Luyten W.J., 1973, Proper Motion Survey with the 48-inch Schmidt Telescope, No. XXXV, (Univ. of Minnesota: Minneapolis)