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A Technique for Determining Proper Motions from Schmidt Plate Scans at ST ScI

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Abstract. In this paper we describe a program of determining proper motions from digitized scans of 1950's-era Palomar Sky Survey (POSS) Schmidt Plates and 1980's-era Palomar Oschin Schmidt 'Quick V' plates that were taken for the *Hubble Space Telescope* (*HST*) Guide Star Catalogue.

1. Introduction

Using two PDS 2020G microdensitometers, scanning the early 1950's-epoch POSS E plates north of $\delta = -18°$ was completed at the Space Telescope Science Institute about three years ago. These scans, together with scans of the Palomar Oschin Schmidt "Quick V" plates taken for the *HST* Guide Star Catalogue provided a baseline of about 30 years from which proper motions may be determined.

2. The Method

Extractions from the scan database are typically done over small regions, no larger than $14'$ on a side, so that distortions are minimized. An in-house software program generates an inventory of all of the objects in an extracted field for each epoch, and outputs a file that contains positions (in both linear units and equatorial coordinates), rough magnitudes, and a "star" or "non-star" classification for each object. Objects that are classified as stars in both frames are matched using a nearest-neighbor algorithm in both spatial directions. The program eliminates those with residuals $\geq 2.25\sigma$ as potential proper motion stars, but retains in the solution those with proper motions, μ, not exceeding $0\farcs035\,\mathrm{yr}^{-1}$. The number of reference stars remaining is typically 25 to 30. After matches are made and accepted, we then determine a solution for an affine transformation from one frame to the other using the least-squares, singular

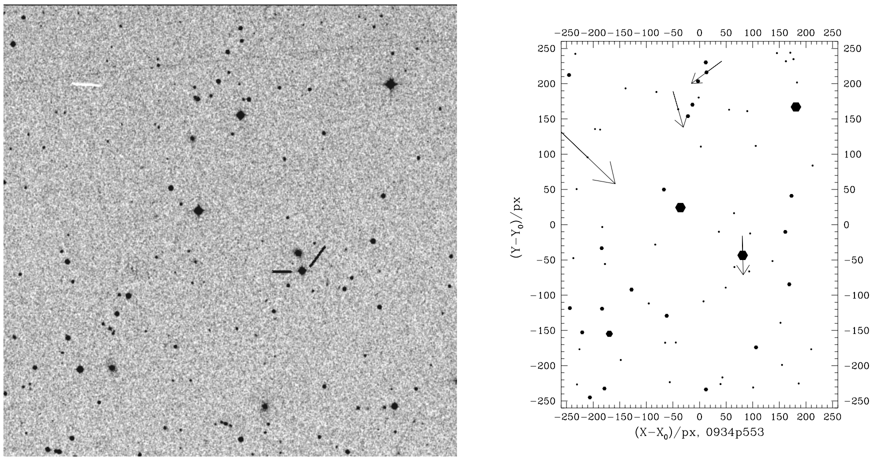

Figure 1. POSS Image of region around PG0923+533 and resulting plot from program.

value decomposition routines from Press et al. (1992). With our material, we have the most confidence in results for stars with visual magnitudes in the range $11 \leq V \leq 18$, and with proper motions in the range $0\farcs05\,\mathrm{yr}^{-1} \leq \mu \leq 0\farcs25\,\mathrm{yr}^{-1}$. We work in either of two ways which we call "Selected-Target" and "Survey" modes.

3. Selected-Target Mode

In this mode, the position of a specific star is centered in an extraction window for each epoch, and the motion is determined for that star. We have been obtaining proper motions of: candidate nearby stars for H. Jahreiß, verifying that some having motions up to $0\farcs3\,\mathrm{yr}^{-1}$ which are not listed in the Luyten or Giclas catalogues; hot DAs from the Palomar-Green (PG) Survey for J. Liebert; sdO stars in the PG survey for R. Saffer; faint, high-latitude carbon stars; and low-mass, post-AGB stars for M. Parthasarathy. Other collaborations are pending.

Figure 1 shows a print (*left*) of the area around one of our single targets, PG0923+533, and the resulting plot (*right*) from the analysis of the field for proper motions. Arrows indicate the magnitude and direction of the proper motion for the stars. We determined a proper motion for this target of $\mu = 0\farcs047\,\mathrm{yr}^{-1}$ and $\theta = 182°$.

4. Survey Mode

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

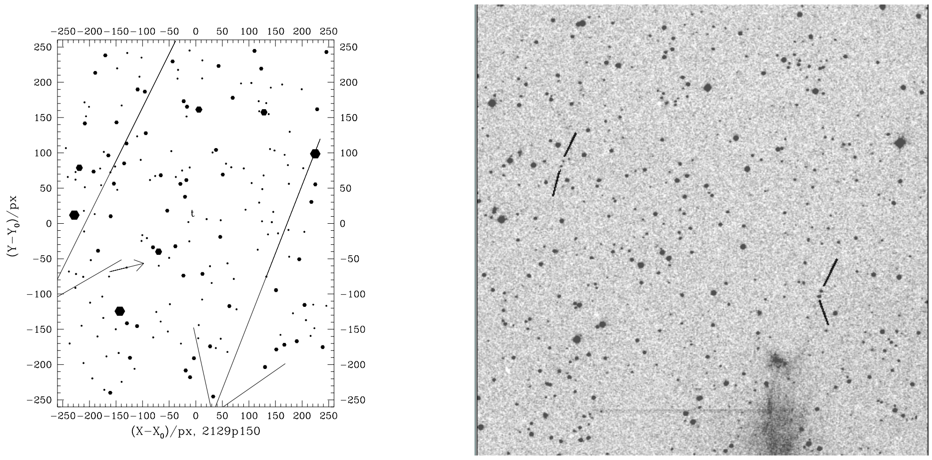

Figure 2. Plot from the program of the area around target PG2129+150 and the POSS Image of the region.

Of 123 Luyten proper motion stars in the common area, we find 44 certain and two possible correspondences; the faintest Luyten R mag of these is 19.8. Of 77 Luyten stars not found, 24 are too faint [R(Luy) $\geq$ 19.9] to appear on the "Quick V" plate and two are too bright (8^{th} mag). Of the 51 remaining, 34 have $\mu \leq 0\farcs06\,\mathrm{yr}^{-1}$—i.e., perhaps too small for us to detect. Of the remaining 17, six are near our faint or bright limit. The largest undetected Luyten proper motion is $0\farcs18\,\mathrm{yr}^{-1}$ for a R=18.9 star. This and other cases of missing known proper motion stars, as well as spurious proper motions, may be attributable to the star/non-star classifier being too conservative and hence eliminating real stars from one or both frames.

Such a case is illustrated in Figure 2 which is a plot showing the stars matched in the field of PG2129+150; the target star, marked with a "t" in the figure, show no motion, but two others, separated by about 9', seem to be a common proper motion pair with $\mu = 0\farcs35\,\mathrm{yr}^{-1}$ and $\theta = 156°$. However, upon inspecting the actual photograph, also in Figure 2, we see that two stars of the right separation and position angle are present in each position. For these spurious motions to be computed, it must be that the star/non-star classifier 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 then reversed the classifications in the late-epoch plate.

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