PROPER MOTIONS REFERRED TO FAINT GALAXIES

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I. Overview of the NPM and SPM Programs

The Lick Northern Proper Motion (NPM) and the Yale-San Juan Southern Proper Motion (SPM) programs have been described on several occasions (Wright 1950; Deutsch and Klemola 1974; Vasilevskis 1973; and Wesselink 1974). The two programs represent an attempt to measure the coordinates and proper motions, with respect to the extragalactic reference frames, for large numbers of stars representing most of the astrophysically-recognized classes. The photographic plate material forming the basis of the NPM program derives from the first (1947-1954) and second (1970-present) epoch phases for 1246 fields with the Lick 51 cm Carnegie double-astrograph for centers at -20° and northward (Shane and Wirtanen 1967). A southern supplement of 144 additional fields takes the program to -30°. The SPM consists of 632 fields with centers at -20° and southward. The first epoch plates were taken between 1965 and 1974 and a partial extension of 72 fields to more northerly declinations is essentially complete. One short and one long exposure permit the measurement of positions and approximate photometry for selected stars and reference galaxies over the blue magnitude range from about 8 to 17-18.

Measured classes of objects include, besides the galaxies for the sky outside the zone of avoidance, stars selected from the astronomical literature on the basis of astrophysical interest, anonymous stars of magnitude 10 and fainter selected for both technical details of the plate reductions and as well as for stellar kinematical studies, and photometric standard stars for the photometric two-color reductions (B, V system). The two programs will consist of more than 500,000 stars and galaxies.

The initial impetus for determining absolute proper motions, or proper motions with respect to the faint galaxies, was to determine

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the corrections to the constants of precession, and thereby improve on the system of the fundamental catalogues. The positions and proper motions in the fundamental catalogue FK4 and those catalogues that are supposed to be on its system, such as the AGK3, provide the reference frame within which we study the effects of differential galactic rotation and determine Oort's constant B, and streaming motions in the galaxy. Fundamental motions are used to measure the expansion rates of the very loose OB Associations, from which kinematical ages can be estimated.

In addition, the solar motion is determined from the Fundamental Catalogue proper motions. Once the solar motion is determined with respect to some homogeneous group of stars, then it is possible to determine the statistical and secular parallaxes of the stars. These quantities are very important for determining the absolute magnitudes of stars beyond the range of trigonometric parallaxes, which unfortunately includes many very interesting types of stars such as the RR Lyrae stars (see for example Hawley, Jefferys, Barnes and Lai, preprint 1985), central stars of planetary nebulae, Barium stars and most other types of evolved stars. Unfortunately, secular parallaxes are very sensitive to errors in the fundamental system that may be functions of the position and magnitude, both of which are known to exist in the FK4. It is hoped that the European Space Agency's astrometric satellite HIPPARCOS will provide a means for removing the local errors in the fundamental system, but it will not be able to establish the important zero point for the proper motions. The information needed to render the HIPPARCOS system inertial will be provided by a connection to both the NPM and the SPM through the observation of stars in common, and also by observations that are planned by the Space Telescope Astrometry Team (Hemenway and Duncombe, 1981). The system of positions and proper motions defined by HIPPARCOS, and made inertial by the NPM, SPM, and ST will then provide the basic reference frame for proper motion studies down to about the 8th magnitude. For stars fainter than this, it will be up to the NPM and the SPM to provide the absolute reference system for statistical and secular parallaxes and also for relating the extragalactic radio reference frame to the optical one.

II. Current Status.

The NPM second-epoch photography is now complete for all 1174 fields with centers at declination -15° to +90°, leaving only the zone at -20° (72 fields) for future work. Measurements are completed for all fields outside the zone of avoidance from 0° to +75°. Current efforts are devoted to the completion of the north polar cap.

Astrometric reductions for proper motions and positions have been completed by Hanson for 617 fields in declination zones 0° to +65° outside the zone of avoidance. Photometric reductions by Klemola are partially completed for these fields, with the provision of blue and yellow magnitudes from the photographs in two colors.

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During the past several years López and van Altena made a number of improvements to the SPM astrograph to increase the quality of the photographs and efficiency of the operations. In 1980 a photoelectric autoguider was installed on one of the 25cm guide telescopes. The autoguider was constructed in the Lick and Yale shops and is a near copy of the very successful Lick-Carnegie Astrograph autoguider. Experience with the autoguider during these past years has borne out hopes for both improved quality and increased efficiency of the operations. In addition, ruggedized plate holder assemblies and plate holders were installed in an attempt to minimize potential problems with flexure during an exposure. This year, improved position encoders and an IBM PC are being installed to provide the precise position of the astrograph and eventually to set the telescope on the next field. It will also keep an up to date record of the SPM fields, guide star offsets and other information that the observer might need. An identical IBM PC will be used in San Juan for program development, data analysis and spare parts for the astrograph PC, should replacements not be readily available.

Four contiguous SPM fields near the South Galactic Pole have been repeated, measured and analyzed by Girard and López. Based on a comparison of; 1) the first-epoch and second epoch blue and yellow plates; 2) the proper motions obtained from the blue and yellow plates separately; and 3) the proper motions in the regions of overlap on the contiguous plates, they project an average accuracy for the SPM proper motions of ±0".005/yr for a 20 year epoch difference. Plans have therefore been made to start the second-epoch photography in 1986.

III. Some Early Results for the NPM

The completion of astrometric measurements and reductions for the band outside the zone of avoidance from declination -3° to +68° permits some early investigations to be made. Hanson selected the new absolute proper motions for a subset of faint Lick NPM stars to test their accuracy and to apply them to a preliminary study of solar motion and galactic rotation. The data used were the motions of the 16th-magnitude "faint anonymous stars" in each of the 6° x 6° fields; these comprise in total about 60,000 stars, referred to about 40,000 reference galaxies. The method employed consisted of the simultaneous solution for rectangular components of the solar motion in several galactic latitude zones, as well as for overall values of the Oort constants of galactic rotation.

The following preliminary results were obtained:

1. Values for the Oort constants: A = +11.0 +/- 0.9 km/sec/kpc and B = -11.2 +/- 0.8 km/sec/kpc, indicating a flat galactic rotation curve with a local circular velocity near 200 km/sec.

2. Solar apex locations situated near the standard apex were obtained from stars in the low-latitude Lick NPM zones, while apex locations

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displaying a strong trend toward the direction of galactic rotation were found from stars in the high galactic latitude zones.

3. RMS external error estimates for Lick NPM proper motions: 0.2"/cent for the absolute zero-point with respect to galaxies in a typical NPM program field, and 0.5"/cent for the proper motion of an individual faint anonymous star.

Further planned applications of the Lick NPM data include studies of the stellar density and solar motions as they vary with distance from the galactic plane. Future work will include data from declination zones from +70° to +90° and -5° to -20° as they become available.

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