STATISTICAL ANALYSIS OF PROPER MOTION SURVEYS

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Proper motion surveys offer a great deal of data bearing on important astronomical problems such as stellar kinematics and the luminosity function in the solar neighborhood. Major obstacles to the full use of proper motions have long been posed by: (1) incompleteness of proper motion surveys, (2) proper motion bias in kinematic studies, and (3) the indirect approaches and kinematical assumptions needed in traditional luminosity studies.

These obstacles can be largely overcome by a new approach (Hanson 1983) using multivariate and conditional distribution statistics (Hanson, Lutz, and Murray 1984) to model the proper motion survey data. The new statistical models provide deeper insight into the kinematic and luminosity information inherent in proper motions, leading to several useful new applications and results.

Hanson (1979) derived the cumulative distribution of proper motion $N(\mu) \propto \mu^{-3}$, which is independent of the form of kinematics assumed, and showed how "proper motion distribution diagrams" (log $N(\mu)$ vs. log μ) can assess the completeness of proper motion surveys.

Hanson (1983) showed how the biased conditional distribution $C(T|\mu)$ of transverse velocities, given proper motions, can be used to evaluate the volume bias $C(T|\mu) \propto T^3V(T)$ introduced by proper motion selection and thus to obtain bias-free kinematic information from proper motion data.

An important potential application of Hanson's proper motion models is to introduce a kinematical dimension into the Bahcall and Soneira (1980) Galaxy model. Hanson (1984) employs a similar approach to use the LHS (Luyten 1979) proper motion data to test for (and confirm) the presence of an intermediate kinematic population (Gilmore and Reid 1983, Reid 1983) in the immediate solar neighborhood.

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Hanson (1983) has devised a powerful new method to use the distribution N(H) of reduced proper motions to determine the stellar luminosity function. Proper use of the conditional distribution $C(T|\mu)$ avoids the fundamental mistakes in the Luyten (1939, 1968) method [e.g., (1) taking the slope $\Delta M/\Delta H$ as a free parameter in determining M from H, (2) implicitly equating $C(M|H)$ with $C(H|M)$]. Moreover, the new method allows more reliance on empirical tests than on kinematical assumptions, and dispenses with the trigonometric parallax calibrations, incompleteness corrections, and distance limits needed in other luminosity function determinations. The N(H) method has been applied (Hanson 1983) to the Luyten and La Bonte (1973) South Galactic Pole survey, and (Hanson 1984) to the LHS catalogue data. The new results confirm the steep drop in the luminosity function for $M_V > 16$, and the "Wielen dip" at $M_V \sim 7$ (cf. Wielen, Jahreiss, and Kruger 1983, Upgren and Armandroff 1981).

A full description of these methods and results is being prepared for submission to the Astronomical Journal (Hanson 1984). I thank T.E. Lutz and C.A. Murray for many useful discussions. This research has been supported by National Science Foundation Grant AST 81-12347.

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Discussion:

GLIESE: Do you think that further proper motion surveys of the very faint stars will solve the discrepancy about the luminosity function of the faint stars?

HANSON: I have assessed the completeness and I think the survey is quite complete. Further proper motion surveys will fill in data, but I have no problem with incompleteness.

NIELL: Does your treatment of the conditional probabilities account for the bias incurred in estimating completeness from integrated number counts?

HANSON: I have derived a theory of the cumulative proper motion statistics.