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Stellar Population and Galactic Evolution: A Photometric and Astrometric Sample Survey

1. Introduction

Strasbourg Observatory, Besançon Observatory (France), C.A.I., Observatoire de Paris and U.P. State Observatory (India) are conducting a sample survey in UBV photometry and proper motions as part of an investigation of galactic structure and evolution supported by the Indo-French centre for the Promotion of Advanced Research — Centre Franco-Indien pour la Promotion de la Recherche Avancée. The project is based on Schmidt plates (from Tautenburg, Palomar, ESO and OCA [Observatoire de la Côte d'Azur] telescopes) digitized with the MAMA machine (C.A.I., Insu Paris). The high astrometric quality of the MAMA gives access to micronic accuracy leading to a few mas per year accuracy on proper motions, using plates spread along a 30 year baseline. Medium photometric accuracy and high proper motion accuracy for complete faint star probes in large fields will give access to the properties of star samples out of the solar neighbourhood. The Schmidt sample survey is complemented by deep CCD photometry in some fields in order to get a wider magnitude range and to give access to faint or remote populations. To interpret this multidimensional data set we have developed a synthetic approach of galaxy modelling. Model simulations compared to observed stellar distributions in the space (V, B-V, U-B, μ_l, μ_b) will lead to suitable tests for galactic structure, dynamics and evolution.

2. Description of the Survey Plan

2.1 Sample survey

The chosen directions constitute a set of fields at high and intermediate latitudes and in the galactic plane:

- near the North Galactic pole (M3, l = 50°, b = 80° [Soubiran, 1992]);

- the direction of M5 (l = 3°, b = 47° [Bienaymé et al. 1992]);
- direction (l = 270°, b = 45°);
- direction (l = 210°, b = 45°);
- special Area 23 (l = 179°, b = 2.5°), a region in the plane of particularly low extinction (Mohan et al. 1988; Robin et al. 1992).

2.2 Photometric reduction

Photometry is made using at least two plates per colour in the three photometric bands UBV. Photometric sequences are photoelectric sequences and CCD photometric ones obtained at the 1.2 metre telescope of Observatoire de Haute-Provence and 1.0 metre telescope of U.P.S.O., Nainital (India). These CCD frames are spread over the Schmidt field and used to check for geometrical variations of the sensitivity over the plates. About 40 to 80 stars are typically used to determine the calibration curve in each passband. Colour transformations between the Johnson system and the instrumental system of the O.C.A. Schmidt have been obtained by Mohan & Crézé (1987). The typical rms magnitude scatter ranges from 0.08 to 0.10 in the magnitude range 11 to 18.

2.3 Astrometric reduction

The present astrometric analysis is purely differential. Except for the low galactic latitude field we use galaxies to determine the absolute proper motions. In the future Hipparcos and Tycho catalogues could be used for this purpose.

The performance of a number of centring algorithms have been intensively tested (Bienaymé et al. 1988; Bienaymé et al. 1992). The autocorrelation centring method gives the best accuracy over the whole magnitude range. A mathematical transform (Legendre polynomial expansion) is used to model the transform between plate coordinates from the two epochs. For this purpose it is assumed that the mean proper motion over the considered field is null or constant. After reduction, galaxies can be used to convert relative proper motions to absolute ones. The mean error corresponds to about 0.5 μm on bright stars. The global errors are definitely less than 3 mas yr^{-1} for bright stars and about 6 mas yr^{-1} for the faintest (V = 17.5).

The final catalogues include photometry in UBV and proper motions to a specified completeness limit in each photometric bands (measured from the maximum of the histogram of star counts).

3. Methods of Analysis

From such a survey the raw observational data do not allow to directly derive intrinsic parameters such as distance, mass, age, space velocities, chemical evolution of individual stars. However some information relevant to the distribution of these quantities is reflected in the n-dimensional distribution of observables. Connecting observable distributions to the main process they come from is basically a multivariate problem for which we have developed at the Besançon Observatory a synthetic approach of Galaxy modelling referred to as the Besançon model (Robin & Crézé, 1986; Bienaymé et al. 1987). Model simulations allow the comparison of predictions from theories or scenarios for galactic structure, dynamics and evolution with observed stellar distributions in multidimensional spaces, leading to suitable tests for the theories.

In this particular project statistical methods have been developed in order to qualitatively and quantitatively constrain the galactic structure parameters. Different methods have been used such as maximum likelihood, χ^2 test, least square fitting, discriminant analysis, and density estimations.

4. Preliminary Results

This synthetic approach and the multivariate sample survey plan have given until now a number of substantial results concerning galactic structure and stellar evolution:

- *determination of the scale length of the old stellar disc and detection of the edge of the galactic disc.* Using the anticentre field, the scale length is measured using Schmidt plate photometry complemented with deep CCD frames. We find a scale length of 2.5 ± 0.3 kpc and a sharp cutoff of the counts at a distance of 5.5 to 6 kpc from the sun (Robin et al. 1992a, b);

- *existence of the thick disc population and constraints on its circular velocity.* From the direction near M5, an analysis of the 5-dimensional space gives constraint on the existence of the thick disc population (Robin et al. 1989) and on its circular velocity. It is found to be about 150 km/s at a distance of 2 kpc above the plane (Robin & Chen, 1992);

- *constraints on the velocity dispersion ratios* have been obtained from data towards M5, the north galactic pole and in the anticentre (Pandey & Bienaymé, 1993, in preparation);

- *constraints on the kinematics of old populations in the direction of the north galactic pole.* Velocity dispersions in U and V are obtained for the old disc, the thick disc and the halo. The intermediate population is found to rotate at 179 ± 16 km/s, compatible with the value obtained in the M5 direction (Soubiran, 1993, in preparation).

We hope to have reduced most of the fields by the end of this year and to start an overall comparison of the data in all directions to give consistent tests for galactic structure and evolution.

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