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SYSTEMATIC MOTIONS IN THE GALACTIC PLANE

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RESUMEN

La combinación de un modelo propio para el cálculo de patrones sistemáticos en un conjunto de datos con el método clásico de Herschel ha dado buen resultado en la búsqueda de componentes sistemáticas en los movimientos propios estelares para estrellas del Catálogo Hipparcos. A la ya publicada determinación del movimiento solar, hay que añadir ahora la determinación de dos movimientos sobre el plano galáctico, que en forma radial afectan a dos muestras de estrellas, relativamente grandes, con sentidos opuestos. El Boletín en Español de la ESA del 26 de octubre de 2004 hace referencia a posibles movimientos de esas características y como ejemplo pone una futura publicación de la revista A&A.

ABSTRACT

The combination of a model to compute systematic trends in a sample of data, plus the classic Herschel's Method, has produced good results in finding systematic components in the stellar proper motions of Hipparcos Catalogue. First, we measure the Solar Motion, and finally, we found the existence of two motions contained in the Galactic plane with a radial direction towards and away from the Galactic center. Each one of these motions is shared by relatively large sample of stars. The ESA Bulletin (spanish version) issued on October 26 2004 talks about the possible existence of this kind of motions in the solar neighbourhood and makes a reference to an oncoming A&A publication about this subject.

Key Words: **ASTROMETRY — GALAXY: KINEMATICS AND DYNAMICS — METHODS: DATA ANALYSIS**

1. INTRODUCTION

The "Polinomio Deslizante" (PD) function was designed to find and measure systematic trends in data, without imposing an analytical expression for such a function (Stock & Abad 1988). The PD values are computed point by point and are based on the data enclosed around the point where the PD is being evaluated. These data will have a distance-dependent weight in the calculation. The radius of the interval surrounding each point makes the PD a continuous function while the weight controls its derivability and order.

The PD is meant to be applied in data affected by problems with no clear or partially understood causes. It has been applied in the unification of astrometric catalogues and in the determination of distortion in the astrometric reduction of photographic plates (Abad 1995).

Herschel's method (Trumpler & Weaver 1953) sets the equations that characterize the radial and tangential components of the common motion of a group of stars gravitationally bound. In this approach, stellar proper motions are represented by great circles on the celestial sphere. This simple but clever idea allows to get the kinematic parameters of the stellar associations, and it is based solely on the stellar proper motions when the distance to one of the members of the cluster is known.

Space-based observation has given astrometry an unsuspected impulse since a few decades ago. The Hipparcos satellite produced a stellar catalogue with an accurate position and proper motion not possible for ground-based observations. In addition to these advantages, this catalogue also includes photometric and spectroscopic information, which makes it an obliged reference for any astrometric work. The future looks even better with GAIA and SIM missions. But not only space-based observations produce large amounts of accurate data, CCD high-quality detectors plus adequate data reduction techniques, but also then generate deep and extense catalogues, for instance UCAC2 catalogue. If we unify such data with the earlier photographic surveys as the Cart du Ciel, we would be able to get stellar proper motions as accurate as those from Hipparcos Catalogue.

The elaboration of dense and extense catalogues encouraged us to explore new forms of working data. We found that the polar representation of Herschel's

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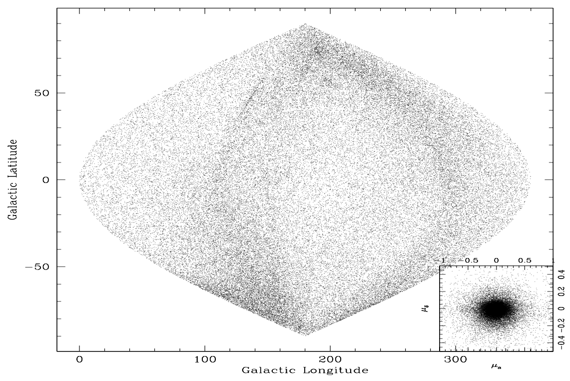

Fig. 1. Comparison of the Point-Vector Diagram and the polar representation of Herschel's method, for all Hipparcos stars.

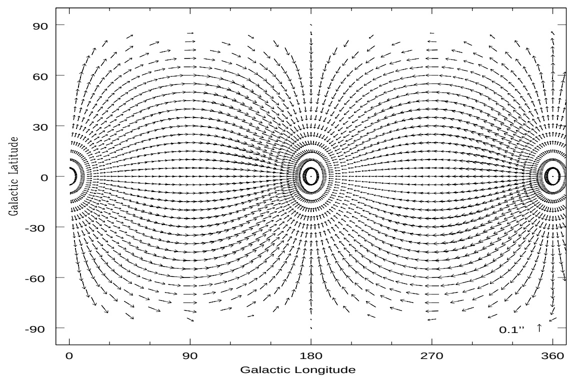

Fig. 2. Vector field of the proper motions, for a sample of stars that share a spatial motion. Apex and antapex are easily distinguished. The start point of these vector are located on meridians and parallels, whose poles are precisely the apex and antapex of the motion.

method allows to extend the representation field of the proper motions from a few square arc-seconds in the Vector-Point Diagram to the whole celestial sphere. Besides, the equations on this approach are easily followed.

The combination of Herschel's method and the PD applied on and the Hipparcos Catalogue has produced a series of results, both general and particular, obtained in a relatively simple way. Solar motion was determined as the systematic component shared by all the stars, extracted from their proper motions (Abad et al. 2003). Using a similar procedure, although restricted to a sample of Hipparcos Catalogue, we found the existence of two spatial motions, radially directed, contained in the Galactic plane and opposed to each other.

2. HOW TO APPLY THE METHOD

The method explained in this work is oriented to search for systematic patterns in samples of stars from all around the solar neighbourhood. Searching for clusters or associations located in a given direction on the sky is not considered in this paper. The method is applied to the Hipparcos Catalogue stars and it requires the knowledge of parallaxes.

The investigation of these motions is based on:

a) an initial representation of the poles of the proper motions corrected for all known patterns,

b) the re-scaled corrected proper motions to a fixed distance,

c) the application of the PD to the re-scaled proper motions,

d) values obtained from PD must fulfill Herschels's equations when the PD is evaluated on a grid of points distributed along meridians and parallels, whose poles are the provisional apex and antapex of the motion.

The process is iterative and outliers stars are discarded when their individual proper motions are too different, either in module or direction, from the one given by the whole sample of stars.

Figure 1 represents a comparison of the polar representacion of the Herschel's method and the Point-Vector Diagram when applied to the whole Hipparcos Catalogue. This figure corresponds to the item a) from the list above, in a very first phase.

Figure 2 is an example of item c) and represents the vector field of proper motions obtained from the stars that fall into the enhanced great circle visible in Figure 1. Proper motions of these stars have been previously corrected for differential galactic rotation and solar motion.

3. NEW MOTIONS IN THE GALACTIC PLANE

The combined application of the PD and the Herschel's method allowed us to discover two patterns of motion contained in the Galactic plane, which have almost opposing directions towards and away from the Galactic center. The parameters defining these groups are:

Sample 1 : has 4566 stars and defines a motion of apex $(l, b) = (177^o8, 3^o7) \pm (1^o5, 1^o0)$ and space velocity $V = 27 \pm 1$ km/s.

Sample 2 : has 4083 stars and defines a motion of apex $(l, b) = (5^o4, -0^o6) \pm (1^o9, 1^o1)$ and space velocity $V = 32 \pm 2$ km/s.

The ESA Bulletin (spanish version) of October 26th 2004, (http://www.esa.int/esaCP/SEM48E0A90E_Spain_0.html), published a press note about the existence of this kind of motions and stated that discoveries like this one justify the future of space-based astrometry, citing the Famaey et al. (2005) paper, where "dynamic streams" were found. Our method is an easy way to search the data for detecting and measuring such motions.

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