GALACTIC WARPING MOTION FROM HIPPARCOS PROPER MOTIONS AND RADIAL VELOCITIES

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ABSTRACT. Based on the Hipparcos proper motions and the available radial velocity data of O-B stars, we have reexamined the local kinematical structure of young disk population of ~1500 O-B stars other than the Gould-belt stars. A systematic warping motion of stars about the axis pointing to the Galactic center has been reconfirmed. A negative K-term has been detected that is a systematic contraction of stars in the solar vicinity. Two different distance scales have been accepted in order to inspect their impact on the kinematical parameters to be determined. We conclude that the adopted distance scale plays a certain role in characterizing the kinematical parameters at the present level of the measurement uncertainty.

1. INTRODUCTION

Thanks to the small velocity dispersion and low rotational lag relative to the LSR of the young disk population of stars, the analysis of large scale velocity fields of objects that belong to the young Galactic disk is the principal tools used by many investigators. Carrying out a proper motion analysis for Hipparcos O-B5 stars, we found a clear warping motion that is a systematic rotation of stars about the axis pointing to the Galactic center (Miyamoto & Zhu 1998). Using Hipparcos proper motions supplemented with radial velocities, a kinematical study of the classical Cepheids gave a negative K-term in our previous work (Zhu 2000). Comerón et al. (1994) examined the local kinematical structure of the O-B stars, and found that stars within the heliocentric distance $r = 1.5$ kpc exhibit a contraction, while stars within 0.4 kpc behave an expansion which may be dominated by the moving groups. A recent work by Bobylev (2004) confirmed that a negative K-term exists in the distant O-B stars. It is noticed that our following work differs from that by Comerón et al. or by Bobylev, because we have removed Gould-belt stars from our analyzing sample.

In the following work, we select O-B5 stars with all kinds of luminosity classes and B6-A0 stars with Luminosity classes I-II, excluding the Gould-belt stars, to reexamine the local kinematics of stars in a heliocentric distance up to $r = 3.0$ kpc. The astrometric data are taken from the Hipparcos Catalogue. The radial velocity data are obtained from the General Catalog of Mean Radial Velocities. In order to inspect the systematic deviation of the distance scales which might disturb the velocity field for the kinematical analysis, we have compared the Hipparcos distance scale derived from trigonometric parallaxes of stars with the spectroscopic SKYMAP distance scale. Statistically, the Hipparcos distance scale is smaller than that of the SKYMAP by about 5% on average.

2. KINEMATICAL STRUCTURE OF O-B STARS

The kinematical solution is derived from the O-B5 stars, B6-A0 supergiants and bright giants at a distance domain 0.2 kpc $\leq r \leq$ 3.0 kpc. Based on the 3-D model (Zhu 2000), the kinematical parameters are determined via the generalized least-squares method.

The total velocity of the Sun S_0 relative to the LSR defined by stars considered, with the apex towards ℓ_0 and b_0, are derived on the basis of the SKYMAP distance scale

$$S_0 = 20.1 \pm 0.4 \text{ km s}^{-1}, \quad \ell_0 = 51.^\circ 2 \pm 1.^\circ 2, \quad b_0 = +22.^\circ 9 \pm 1.^\circ 1, \tag{1}$$

and based on the Hipparcos distance scale

$$S_0 = 16.9 \pm 0.4 \text{ km s}^{-1}, \quad \ell_0 = 47.^\circ 2 \pm 1.^\circ 3, \quad b_0 = +22.^\circ 2 \pm 1.^\circ 2. \tag{2}$$

Our previous determination of the solar motion gave

$$S_0 = 19.1 \pm 0.5 \text{ km s}^{-1}, \quad \ell_0 = 49.^\circ 2 \pm 1.^\circ 6, \quad b_0 = +21.^\circ 9 \pm 1.^\circ 3, \tag{3}$$

that was obtained from a proper motion analysis of O-B5 stars based on the SKYMAP distance scale (Miyamoto & Zhu 1998). The present determinations coincide with the previous one within the standard errors, except the total solar motion on the Hipparcos distance scale.

The combinations of the Oort constants A and B in a circular stream model give

$$A-B = 29.05 \pm 1.11 \text{ km s}^{-1} \text{ kpc}^{-1}, \quad A+B = \left(\frac{\partial V_\theta}{\partial R}\right)_{R=R_0} = -3.34 \pm 1.11 \text{ km s}^{-1} \text{ kpc}^{-1}, \tag{4}$$

for the SKYMAP distance scale, and

$$A-B = 31.05 \pm 1.22 \text{ km s}^{-1} \text{ kpc}^{-1}, \quad A+B = \left(\frac{\partial V_\theta}{\partial R}\right)_{R=R_0} = 1.58 \pm 1.22 \text{ km s}^{-1} \text{ kpc}^{-1}, \tag{5}$$

for the Hipparcos distance scale. Here, the azimuthal angle θ is pointing to the opposed direction of the Galactic rotation. The combination $(A+B)$ expresses the slope of the rotation curve at the Sun. It indicates that the variation of the distance scale does not only changes the rotational speed of the Galaxy, but also changes its gradient at the Sun.

In our previous work, a clear warping motion $+3.8\pm1.1$ km s^{-1} kpc^{-1} of stars about the axis pointing to the Galactic center has been found (Miyamoto & Zhu 1998). The present analysis gives a value of $+2.6\pm1.1$ km s^{-1} kpc^{-1} for both SKYMAP distance scale and Hipparcos distance scale. The determination of the warping motion is favorably independent of the distance scale adopted. The K-terms are found to be $K=-2.2\pm0.8$ km s^{-1} kpc^{-1} from the SKYMAP distance scale, and $K=-4.2\pm0.9$ km s^{-1} kpc^{-1} for the Hipparcos distance scale, respectively. The negative K-term means an overall contraction of stars at the solar vicinity.

In general, we conclude that the kinematical structure of O-B stars other than the Gould-belt stars, exhibits an overall rotation around the Galactic gravitation center on the Galactic plane simultaneously with a warping motion and a contraction. The adopted distance scale plays an important role in characterizing the kinematical parameters at the present level of the measurement uncertainty.

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3. REFERENCES

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