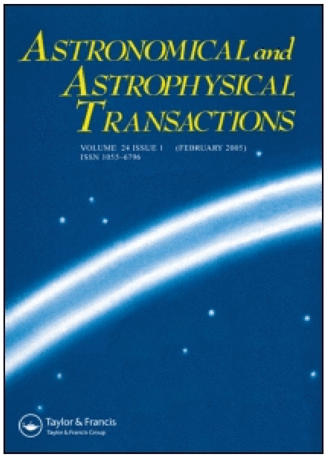

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Gould Belt kinematics on the basis of the open clusters and OB associations

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Gould Belt kinematics on the basis of the open clusters and OB associations

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The kinematic parameters of the Gould Belt are redetermined using modern data on the motion of nearby young ($\log t < 7.91$) open clusters, OB associations and moving stellar groups. The modelling carried out shows that the residual velocities achieve the maximal values equal to -4 km s^{-1} for rotation (in the direction of the Galactic rotation) and $+4$ km s^{-1} for expansion, when the distance from the kinematic centre is about 300 pc. We assumed the following parameters of the Gould Belt centre: $l_0 = 128°$ and $R_0 = 150$ pc. It is shown that the whole structure of the Gould Belt is moving relative to the local standard of rest with a velocity of 10.7 ± 0.7 km s^{-1} in the direction towards $l = 274 \pm 4°$, $b = -1 \pm 3°$. Using the rotation velocity, we obtained the virial estimation of the Gould Belt mass as $1.5 \times 10^6 M_\odot$.

Keywords: Gould Belt; Structure; Kinematics

The Gould Belt is a system of nearby OB associations [1], H I clouds [2] and H_2 molecular cloud complexes [3]. At present, there exist several scenarios for the formation of the Gould Belt. According to the first scenario, the Gould Belt is formed as a result of the collision of high-speed neutral hydrogen clouds with the Galactic disc [4]. According to the second scenario, the Gould Belt is formed owing to explosion of supernovae [2, 5]. According to the third scenario [6], the formation of the Gould Belt is a stage of kinematic evolution of the Local Stellar System. Linblad [7] suggested a model of proper rotation and expansion of the Gould Belt which takes into account the inclination of the disc to the Galactic plane (20°). In the work of Bobylev [8], the well-known Linblad approach is developed for the case when star heliocentric distances are determined exactly. The goal of this work is redetermination of the kinematic parameters of the Gould Belt structure using modern data on open clusters. The advantage of such an approach is that the estimations of ages and distances of open clusters are more reliable than those of individual stars. The catalogue of 652 open clusters hereafter we denote as COCD [9, 10]. Our working list is composed primarily of the COCD young open clusters with age $\log t < 7.9$, denoted in the paper by Piskunov *et al.* [10] as OCC1. In the COCD catalogue, random errors of mean proper motions of the clusters are small because of the use of the

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combined catalogue ASCC-2.5 [9]. The radial velocities of the COCD open clusters are based on the catalogue published by Barbier-Brossat and Figon [11]. We use more comprehensive star radial velocities from the Orion Spiral Arm Catalogue (OSACA) [12], which combines a number of large catalogues of radial velocities including those of Duflot *et al.* [13], Barbier-Brossat and Figon [11], Nordström *et al.* [14] and Famaey *et al.* [15]. In comparison with the work in [3], we made essential supplements for stars of the Sco–Cen complex using the list compiled by de Zeeuw *et al.* [1] and the OSACA. We considered the open cluster Chamaeleontis. We used modern data for 25 stars of the cluster TWA as well. Our approach to kinematic analysis is based on the following equations [8]:

$$\begin{aligned} V_r = {} & -u_\odot \cos b \cos l - v_\odot \cos b \sin l - w_\odot \sin b + \cos^2 b\, k_0 r + (R - R_0) \\ & \times [r \cos b - R_0 \cos(l - l_0)] \cos b\, k_0' - R_0(R - R_0) \sin(l - l_0) \cos b\, \omega_0', \end{aligned} \tag{1}$$

$$\begin{aligned} r\mu_l \cos b = {} & u_\odot \sin l - v_\odot \cos l - (R - R_0)[R_0 \cos(l - l_0) - r \cos b]\omega_0' \\ & + r \cos b\, \omega_0 + R_0(R - R_0) \sin(l - l_0) k_0', \end{aligned} \tag{2}$$

$$\begin{aligned} r\mu_b = {} & u_\odot \cos l \sin b + v_\odot \sin l \sin b - w_\odot \cos b - \cos b \sin b\, k_0 r - (R - R_0) \\ & \times [r \cos b - R_0 \cos(l - l_0)] \sin b\, k_0' + R_0(R - R_0) \sin(l - l_0) \sin b\, \omega_0'. \end{aligned} \tag{3}$$

Here, $r = 1/\pi$ is the heliocentric distance of a star, R_0 is the distance from the Sun to kinematic centre, l_0 is the direction to the centre, and $u_\odot$, $v_\odot$ and $w_\odot$ are the components of the solar peculiar velocity. The components $\mu_l \cos b$ and μ_b are expressed in milliarcseconds per year, the radial velocity V_r in kilometres per second, the parallax π in milliarcseconds and the distances R, R_0 and r in kiloparsecs. The quantity ω_0 is the angular velocity of rotation, k_0 is the radial expansion–contraction velocity of a star system at the distance and the parameters ω_0' and k_0' are the corresponding derivatives. The distance R from a star to the centre is evaluated as $R^2 = r^2 \cos^2 b - 2R_0 r \cos b \cos(l - l_0) + R_0^2$. The system of conditional equations (1)–(3) contains seven unknowns which we determine using the minimum least-squares technique. It is assumed that the left-hand sides of the equations are free from the Galactic differential rotation.

The second method of kinematic analysis is based on linear residual velocities which we approximate as

$$V_i = V_{0,i} + a_i(R - R_0) + b_i(R - R_0)^2, \tag{4}$$

where $i = (R, \theta)$, and the residual velocity V_R of expansion and the residual velocity V_θ of rotation must be obtained by decomposition of the spatial velocity components u and v into radial and tangential parts using the known centre parameters l_0 and R_0. The results of the analysis are presented in figures 1 and 2. We can conclude that it is shown in our work that the Gould Belt structure takes part in several motions. Firstly, the whole complex, free from common Galactic rotation, is moving relative to the local standard of rest [16] with a velocity of $10.7 \pm 0.7\,\mathrm{k\,s^{-1}}$ in the direction towards $l = 274 \pm 4°$, $b = -1 \pm 3°$. Secondly, residual rotation and expansion of the whole system exist. We used the following parameters of the kinematic centre: $l_0 = 128°$ and $R_0 = 150$ pc [8]. The modelling carried out shows that the residual velocities are reliable in a small region near $R \approx R_0$ and are equal to $-2.8 \pm 0.7\,\mathrm{km\,s^{-1}}$ for rotation (in the direction of the Galactic rotation) and to $+3.3 \pm 0.7\,\mathrm{km\,s^{-1}}$ for expansion. The maximal values are achieved when the distance from the kinematic centre is about 300 pc and are equal to $-4.3 \pm 1.9\,\mathrm{km\,s^{-1}}$ for rotation and to $+4.1 \pm 1.4\,\mathrm{km\,s^{-1}}$ for expansion. Using the rotation velocity, we obtained the virial estimation of the Gould Belt mass as $1.5 \times 10^6 M_\odot$.

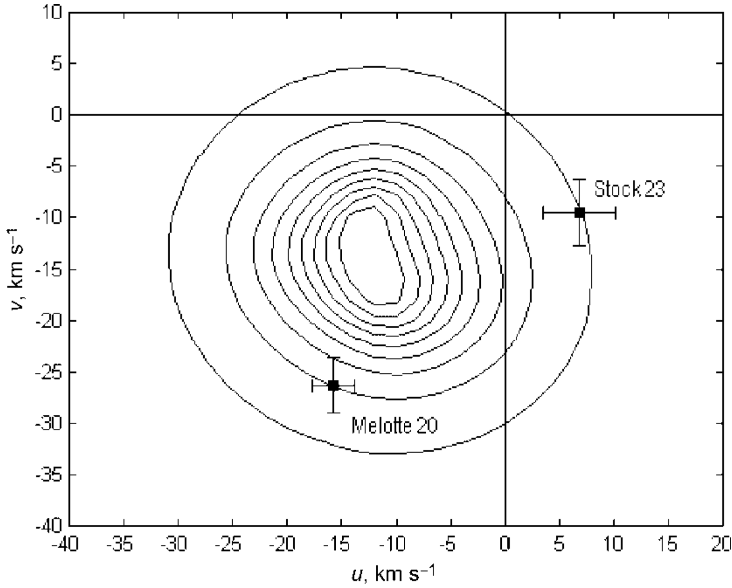

Figure 1. Smoothed distribution of the u and v residual velocities.

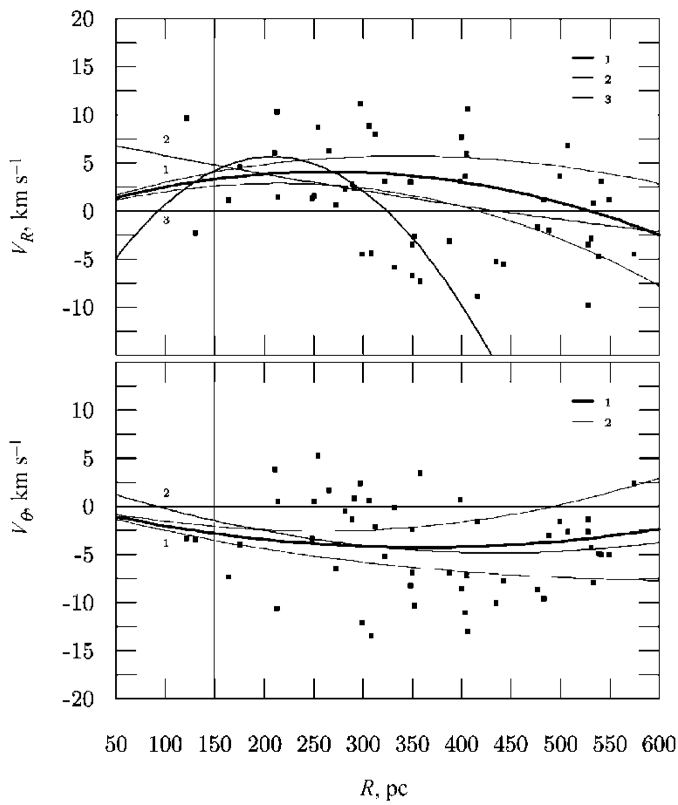

Figure 2. Residual velocities V_R (top) and V_θ (bottom) versus distance R from the kinematic centre $l_0 = 128°$, $R_0 = 150$ pc; the vertical line indicates the value of R_0.

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