# Result

**(1) Space distribution:**

Many researchers have discovered the noticeable distribution of the Gould Belt with O, B stars and the late type stars on the XZ-plane and the sub-spiral on the XY-plane (e.g. Moreno *et al*., 1999; Torra *et al*., 2000; Palouš, 1983, 1985; Lindblad *et al*., 1997 and, Guillout *et al*., 1998). The OB stars in the XYZ coordinates could be separated at least two groups by using the least squares method locally with assuming Gaussian distribution. One of these groups is the Gould Belt which inclines an projected angle about 16.5 degree with respect to the galactic disk on the XZ plane and the angle projected on the YZ plane is about 7.2 degree with respect to the galactic plane (Fig. 2; Fig. 3). Whether data are combined with radial velocity or not, the oblique belt spreads on XZ-, YZ- plane looks similar.

On the XY plane, two dense regions extending from upper-right corner to lower-left corner might belong to different groups. Stars projected on the YZ plane shows a $38^\circ$ oblique belt different from the Gould Belt with angle $16^\circ.5$ on the same plane. When the XYZ distribution of the belt with angle $38^\circ$ is compared to each other, this belt happens to lie on one of the dense region on the XY plane. The space position of the strange belt is different from disk stars and from the members of the Gould Belt lies near Orion. These stars should be in a region similar to the Gould Belt on the XZ plane. Furthermore, the stars whose relative parallax error less or equal 50%, express the Gould Belt more observably (Fig. 4; 5).

When the region in the Gould Belt is defined roughly from the diagrams, X = [- 500, 180], Y = [- 500, 0], and the distribution in the Z direction is in the range between - 200 pc to 200 pc. Compared the model proposed by Guillout *et al.* (1998), XYZ distribution doesn't consistent a little with the model Guillout proposed. The interstellar absorption in the direction toward galactic center affects the observation in optical band, so it may result in the unclear distribution toward the galactic center.

The distribution diagrams of the A0 – A5 stars projected on the XZ- and YZ- planes look like no clear track of the Gould Belt (Fig. 6; 7). The stellar XYZ distribution shows broader region of the galactic disk and that of the Gould Belt is broader, too. Apparently the A type stars have dispersed and the belts would be more unobvious. On the other hand, the data with radial velocity of A0 – A5 stars are so few that the stars spread on the narrow and indistinct region, which could be the Gould Belt, on the XYZ diagram. While the A0V ~ A5V stars are chosen the precision $\sigma_\pi/\pi$ less or equal 50% (Fig. 8; 9), the Gould Belt has been shown on the XZ plane and YZ plane. Because the age of Gould Belt is thought be from 30 Myrs to 80 Myrs, the A type stars beyond main sequence (giants) should be older than 100 Myrs.

**(2) The proper motion vector point diagram:**

The vector point diagram of the stellar proper motions on the equatorial coordinate system and the galactic coordinate system looks like two group there (Fig. 10). The distribution of the $\mu_\alpha \cos\delta$ and $\mu_\delta$ of OB stars may be divided into two groups by eye, and the $\mu_l \cos b$ and $\mu_b$ are divided into two groups, too. The distribution of $\mu_l \cos b$ and $\mu_b$ is the angular components of motion, so the proper motion are transferred to the galactic components of velocity, $V_l$ and $V_b$, to indicate the existence of the groups (Fig. 11). The diagram of phase space $V_l$ and $V_b$ shows two groups, too. The central proper motion of these two groups on the vector point diagram of ($\mu_\alpha \cos\delta$ and $\mu_\delta$) and ($V_l$ and $V_b$) are calculated with the Gaussian distribution locally (Table 5). The larger group, group A, lies on the upper part of the proper motion vector point diagram. If the kinematical property can be divided by the velocity distribution, the group A should be respond to the galactic disk stars.

Table 5 The central groups on the vector point diagram.

| | central proper motion | $(\sigma)_l$ | $(\sigma)_b$ |
|---|---|---|---|
| ($\mu_l \cos b$, $\mu_b$ )- the group A | (1.3", 1.51") | 7.37" | 8" |
| ($\mu_l \cos b$, $\mu_b$ )₋ the group B | (2.56", -7.63") | 7.67" | 4.6" |
| ($V_l$, $V_b$ )- the group C | (1.26", 4.82") | 13.3" | 13.36" |
| ($V_l$, $V_b$ )- the group D | (3.35", -12.27") | 12.91" | 9.37" |

The group A- and group C are located on the upper of the proper motion vector point diagram and of velocity diagram. The group A and group C are located on the lower part.

From the position distribution of stars on the XYZ planes for the stars of group D on the $V_l$ vs. $V_b$ diagram (Fig. 12-a; 12-b; 12-c; 12-d) and for the stars of group B on the $\mu_l \cos b$ vs. $\mu_b$ diagram (Fig. 13-a; 13-b; 13-c; 13-d), the kinematical property of the Gould Belt could be indicated out.

For A0 – A5 stars, there is no two groups clearly could be found from the proper motion vector point diagram, but the main sequence stars A0V – A5V seems to have two group (Fig. 14; 15). The situation is clearer when the error of the parallax restricted to be less than or equal 50% (Fig. 16; 17). If the property of kinematics for A0 – A5 stars belonging to the Gould Belt is similar to that of OB stars in the same system, the distribution on the vector point diagram and velocity diagram should be looked like. The Gould Belt for A0 – A5 stars could be find in the same way. The oblique belt can be looked with eyeball after Divided from the same region (see, table 5) of the $\mu_l \cos b$ vs. $\mu_b$ diagram (Fig. 18-a; 18-b) and that of the $V_l$ vs. $V_b$ diagram (Fig. 19-a; 19-b).

When the data of OB stars and A0V-A5V stars are Combined, many stars in the lower group on the vector point diagram could belong to the Gould Belt according to the space distribution of X, Y and Z. The presentation of the Gould Belt from both proper motion and position is clearer than what are just from the space distribution.

**(3) UVW diagram:**

The proper motion and parallax combined with the information of radial velocity are transferred to the UVW velocity. The UVW diagram of OB stars could be divided into two groups roughly, but the groups are not as observable as the proper motion vector point diagram (Fig. 20). From the vector point diagram, these two separated group look like belong to the different groups. Similarly the UVW diagram of the groups, which are reflected as the members of the Gould Belt, and the other, should be different and recognized by the UVW characteristics (Fig. 21; 22). Both of the proper motion vector point diagram and velocity diagram indicate that most stars of the Gould Belt move to the negative directions of U, V, and W (Fig. 23-a; 23-b; 24-a; 24-b). In addition, the other group, which mainly belongs to galactic plane, move toward the negative velocity of U, V, but the amount of stars with positive W and with negative W are almost the same. In the case, the negative values of U, V, and part W are due to the solar motion because the data haven't removed the effect of the solar motion.

When the entirely negative values of UVW (are thought to belong to the Gould Belt) are considered. From XYZ diagram (Fig. 25), this property of all negative values of UVW could be probably explained by the expansion or the impact of a high velocity cloud to the galactic disk, but it can't expel any model that could not the real origin of the Gould Belt. The expansion model can be examined and explained that the members of the Gould Belt should motion to the direction of positive Z in the position upper than the disk, while stars locate at the lower part of the galactic plane would motion to the other direction. On the other hand, all members of the Gould Belt should have the component of the velocity motion to the negative W if they formed from an event of impact, which is a high velocity cloud impacting the galactic disk (see, Comerón & Torra, 1992). In the XYZ distribution of the stars with entirely negative values of UVW, stars lay on the position lower the galactic plane, however, can't make sure which model is the most possible.

Considering the case of A0 – A5 stars, the points on the UVW diagram scatters over the UV plane but the two different distributions still could be seen very roughly (Fig. 26). These diagrams from the proper motion and from the velocity calculated by proper motion are transferred to the UVW system and show that the space velocities of the stars lie on the Gould Belt are spread on the UV plane but with the negative W, while the other stars are distributed symmetrically in the W direction (Fig. 27-a; 27-b; 28-a; 28-b). There are two groups are seen clearly on the UVW diagrams for the selected stars (Fig. 29; 30). For A0V ~ A5V stars, there are two groups could be seen on the UVW diagram, too.

**(4) Solar motion and Oort's constants**

The relation between the Gould Belt and disk in the solar neighborhood should be responded to the solar motion itself. The values of solar motion is calculated by use of the method of least squares to the equations of (6-16) ~ (6-24) from the "Galactic Astronomy" (Mihalas & Binney, 1981).

The values of the solar motion have been calculated by proper motion and radial velocity in the work and are listed on table 6. The values of the solar motion for OB stars from the work of Torra *et al*. (2000) are: (9.0, 13.4, 8.3) ±

(0.8, 0.7, 0.5) km/sec for the distance range between 600 pc to 2000 pc and (11.0, 12.9, 6.8) ± (0.2, 0.2, 0.1) km/sec for the distance range between 100 pc to 2000 pc respectively.

Table 6 Results of the solar motion

| ***Solar motion and stellar motion*** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Stars | The data for calculating | $U_\odot$ | $V'_\odot$ | $W_\odot$ | <U*> | <V*> | <W*> |
| OB stars | From proper motion | 10.6 | 12.4 | 7.5 | 8.1 | 4.0 | 6.8 |
| | From radial velocity | 8.9 | 15.8 | 9.3 | 6.4 | 7.4 | 8.6 |
| A0 – A5 stars | From proper motion | 6.8 | 12.7 | 3.9 | 5.3 | 5.1 | 2.5 |
| | From radial velocity | 10.1 | 13.7 | 6.9 | 8.6 | 6.1 | 5.5 |
| ***Stars with relative errors of $\pi$ and radial velocity $\leq$50%*** | | | | | | | |
| OB stars$_1$ | From proper motion | 12.8 | 12.8 | 7.8 | | | |
| | From radial velocity | 9.6 | 15.7 | 9.4 | | | |
| OB stars$_2$ | From proper motion | 13.3 | 12.8 | 3.8 | | | |
| A0 – A5V stars$_1$ | From proper motion | 8.2 | 11.6 | 4.5 | | | |
| | From radial velocity | 9.1 | 13.7 | 7.9 | | | |
| A0 – A5V stars$_2$ | From proper motion | 13.0 | 12.6 | 5.4 | | | |
| ***OB Stars thought to belong to the disk components*** (distance beyond 100 pc in x-axis and within Z = ± 20 pc) | | | | | | | |
| OB stars$_1$ | From proper motion | 9.3 | 13.0 | 5.0 | | | |
| | From radial velocity | 8.4 | 15.5 | 8.6 | | | |
| A0 - A5V stars$_1$ | From proper motion | 8.2 | 11.1 | 4.4 | | | |
| | From radial velocity | 8.2 | 13.2 | 5.6 | | | |

The subset '1' refers to the data contains radial velocity, and the subset '2' doesn't contains the radial velocity. They have different quantities of data. The U, V and W are with unit km/sec, while the U*, V*, and W* are average velocity removing the solar motion in the calculating way.

Stellar position and motion are also affected by the galactic differential rotation that relation to the Oort's constants, A and B.  The Oort's constants can be calculated from proper motion, $\mu_l$ and galactic longitude, *l*:

$$\mu_{\lambda} = \frac{A\cos 2l + B}{4.74},$$

The relation of radial velocity, Rv and the galactic longitude *l* is also displayed the double-sine function of *l* :

$$\mathrm{Rv} = \mathrm{Ad} \sin 2l$$

Comparing the Oort's constants of the stars in the solar neighborhood with that of distance stars, it is indicated that the characteristic of the stellar kinematics in the solar neighborhood is mainly affected by the sub-system: Gould Belt. According to the equation derived by Oort and the evolved by Lindblad (1941), Blaauw (1952), Lesh (1968), Torra, Fernández, Fig.ueras (2000) and *etc*., the Oort's constants calculated in this research work are expressed in the table 7, which respond to the values calculated from the Gould Belt stars and the disk stars.

Comparing with the results of others (on table 8), the Oort's constants for all OB stars and that of A0 – A5 stars in the research work are much different.

Table 7 The Oort's constants

| Data | Method | | A | B | C | K | note |
|---|---|---|---|---|---|---|---|
| OB | Rv | | -3.8±4.5 | -0.3±8.3 | -- | -- | O |
| | $\mu_l \cos b$ | | -4.0±3.9 | -0.1±3.9 | -- | -- | O |
| A0 – A5 | Rv | | -10.0±3.2 | 34.9±4.4 | -- | -- | O |
| | $\mu_l \cos b$ | | -6.5±6.8 | 30.6±6.8 | -- | -- | O |
| Selected stars with Rv data | OB | Rv | 7.4 | -- | -1.1 | -10.4 | T |
| | A0 –5 | Rv | 12.1 | -- | -18.0 | 12.5 | T |
| | OB | $\mu_l \cos b$ | 9.5 | 14.9 | -9.0 | -- | T |
| | A0 –5 | $\mu_l \cos b$ | -8.4 | -18.0 | -2.0 | -- | T |
| OB disk stars* | Rv | | -7.8 | | 12.6 | -6.7 | T |
| | $\mu_l \cos b$ | | 1.3 | -1.5 | -2.2 | | T |
| A0V-A5V disk stars* | Rv | | -10.7 | | -16.3 | -4.9 | T |
| | $\mu_l \cos b$ | | -9.9 | -13.7 | -3.7 | | T |

Note: T means that the equations are from Torra, Fernández, Fig.ueras (2000), while O means that the original equations are from Oort and choose the first order approximation.

* : Stars thought to belong to the disk components

Table 8 The result from other published papers

| A | B | C | K | Note | |
|---|---|---|---|---|---|
| 11.0±1.0 | -13.2±0.5 | -- | -- | For early type dwarfs from $\mu$ | Mignard (2000) |
| 14.5±1.0 | -11±1.0 | -- | -- | For the distant giants from $\mu$ | |
| (mean) 10.9±0.8 | -13.3±0.6 | -- | -- | A0 – A5 with $\|b\| < 30^\circ$ | |
| 14.8±0.4 | 12.4±0.6 | | | Cepheids (Hip. cat.) From $\mu$ | Feast & Whitelock (1997) |
| 15.1±0.3 | | | | Radial velocity | Feast *et al.* (1998) |
| 14.2 -15.6 | -26.5±3.8 | | | OB stars with R<450 pc | Tsimoumis & Frick (1979) |
| 13.1±3.2 | -13.2±3.4 | | | OB stars with 450<R<1300 | |
| 13.4±5.4 | -11.5±3.3 | | | (expansion model) O – A0 with age $\leqq 6\ 10^7$ | Westin (1985) |
| 8.9 | -15.4 | | | (linear density wave model) O – A0 with age $\leqq 6\ 10^7$ | |
| 16 | | | | H II region | Rohlfs *et al.* (1986) |
| 11.8±0.4 | -12.3±0.4 | 0.4±0.4 | -2.0±0.4 | OB stars with 100<R<2000pc | Torra *et al.* (2000) |
| 13.0±0.7 | -12.1±0.7 | 0.5±0.5 | -2.9±0.6 | OB stars with 600<R<2000pc | |

* All the data are what contain the radial velocity, and constants A, B, C, K are with unit km / sec / kpc

### (5) Transfer into the Gould Belt's coordinate system

According to the model of the Guillout *et al.* (1998), the semi-major of Gould belt is 500 pc in the direction of $l$ = 15°/195°, and the semi-minor is about 340 pc in the direction of $l$ = 105°/285°. The center lies on the node line, $l$ = 130°/310° and the distance between the center and the sun is about 200 pc.

Let the x-axis and y-axis of Gould Belt are the direction of the semi-major and semi-minor, respectively. The z-axis of Gould Belt is the direction perpendicular to the plane of the Gould Belt. The transformation equations can be obtained by using formula – three Eulerian angles. Three angles, the angle between x-axis of Gould belt and the node line, the angle between GB plane and Galactic plane (inclining angle), and the angle between $l$ = 0 and the node line, are 87 degree, 20 degree, and –50 degree in the model.

The OB stars chosen from Hipparcos catalogue for this work are fitted to the model proposed by Guillout *et al.* (Fig. 31), Olano (Fig. 32), and Lindblad *et al.* (Fig. 33). Comparing the diagram of XYZ plane on the Gould coordinate system for these three models, there is little difference on the all three model, but the Gould Belt looks like narrower in the model of Guillout *et al.* For OB stars and A0V ~ A5V stars with relative error of parallax less than or equal 50% (hereafter called sample OBA5, the Gould Belt is more easy to see on the XYZ diagrams in the Gould belt coordinate system (Fig. 34; 35).

The parameters, the center in the direction of $l$ = 36°, the inclining angle of 22°, and the node line on $l$ = 132°, are found by eyeball in terms of comparing the XYZ diagram for the sample OBA5. These parameters are used to transfer the position from galactic coordinates to Gould belt coordinates for OB stars with relative error of parallax less than or equal 50% (Fig. 36) and A0V to A5V stars with relative error of parallax less than or equal 50% (Fig. 37).