Astrometric Error Caused by Gravitational Microlensing Effect in the Galactic Bulge Stars

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We have investigated an expected deviation of the positions or the proper motions of stars as the cosmic error caused by the gravitational microlensing effect [1]. In observing stars in the Galactic bulge region, we obtain an expected deviation of a star positions by gravitational microlensing effect of about 7 μas. We have also estimated the expected deviation of the proper motions of stars in the Galactic bulge caused by the gravitational microlensing effect. The expected deviation of the proper motions is mainly caused by the lens object located at the nearest angular distance from the source star. Each deviation of the proper motion has a value of less than 0.02 μas/yr for 99 % of the sources.

In estimating the the expected deviations of positions of stars and those of proper motions of stars in the Galactic bulge region, we assume that the optical depth, τ, is about 1×10^{-6}. The typical relative proper motion between a bulge star and a lens object can be estimated as several mas/yr using the Oort constants, solar motion, and velocity dispersion. Accordingly we assume that the proper motion is about 5 mas/yr.

We have investigated the correlation of the deviation of Galactic bulge stars caused by the gravitational microlensing effect. In order to estimate the correlations of these deviations of two sources, we define the correlation between deviations of source A and source B, ρ_{AB}, as follows,

$$\rho_{AB} = \frac{\langle \boldsymbol{\delta_A} \cdot \boldsymbol{\delta_B} \rangle}{\sqrt{\langle \delta_A^2 \rangle \langle \delta_B^2 \rangle}}, \quad (1)$$

where δ_A and δ_B are positional deviations of source A and source B, respectively. The correlation ρ has a value between −1 and 1. If the value is around 1, deviations of two sources are strongly correlated. On the other hand, if the value is 0, deviations are not correlated.

Here we define the dimensionless correlation angle at which the value of the correlation is equal to 0.5. Then we can say that the deviations of two sources, separated with an angle smaller than correlation angle, are correlated. And if not, uncorrelated.

The value of the correlation angle of the positional deviation is estimated to be about 1 arcmin. In the same way, we have estimated the correlation angle of the deviation of the proper motions. The angle is estimated to be about 1 arcsec. The following difference distinguishes the deviation of the position and that of the proper motion. The positional deviation is affected not only by lenses near the source but also by the lenses far from the source. On the other hand, the deviation of the proper motion by microlensing is mainly only caused by the nearest lens from the source. This difference causes that of the correlation angle.

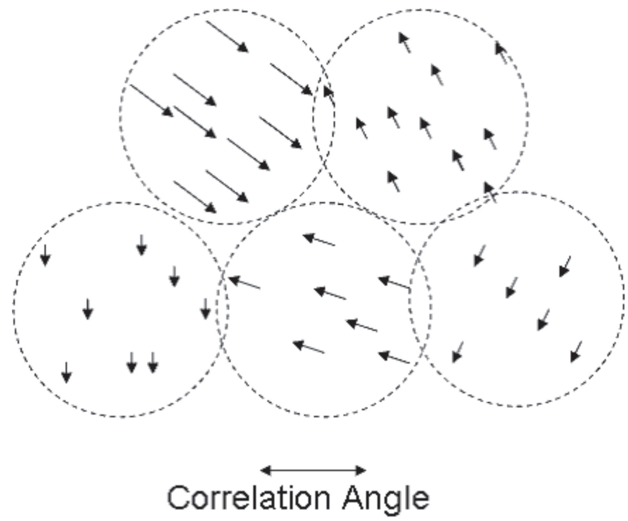

Figure 1: Schematic of the deviations and correlation angle.

Upcoming observation by an astrometric satellite like Gaia or JASMINE [2] will provide the catalogue with the accuracy of about 10 μas. Then the typical deviation with the value of 7 μas is less than the value of the observing accuracy by the forthcoming astrometric satellites. Therefore it is not a crucial problem for astrometry missions such as Gaia or JASMINE. However it will be a serious problem for the next generation of astrometry missions with the accuracy of 1 micro-arcsecond level.

References

[1] Yano, T.: 2012, *ApJ*, **757**, 189.
[2] Yano, T., Gouda, N., Kobayashi, Y., Tsujimoto, T., Hatsutori, Y., Murooka, J., Niwa, Y., Yamada, Y.: 2011, *EAS Publications Series*, **45**, 449.