

ON THE INFLUENCE OF THE TANGENTIAL SOLAR-MOTION COMPONENT

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SUMMARY: The influence of the tangential component of the solar motion (towards $l = 90^\circ$, $b = 0^\circ$) corrected for the value of the asymmetric drift, on the galactocentric orbits of selected nearby stars is studied. Different models of the Galaxy potential are used. It is noticed, in general, that the increase of this corrected velocity component is followed by changes of the orbital elements characterising the motion in the galactic plane (the component perpendicular to the galactic plane remains practically unaffected); the orbital eccentricity increases or decreases depending on whether the galactocentric tangential velocity component of a given star exceeds or not the value of the circular velocity involved by the used model.

1. INTRODUCTION

As well known, the amounts of the components of the solar motion are of importance. The values for the radial (towards $l = 0^\circ$, $b = 0^\circ$) and vertical (towards $b = 90^\circ$) components seem now sufficiently well established, considering that one very often meets the values of 10 km s^{-1} and 7 km s^{-1} , respectively (e.g. Chen, 1997; Metzger *et al.*, 1998; Miyamoto and Zhu, 1998; Dehnen and Binney, 1998; Reid, 1998; Feast, 2000; Popović, 2000). On the other hand, the tangential one (towards $l = 90^\circ$, $b = 0^\circ$) seems a little bit problematic, first of all since for the purpose of calculating the galactocentric velocity components of a given star one in fact needs the value of this component corrected for the amount of the asymmetric drift. This corrected quantity seems to be close to zero (e.g. Chen, 1997; Dehnen and Binney, 1998; Feast, 2000). Recently the present author and his coworkers (Ninković *et al.*, 1999 - in further text referred to as Paper I) studied the galac-

tocentric orbits of some nearby stars varying the values of the components of the solar motion, but there the amount of the asymmetric drift was fixed. Due to this circumstance the present author's opinion is that the galactocentric orbits of some selected nearby stars should be examined for the influence of this effect.

2. MATERIAL AND APPROACH

Nearby stars from the Catalogue of Gliese and Jahreiss are chosen as the material to be subjected to the analysis. As well known, this catalogue is unpublished, however it has been used in earlier papers of the present author (Paper I and references therein) and for all relevant details concerning its use these papers should be looked in. In order to avoid large parallax errors the precedence is given to stars sufficiently close to the Sun. A group of such stars was the subject of an earlier analysis (Lippincott, 1978). Lippincott's samples contain stars within about 5 pc around the Sun and the data were largely taken from

old Gliese's catalogue (1969). These stars are inspected in the light of more recent data, i. e. Gliese and Jahreiss (in further text simply referred to as the Catalogue). Their heliocentric velocity components, as given in the Catalogue, are corrected for the solar motion along the radial and vertical directions as related in Introduction. The remaining component is taken, as stated above, with the correction for the asymmetric drift and in the present paper it is varied between -5 km s^{-1} and $+5 \text{ km s}^{-1}$. The reasons are self-evident in view of what has been said above. Since the stars under study are practically in the same galactocentric position as the Sun, with these assumptions all initial conditions are given - the galactocentric distance of the Sun and the corresponding value for the circular velocity depend on the used model (potential) of the Milky Way. Finally, as in Paper I the distance of the Sun to the galactic plane is neglected.

In the present paper two different models of our Galaxy are used: that of Kutuzov and Osipkov (1989) and the one of the present author (1992). The two main model constants - the galactocentric distance of the Sun (R_{\odot}) and the corresponding circular velocity ($u_c(R_{\odot})$) - are given in these references.

3. RESULTS

Lippincott's list contains 47 stars. As could be expected, those are largely stars of the galactic (thin) disc. The situation is quite similar to that described in Paper I. Therefore, many details communicated there are practically the same. They concern the shape of the orbits, the remarks on the Lindblad case, the definition of the orbital eccentricity and so on. Generally it is noticed that the orbital shape remains usually unchanged after varying the tangential component of the solar motion corrected for the asymmetric drift. The changes are quantitative and they largely concern the orbital eccentricity. More precisely the orbit dimensions in Z (perpendicular to the galactic plane) are not affected, whereas the amounts of R_a and R_p are subject to changes (R_a and R_p - maximal and minimal distances to the galactic rotation axis, respectively, also see Paper I); both increase with the increasing of the value for the solar-motion tangential component corrected for the asymmetric drift. This is not surprising because, as already said, the majority of the studied stars belong to the Milky-Way disc and, therefore, the sense of their galactocentric tangential velocity component (towards $l = 90^\circ$, $b = 0^\circ$) is the same as for the Sun, consequently, it increases with the increasing of the value of the solar-motion tangential component corrected for the asymmetric drift. Of course, the resulting change of the eccentricity cannot be large since here only insignificant variations in the mentioned solar-motion component are dealt with. In view of the level up to which the solar motion is known, it is clear that only a study of such variations can be reasonable.

On the other hand, the rate of the increase in R_a and R_p depends on whether the galactocen-

tric tangential velocity component of a star is larger or smaller than the circular velocity given by the model. For those stars where the former applies R_a increases more rapidly than R_p and, as a result, the orbital eccentricity increases. If the latter case is true, then one has the reverse situation: R_p increases more rapidly and, consequently, the orbital eccentricity diminishes. Generally, since the stars studied here, as already said above, largely belong to the galactic (thin) disc, their orbits are nearly planar with eccentricities rarely exceeding 0.3.

4. DISCUSSION AND CONCLUSIONS

In the present paper the galactocentric orbits within a sample of nearby stars are studied. Two different models of the Milky Way are used, the values of the solar-motion velocity components along the directions towards $l = 0^\circ$, $b = 0^\circ$ and towards $b = 90^\circ$ are fixed, whereas the one along $l = 90^\circ$, $b = 0^\circ$, corrected for the asymmetric drift, is varied. In view of the actual level up to which the values of the solar-motion components are known these variations cannot be significant and, as a consequence, they result in insignificant changes of the orbital elements. It is shown that equally as in the case of varying the solar-motion components only, with fixed asymmetric drift, (Paper I) the resulting changes of the orbital elements are insignificant whereas the orbital shapes are changed in some rare cases only. The circumstance that here the calculations are performed with two galactic potentials parallel does not change much the results. This is especially true when the orbital eccentricity is concerned. In this way is confirmed the conclusion of Ninković *et al.* (2002) that the treatment of the same stars in different galactic potentials usually yields very similar results. Of course, it should be borne in mind that this conclusion was reached when the unit for the mean distance of a star to the galactic rotation axis was the distance of the Sun to the same axis assumed in the used model. The present paper, however, does not deal with the distance of the Sun to the galactic rotation axis. It should be noted only that the value of this distance can be influential. As an example will be mentioned the result of Ossipkov *et al.* (2001) who determined the tangential component of the galactocentric velocity of the Sun as a function of its distance to the galactic rotation axis. First, according to recent comments both values recommended by the IAU, that for the circular velocity at the Sun and the one concerning the distance between the Sun and the axis of galactic rotation, should be corrected downwards (say 8 kpc and 210 km s^{-1} , e.g. Sackett, 1997). It is curious that such corrections would preserve the value of the corresponding angular velocity (about $26 \text{ km s}^{-1} \text{ kpc}^{-1}$). Now, if the assumption of the present paper concerning the tangential galactocentric-velocity component of the Sun and the asymmetric drift were applied to the result of Ossipkov *et al.* (2001) provided that the angular velocity is fixed at the mentioned value, then the distance between the Sun and the axis of galactic rotation should be 8.5-9 kpc.

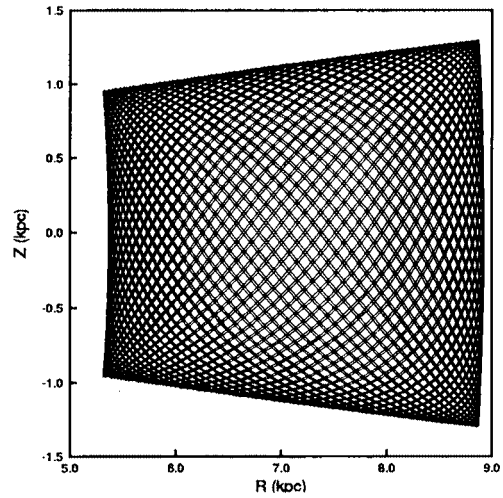
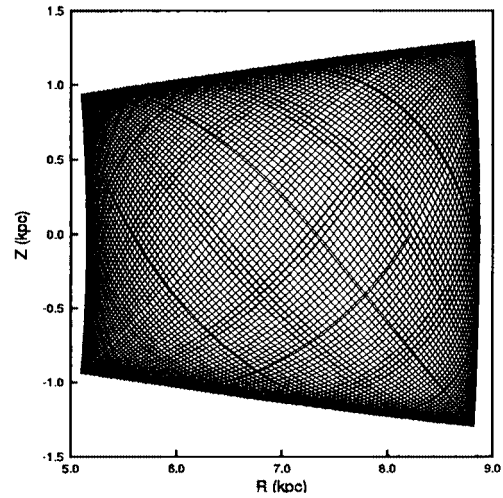
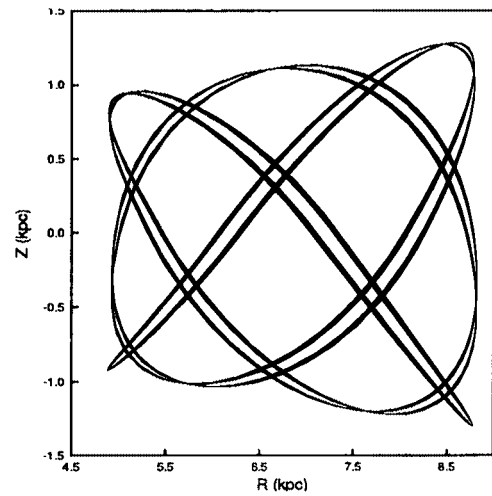
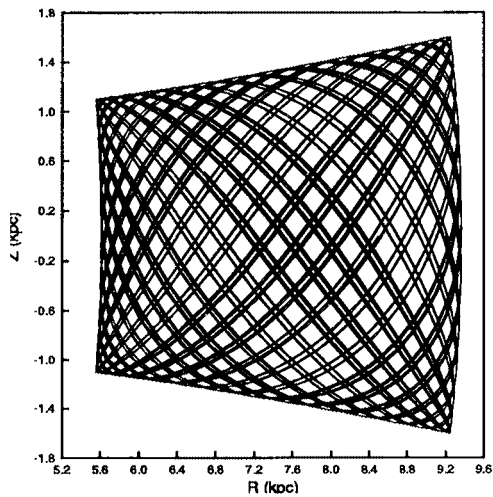
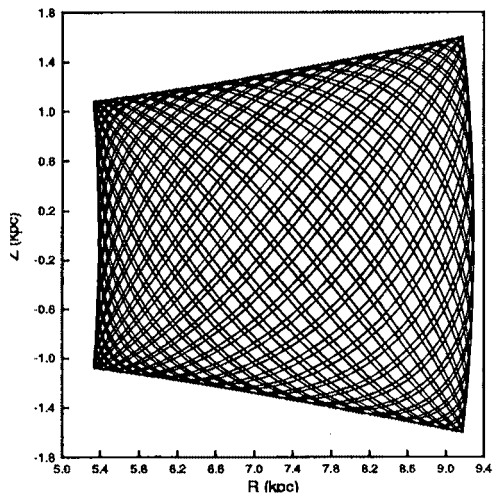
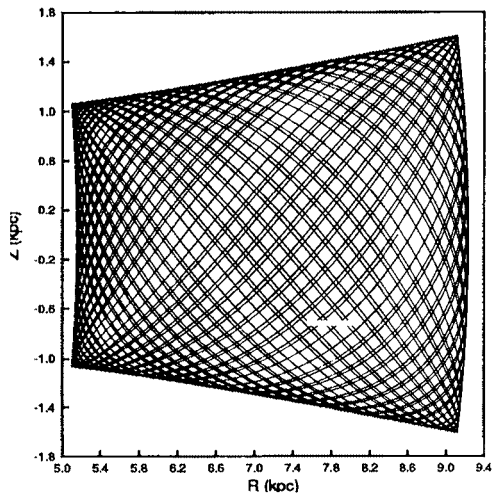


Fig. 1. Galactocentric orbit of the star Gl 411, potential Ninković, 1992: a) tangential solar-motion component corrected for asymmetric drift (V) equal to -5 km s^{-1} ; b) $V = 0$; c) $V = 5 \text{ km s}^{-1}$; other initial conditions unchanged.

Fig. 2. Galactocentric orbit of the star Gl 411, potential Kutuzov and Osipkov, 1989: a) tangential solar-motion component corrected for asymmetric drift (V) equal to -5 km s^{-1} ; b) $V = 0$; c) $V = 5 \text{ km s}^{-1}$; other initial conditions unchanged.

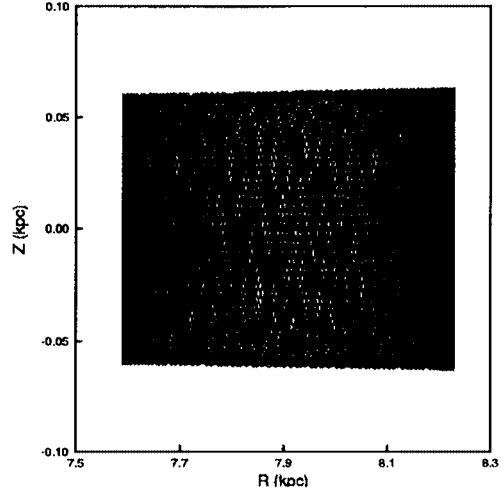
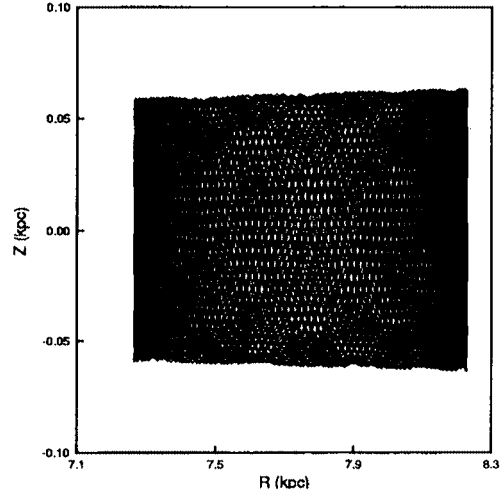
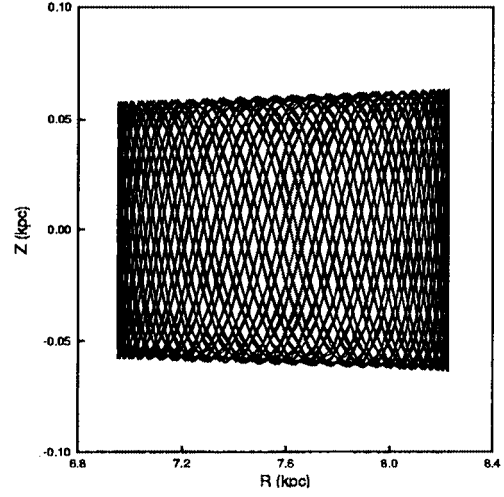
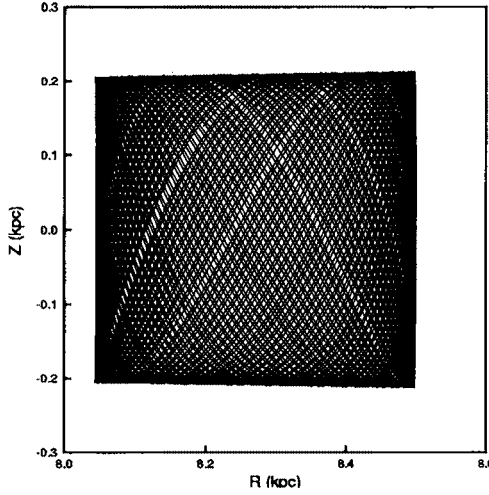
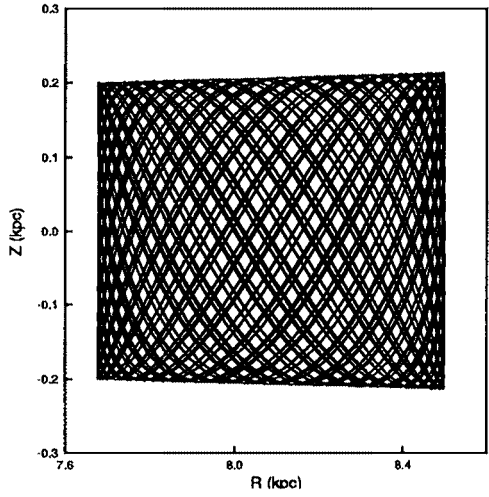
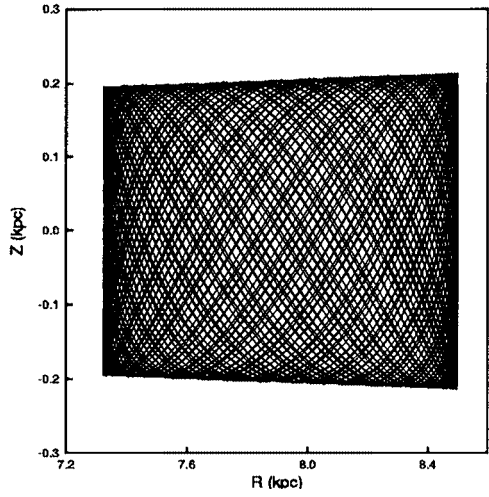


Fig. 3. Galactocentric orbit of the star Gl 876, potential Ninković, 1992: a) tangential solar-motion component corrected for asymmetric drift (V) equal to -5 km s^{-1} ; b) $V = 0$; c) $V = 5 \text{ km s}^{-1}$; other initial conditions unchanged.

Fig. 4. Galactocentric orbit of the star Gl 876, potential Kutuzov and Osipkov, 1989: a) tangential solar-motion component corrected for asymmetric drift (V) equal to -5 km s^{-1} ; b) $V = 0$; c) $V = 5 \text{ km s}^{-1}$; other initial conditions unchanged.

Undoubtedly, any further removing of uncertainties in the values of the quantities characterising the galactocentric position and velocity of the Sun, together with a higher accuracy of the observational data, will contribute essentially to a much better understanding of the galactocentric motion of nearby stars.

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О УТИЦАЈУ ТАНГЕНЦИЈАЛНЕ КОМПОНЕНТЕ СУНЧЕВОГ КРЕТАЊА НА ГАЛАКТОЦЕНТРИЧНО КРЕТАЊЕ ОБЛИЖЊИХ ЗВЕЗДА

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Оригинални научни рад

Проучава се утицај тангенцијалне компоненте Сунчевог кретања ка апексу (ка $l = 90^\circ$, $b = 0^\circ$), исправљене за вредност „заостајања“ брзине галактичке ротације у односу на кружну брзину, на галактоцентричне путање одабраних оближњих звезда. Користе се различити модели потенцијала Галаксије. У општем случају се примећује да је пораст ове компоненте брзине праћен променама путањ-

ских елемената који карактеришу кретање у равни Млечног пута (компонента нормална на ову раван остаје практично потпуно иста); ексцентричност путање расте или опада у зависности од тога да ли је галактоцентрична тангенцијална компонента брзине дате звезде већа или мања од кружне брзине која проистиче из коришћеног модела.