Giant Nemesis candidate HD 107914 / HIP 60503 for the perforation of Oort cloud

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Abstract

So far, GJ 710 is the only known star supposed to pass through outskirts of the solar system within 1 ly. We have reexamined the SIMBAD database for additional stellar candidates (from highest ratios of squared parallax to total proper motion) and compared them with new HIP2 parallaxes and known radial velocities. At the moment, the best nominee is double star HD 107914 in the constellation Centaurus at ≈ 78.3 pc from the Sun whose principal component is a white (A-type) giant. It does not seem to appear neither in general catalogues of radial velocities available at SIMBAD nor in authoritative García-Sánchez et al. papers on stellar encounters with the solar system. Awaiting for the value v_r of its radial velocity, unknown to the author, we have calculated limits of $|v_r|$ necessary to this star to pass within 1 ly and 1 pc from the Sun in linear approximation. A very accurate value of its total proper motion is also extremely important. In the case of $v_r = -100$ km/s and most "advantageous" HIP2 data, HD 107914 could pass as near as 8380 AU from the Sun in an almost direct collision course with the inner part of the solar system! Inversely, if v_r had a great positive value, then HIP 60503 could be the creator of peculiar trajectories of detached trans-Neptunian objects like Sedna.

1 Introduction

Many authors (*cf.* [1–4]) have searched past and future stellar perturbers of the Oort cloud. Indeed, it turns out that a massive star passing within 1 ly would have a significant influence on long-period comets. More closely, at 10000 AU, such a star would have a serious direct influence on trans-Neptunian objects.

Recently, Bobylev [1] has updated the list of stars supposed to transit within 2 pc from the Sun using new HIP2 parallaxes. HD 107914 is beyond the current scope of 30 pc in Bobylev's studies. This star has two currently known components CCDM J12242-3855AB of visual magnitudes 7.0 and 12.8 resp. CCDM attributes the spectral type A5 to the A-component

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while SIMBAD considers the double star as an A7/8 giant. [For the sake of comparison, A5-giant NSV 8327 at ≈ 94.9 pc has the A-component of spectral type A2 with $V_{\rm mag} = 6.0$ and B-component with $V_{\rm mag} = 14.5$ according to CCDM.] Two components are separated by 4.6 arcsec which gives, at least, 350 AU at their current distance. The total mass of the system should be greater than $2M_\odot$.

2 Estimations from proper motions and parallaxes

We use Julian years and light-years so that 1 parsec $= p \approx 3.261563777$ ly and 1 km/s corresponds to the velocity of c^{-1} ly/y where $c \approx 299792.458$ is the speed of light in km/s.

Let X be a star with parallax π_X (in mas) at the current distance of $d_X = p \cdot 10^3/\pi_X$ ly from the Sun denoted by the symbol $\odot$. The minimal distance $d_{\odot X}^{\rm min}$ from X to $\odot$ is equal to the radius R of the sphere centered at the Sun and tangent to the trajectory of X. It is easy to show that

$$\left|\frac{v_r}{v_t}\right| = \sqrt{\left(\frac{d_X}{R}\right)^2 - 1} \tag{1}$$

where v_r and v_t are radial and transverse velocities of a star X respectively. The transverse velocity can be easily calculated from available catalogue values :

$$v_t = \frac{\pi c}{648 \cdot 10^6}\mu_T d_X \text{ km/s} \tag{2}$$

where μ_T is the total proper motion of X in mas and $\frac{\pi}{648\cdot 10^6}$ the number of radians in 1 mas. From these two formulas we obtain

$$d_{\odot X}^{\rm min} = \frac{d_X}{\sqrt{K^2+1}} \text{ where } K = \frac{v_r}{v_t} = \frac{648 \cdot 10^6}{\pi c} \times \frac{v_r}{\mu_T d_X}. \tag{3}$$

Supposing that $|v_r| = 100$ km/s and $R \leqslant 1$ we should get

$$\frac{\pi_X^2}{\mu_T} \gtrapprox \frac{\pi c p^2}{64800} \approx 154.6 \tag{4}$$

So, basically, the minimal distance to nearby stars is governed by the π_X^2/μ_T ratio and $\pi_X^2/\mu_T \gtrapprox 154.6$ is necessary to see a star within 1 ly from the Sun.

For example, GJ 710 has $\pi_X = 51.12$, $\mu_\alpha \cos(\delta) = 1.15$, $\mu_\delta = 1.99$ and $v_r = -13.8$ according to HIP2 and PCRV [5, 6]. So, $\pi_X^2/\mu_T \approx 1137$ and $d_{\odot X}^{\rm min} \approx 0.985$ ly in a good agreement with known predictions [1, 4].

3 Calculation of limit radial velocities

Limit radial velocities $|v_{r,1}^{\rm lim}|$ and $|v_{r,p}^{\rm lim}|$ for stellar transits within 1 ly and 1 pc can be obtained from formula (1) with $R = 1$ and $R = p$ resp. HIP2 attributes $\pi_X = 12.77 \pm 0.46$ and proper motions $\mu_\alpha \cos(\delta) = 0.55 \pm 0.4$,

$\mu_\delta = -0.02 \pm 0.3$ to our Nemesis candidate. [Hipparcos and SIMBAD give the following values : $\pi_X = 12.89 \pm 0.80$, $\mu_\alpha \cos(\delta) = -0.24 \pm 0.66$ and $\mu_\delta = 0.77 \pm 0.52$.] Note that proper motions seem to swing around zero in different prediction modes. We summarize results in table 1 taking into account HIP2 values and measurement errors.

Table 1: Worst, **main** and best predictions for limit radial velocities necessary for HIP 60503 to pass within 1 ly and 1 pc using HIP2 data.

π_X (mas)	d_X (ly)	μ_T (mas/yr)	π_X^2/μ_T (mas×yr)	v_t (km/s)	$\lvert v_{r,1}^{\lim}\rvert$ (km/s)	$\lvert v_{r,p}^{\lim}\rvert$ (km/s)
12.31	264.95	1.0024	151.17	0.3860	102.28	31.36
12.77	255.41	**0.5504**	296.30	0.2043	**52.18**	**16.00**
13.23	246.53	0.15	1166.9	0.0537	13.25	4.06

Supposing now $|v_r| = 100$ km/s, we would get $d_{\odot X}^{\min} \approx 0.1325$ ly ≈ 8380 AU in the case of "best" predictions!

4 Discussion

Nearby stars with very small proper motions are the best targets in the search of potential Nemeses. Our example shows that very accurate measurements of proper motions are indispensable for such stars. Then one can easily create a more or less full list of Nemesis candidates only from parallaxes and proper motions and calculate limit radial velocities. Finally, eliminating stars with small radial velocities, one can use elaborated models of the galactic potential (*cf.* [4]) to calculate stellar trajectories and minimal distances from target stars to the Sun.

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