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LETTER TO THE EDITOR

HIP 21539 is not a past very close neighbour of the Sun

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ABSTRACT

Aims. A previous study claimed that the star HIP 21539 passed close to the Sun, at a distance of 1.9 pc, around 0.14 Myr ago. We show that this is not the case.
Methods. We redetermined the trajectory of the star relative to the Sun using a new accurate radial velocity from the HARPS spectrograph combined with the recent *Gaia*-TGAS astrometry.
Results. With this new data, the closest approach of HIP 21539 to the Sun is now 17 pc, instead of 1.9 pc.
Conclusions. At this distance, the star has not perturbed the Oort cloud.

Key words. solar neighborhood – techniques: radial velocities – catalogs – stars: kinematics and dynamics

1. Introduction

We present a short improvement to the interesting paper by Dybczyński & Berski (2015) about close stellar passages at less than 2 pc from the Sun with a possible impact on cometary orbits. As part of the work aimed at defining stellar radial velocity standards (RV-STD) for the calibration of the *Gaia* Radial Velocity Spectrometer (RVS; Crifo et al. 2010; Soubiran et al. 2013), we obtained a much better radial velocity (RV) for one of their targets, i.e. HIP 21539. This new RV is derived from three independent observations by the HARPS spectrograph and rules out the possibility for this star to have had such a close passage in the recent past. New values for the date and minimum distance are estimated with the straight line approximation.

2. The problem

Dybczyński & Berski (2015) carefully examined the possible candidates for close passages of already nearby stars at a distance less than 2 pc from the Sun, as such objects may strongly perturb the Oort cloud. Just before, Bailer-Jones (2015) carried out a very similar work. Both papers used the XHIP catalogue by Anderson & Francis (2012) as an entrance list. The XHIP catalogue contains all necessary data. Parallaxes and proper motions are taken from the HIP-2 catalogue (van Leeuwen 2007): but radial velocities come from a vast compilation made by Anderson and Francis, who really searched deep in the literature for all possible existing data.

The star HIP 21539 is found only in the paper by Dybczyński & Berski (2015); it is supposed to have had its closest approach 0.14 Myr ago at a perihelion distance of 1.92 pc. The corresponding radial velocity is 248 km s^{-1}, issued from the Barbier-Brossat et al. (1994) catalogue, itself referring to Contreras & Stock (1970), "Radial velocities for twenty-three stars selected from an objective prism survey are communicated.

The data indicate that the peculiar G- and K-stars included in the program constitute a high velocity group". The data quality is quoted as "D" in XHIP, i.e. the lowest quality. No other value is available in Simbad or Vizier.

3. New radial velocity

In order to find additional RV-STD for the *Gaia* RVS, we searched the AMBRE-HARPS catalogue (De Pascale et al. 2014). This catalogue provides atmospheric parameters for the ESO:HARPS archived spectra, together with radial velocities either derived by the ESO:HARPS reduction pipeline or by the AMBRE pipeline. The HARPS spectrograph is a velocimeter mounted on the ESO 3.6 m telescope at La Silla, with a resolving power of $R = \lambda/\Delta\lambda = 115\,000$; for more details see Pepe et al. (2000).

To be consistent with our previous lists of RV-STD candidates (Crifo et al. 2010; Soubiran et al. 2013), the RV measurements must be expressed in the SOPHIE scale; SOPHIE is another velocimeter at Observatoire de Haute-Provence with $R = 75\,000$ and a reduction pipeline similar to that of HARPS.

For HIP 21539, the AMBRE-HARPS catalogue provides three measurements of RV from the ESO pipeline at dates 2003/12/11, 2004/02/01, and 2004/11/26, i.e. a time span of 351 days.

The weighted average of these three values gives

$$\text{RV} = 26.926 \text{ km s}^{-1}; \quad \sigma_{\text{RV}} = 0.0026 \text{ km s}^{-1}.$$

The star was integrated into the list of radial velocity standards for the RVS.

4. Linear approximation

We now calculate a new approximate minimum distance and corresponding date for the closest approach of the star to
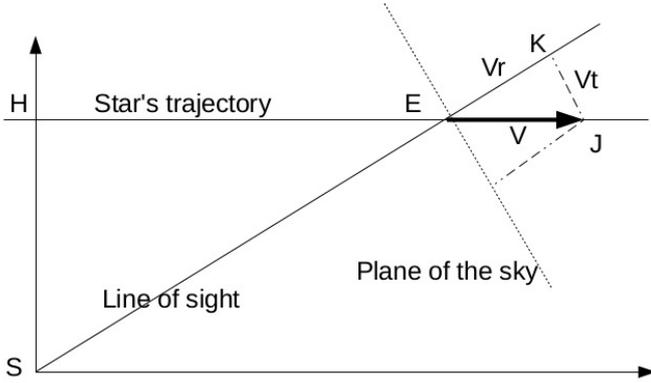
Fig. 1. Trajectory of the star relative to the Sun. The star E moves uniformly along the straight line. H is the perihelion.

the Sun, called d_{ph} and t_{ph} (distance and time from perihelion) according to Bailer-Jones (2015). Bailer-Jones and Dybczyński & Berski first computed d_{ph} and t_{ph} with the linear approximation and then with the introduction of the Galactic potential perturbing the linear motion; Bailer-Jones used the linear approximation for a first gross selection within the XHIP catalogue (Anderson & Francis 2012). In their Table 2, Dybczyński & Berski (2015) compare the results of the two calculations: the difference for d_{ph} becomes noticeable for $|t_{ph}| > 3$Myr, i.e. for far-away stars that travelled long enough in time to have felt the influence of the Galactic potential. In our case, the linear approximation is largely sufficient; moreover the final value of t_{ph} (~1 Myr) shows that it is appropriate.

Figure 1, taken from Green (1985, Fig. 11.1), illustrates the positions: S = Sun; E is the star at our epoch (SE = r), and assumed to move with an uniform velocity along a straight line; H is the closest approach to the Sun (perihelion for Bailer-Jones), at a distance SH = d_{ph} and a time t_{ph} to be calculated (origin of time at E). The total velocity V is projected over the line-of-sight SE and the plane of the sky; the components are V_r and V_t.

In the right triangle EKJ we have EK = V_r; JK = V_t. By comparing the right triangles EKJ and EHS, we may write

$$\text{SH/SE} = \text{JK/JE} = V_t / V_{tot} = d_{ph}/r$$
$$\text{HE/SE} = t_{ph} \cdot V_{tot}/r = \text{KE/JE} = V_r/V_{tot}.$$

Hence,

$$d_{ph} = r.V_t/V_{tot}; \quad t_{ph} = -r.V_r/V_{tot}^2.$$

A sign "−" must be introduced in front of the expression of t_{ph}, as the origin of time is supposed to be at position E, and V_r is positive when the star is receding from the Sun.

The values V_t and V_{tot} are calculated from the proper motion components μ_α and μ_δ and the parallax ϖ,

$$V_t = k.\sqrt{\mu_\alpha^2 + \mu_\delta^2}/\varpi; \quad V_{tot} = \sqrt{V_t^2 + V_r^2},$$

where $k = 4.74$ is the coefficient converting the arcsec yr^{-1} in km s^{-1} (see Bailer-Jones Eq. (5); Green, Eq. (11.8)).

5. Results

The resulting numerical values are given in Table 1 in the following three cases:

– cases "old" and "new" for the two values of RV: the old bad value and the new HARPS value, combined with

Table 1. Calculation of old and new distance of perihelion.

Case	ϖ mas	μ_α mas yr^{-1}	μ_δ mas yr^{-1}	V_r km s^{-1}	d_{ph} pc	t_{ph} Myr
Old	28.580	−80.73	15.70	248.000	1.92	−0.14
Sig	1.340	1.08	1.28	20.000	0.20	0.04
New	28.580	−80.73	15.70	26.926	15.81	−1.03
Sig	1.340	1.08	1.28	0.003	1.06	0.05
TGAS	27.270	−81.31	15.27	26.926	17.27	−1.06
Sig	0.280	0.08	0.09	0.003	0.25	0.01

the parallax and proper motion from HIPPARCOS-2, as in Dybczyński & Berski, Table 2;
– case "TGAS" for the HARPS RV combined with the recently published parallax and proper motion from the TGAS Catalogue: *Tycho-Gaia* subset, available at CDS (Gaia Collaboration 2016).

In Table 1, each "case" is made of two lines: the upper line contains the data itself; the lower line (noted "sig") contains the corresponding errors, taken from SIMBAD (HIP2) or TGAS. An arbitrary error of 20 km s^{-1} was adopted for the old RV of 248 km s^{-1} (order of magnitude for error on radial velocities obtained with objective prism, but unrealistic here). Using the TGAS data instead of HIP-2 improves the accuracy of d_{ph} and t_{ph}.

With updated RV, parallax and proper motion, the closest approach of HIP 21539 to the Sun is now 17.3 pc, ~1 Myr ago instead of 1.9 pc and 0.14 Myr ago, as first computed by Dybczyński & Berski.

6. Conclusions

These new data show that HIP 21539 did not pass very close to the Sun; it therefore certainly did not perturb the Oort cloud. This short paper shows the importance of reliable RV for a good description of the solar neighbourhood and Galactic mechanics. The RVS on board *Gaia* is expected to provide radial velocities for more than 100 millions stars and revolutionize our knowledge of kinematics in the solar neighbourhood.

References

Anderson, E., & Francis, C. 2012, Astron. Lett., 38, 331
Bailer-Jones, C. A. L. 2015, A&A, 575, A35
Barbier-Brossat, M., Petit, M., & Figon, P. 1994, A&AS, 108, 603
Contreras, C., & Stock, J. 1970, Publications of the Department of Astronomy University of Chile, 2, 40
Crifo, F., Jasniewicz, G., Soubiran, C., et al. 2010, A&A, 524, A10
De Pascale, M., Worley, C. C., de Laverny, P., et al. 2014, A&A, 570, A68
Dybczyński, P. A., & Berski, F. 2015, MNRAS, 449, 2459
Gaia Collaboration (Brown, A. G. A., et al.) 2016, A&A, 595, A2
Green, R. M. 1985, Spherical astronomy (Cambridge, New York: Cambridge University Press)
Pepe, F., Mayor, M., Delabre, B., et al. 2000, in SPIE Conf. Ser. 4008, eds. M. Iye, & A. F. Moorwood, 582
Soubiran, C., Jasniewicz, G., Chemin, L., et al. 2013, A&A, 552, A64
van Leeuwen, F. 2007, A&A, 474, 653