Discovery of a Wide Binary in the Solar Neighborhood

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Abstract: During the work on a report with the topic of star systems in the solar neighbourhood up to 10 parsecs a so far unknown wide binary was discovered at a distance of ~8.1 parsecs from the Sun. This comes rather as a surprise as stars in the solar neighborhood are most likely the best investigated stellar objects

Part of the work on a report on star systems in the solar neighborhood up to 10 parsecs (currently in progress) was the selection of GAIA DR2 objects with parallax > 100mas and parallax error < 0.5% and Gmag < 18. The resulting 34 objects at a distance up to 10 parsecs included a pair so far not listed in the WDS catalog or other catalogs with binaries/multiples in the solar neighborhood.

The primary is TYC 3980-1081-1 (Gaia DR2 2202703050388170880) at J2000 position RA 21 51 38.297 Dec +59 17 38.456 with Gmag 9.3832 and parallax 123.0568 mas with error 0.5944 which means a distance of ~8.1 parsecs from the Sun. The secondary is UCAC4 747-070768 (Gaia DR2 2202703050401536000) at J2000 position RA 21 51 40.108 Dec +59 17 34.854 with Gmag 14.3852 and parallax 118.1243 mas with error 0.0208. Using the DR2 data for a Monte Carlo simulation calculating spatial distance between the components (see Appendix) results in a minimum distance of ~33,000 AU, a median distance of ~70,000 AU and a maximum distance of ~105,000 AU suggesting strongly a potential gravitational relationship (see Figure 1).

It seems a bit surprising to detect a new likely physical pair this close to the Sun, but this might be explained by the rather large delta parallax of ~5 mas between the two components making a potential gravitational relationship not very obvious at first glance.

Even more surprising is the fact that not even the primary is listed as close to the neighboring object in, for example, the RECONS project – this asks for additional research. Finch et al. 2016 give a parallax of 154.8 mas with a rather large error of 12.1 mas and for this reason this object was not included in the Henry et al. 2018 paper on new discoveries within 10pc. So there might be some caveats regarding this object but nonetheless the currently given data suggests a so far not identified physical system at a distance within 10 parsecs from the Sun even if DR2 proper motion data are somewhat different.

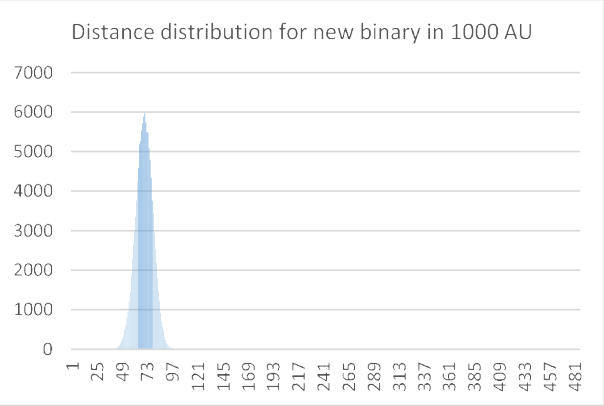

Figure 1. Distance distribution for newly detected binary in 1000 AU.

Gaia DR2 lists neither for the primary nor for the secondary a duplicated_source indication but the RUWE value for the primary is > 16 suggests that the Gaia DR2 single-star model does not provide very good fit to the astrometric observations – in this case just indicating for good reasons that the source is a non-single object.

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The Gaia DR2 StarHorse catalog (Anders et al. 2019) provides a median mass for the primary of ~0.5 Sun mass but no such value for the secondary – an estimation based on magnitude difference gives ~0.15 Sun mass for the secondary. Based on these values a potential orbit (see Appendix) would have a minimum period of several million years, which means that most likely no human time frame will deliver enough observations for a reliable calculation of such a long period orbit.

Data for KPP4430 (WDS 21516+5918) based on Gaia DR2 2015.5 values are as follows:

- 327.90966427 RA J2000 in degrees
- 59.29440774 Dec J2000 in degrees
- 111.954 Position angle J2015.5
- 0.003 Error position angle
- 14.64214 Separation in arcseconds
- 0.00078 Error separation
- 10.93868 Estimated Vmag primary
- 0.00286 Error estimated Vmag Primary
- 14.58762 Estimated Vmag secondary
- 0.00227 Error estimated Vmag secondary
- 123.0568 Parallax primary in mas
- 0.5944 Error parallax primary
- 8.12633 Distance primary from the Sun in parsecs
- 118.1243 Parallax secondary in mas
- 0.0208 Error parallax secondary
- 8.46566 Distance secondary from the Sun in parsecs
- -79.190 Proper motion RA primary in mas/yr
- 10.517 Proper motion Dec primary in mas/yr
- -86.799 Proper motion RA secondary in mas/yr
- -19.190 Proper motion Dec secondary in mas/yr
- 33,031 Minimum spatial distance between the components in AU
- 0.50268 StarHorse median mass for primary in Solar masses
- 0.15000 Estimated mass for secondary in Solar masses
- 7,472,048 Minimum period of a potential orbit in years

Acknowledgements

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- DSS2 images
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- Aladin Sky Atlas v10.0
- GAIA DR2 catalog
- GAIA DR2 StarHorse catalog
- Washington Double Star Catalog
- CDS VizieR
- CDS TAPVizieR
- Gaia@AIP Services hosted by the Leibniz-Institute for Astrophysics Potsdam (AIP)

References

F. Anders, et al., 2019, "Photo-astrometric distances, extinctions, and astrophysical parameters for Gaia DR2 stars brighter than G = 18", *Astronomy & Astrophysics*, **628,** A94.

Finch, Charlie T., Zacharias, Norbert, 2016, "Parallax Results from URAT Epoch Data", *The Astronomical Journal*, **151**, Issue 6, article id. 160, 12 pp.

Todd J. Henry, et al., 2018, "The Solar Neighborhood XLIV: RECONS Discoveries within 10 parsecs", *The Astronomical Journal*, 155:265 (23pp).

Knapp, Wilfried R. A., 2018, "A New Concept for Counter-Checking of Assumed Binaries", *Journal of Double Star Observations*, **14** (3), 443.

Appendix

Description of the Potential Gravitational Relationship assessment procedure (according to Knapp 2018):

GAIA DR2 data for RA/Dec and Plx are used for a Monte Carlo simulation assuming a normal distribution for these parameters with the given error range as standard deviation. The distance between the components is calculated from the inverted simulated parallax data and the simulated angular separation using the law of cosines

$$\sqrt{a^2 - 2ab\cos\gamma + b^2}$$

with a and b = distance vectors for the stars A and B in lightyears calculated as (1000/Plx)*3.261631 and γ = angular separation in degrees calculated as

$$\gamma = \arccos\left[\sin(DE1)\sin(DE2) + \cos(DE1)\cos(DE2)\cos(|RA1 - RA2|)\right]$$

The likelihood for potential gravitational relationship (LPGR) is the percentage of simulation results < 200,000 AU (~1 parsec) out of the simulation sample with a size of 120,000 corresponding with the likelihood that the real distance is smaller than 200,000 AU with an margin of error of 0.37% at 99% confidence.

The minimum, median, and maximum distance is the smallest, median, and largest result of the simulation sample.

Ignoring the likely effects of eccentricity the smallest/median/largest distance is used as estimation for the value for the semi-major axis of a potential orbit allowing for the calculation of a minimum/median/maximum orbit period assuming zero inclination using either median mass data from Anders et al. 2019 or if not available mass estimation from other sources.