

TYC 2036-1173-1: An Optical Triple Star System in Corona Borealis?

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Abstract: TYC 2036-1173-1 is a $V=12.4$ mag star in Corona Borealis, neighbored by two fainter stars of $V=15.7$ mag and $V=17.1$ mag. While their colours and comparable proper motion might be suggestive of a true visual triple star system, astrometric data from Gaia DR2 and UCAC5 indicate that they may potentially be unrelated.

Introduction

While hunting for uncataloged multiple stars in SDSS images, I came across an interesting group of three stars that give the appearance of a visual triple star system in survey imagery (see figure 1). The system is composed of TYC 2036-1173-1 ($V=12.36$), UCAC4 579-051312 ($V=15.65$) and UCAC4 579-051311 ($V=17.13$), which I have decided to label A, B and C respectively throughout the rest of this paper. The group appears to be absent from the SIMBAD, Stelle Doppie and Vizier database.

In the case of A, the Visual Magnitude and the B-V colour index were extracted from the APASS (Henden, 2016) catalogue. However, due to the fainter nature of B and C, their B-V indices and Visual magnitude could only be determined from GSC2.3 (STScI, 2006) data.

The B-V and the Gaia Bp-Br colour indices (Gaia Collaboration, 2018) of these stars indicate that they have the following spectral types: G9.5V or K1V (A), K4V or K6.5V (B), and K6.5V or M1.5V (C). These colours reflect the appearance of the stars in survey imagery (e.g. figure 1), as well as those of a potentially true trinary system. Based on the absolute magnitude of the Gaia G filter (MG) and the Bp-Br colours (Gaia Collaboration, 2018) it appears that A and B are of the main sequence (Gaia Collaboration, 2018b). The lack of Gaia DR2 parallax data for the faintest component (see Table 3) makes it impossible to calculate its MG. However, the object's faint Mid-IR response in WISE suggests that it is most likely a main-sequence star rather than a K or M-type giant. The photometric properties of these stars are summarized in Table 1.

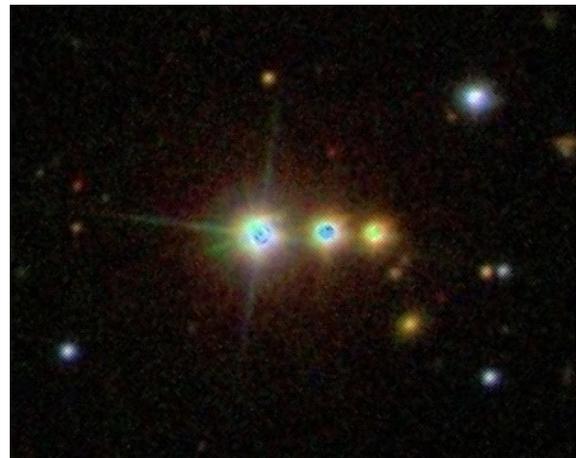


Figure 1: Discovery SDSS image extract showing the group of three stars. Their visual appearance in this image is much like that of a triple star system. From left to right: TYC 2036-1173-1 (A), UCAC4 579-051312 (B) and UCAC4 579-051311 (C). The image was taken on B2003.4818.

| Star | Mag | MG | G | Bp | B-V | Bp-Br |
|------|------|-----|------|------|------|-------|
| A | 12.4 | 3.5 | 12.3 | 12.7 | 0.83 | 0.96 |
| B | 14.0 | 7.3 | 14.0 | 14.6 | 1.62 | 1.32 |
| C | 16.0 | -- | 15.4 | 16.2 | 2.17 | 1.69 |

Table 1. Photometry (APASS, Gaia DR2 and GSC2.3)

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| Star | UCAC5 PM (RA) | UCAC5 PM (DEC) | URAT1 PM (RA) | URAT1 PM (DEC) |
|------|------------------|-------------------|------------------|-------------------|
| A | -9.3 | 12.3 | -6.4 | 17.7 |
| B | -7.4 | 13.8 | -5.5 | 21.6 |
| C | -13.8 | 7.0 | -5.1 | 17.2 |

Table 2: Proper Motion (UCAC5 and URAT1)

Astrometry

In regards to the astrometric properties of this system, the URAT1 (Zacharias, 2015) catalogue indicates that all three stars have a relatively similar proper motion, especially A and C (see Table 2), very much like a true common proper motion triplet. UCAC5 (Zacharias, 2017) shows comparable proper motion values to URAT1, but indicates that A and B are significantly more similar in terms of their proper motion than C (see Table 2).

Interestingly, astrometric data from Gaia DR2 shows that A and B are likely unrelated based on their parallax. Indeed, B appears to be significantly closer than A (~ 950 ly and ~ 1860 ly respectively), even when including the measurement uncertainties. Gaia DR2 measurements were also used to calculate the apparent separation (Sep) and the Position angle (PA). The Gaia DR2 astrometry measurements for these stars are summarized in Table 3. Note that the UCAC5 measurements are significantly more similar to Gaia DR2 in comparison to URAT1.

Unfortunately, Gaia DR2 does not list any astrometric data for C, with the exception of positional data. Hence, it is not possible to rule out the possibility of C being at a similar distance to A or B. Indeed, the apparent separation is such that C could theoretically be gravitationally bound to either A or B, based on the parallax measurements of the latter two. More specifically, assuming C is at the same distance as A, the physical distance would be ~ 2.5 ly. In comparison, the separation would be ~ 0.5 ly if at the same distance (bound) to B. However, due to the differences in the proper motion measured by UCAC5, it is possible that C may be unrelated to A and B.

Conclusion

While the colors and the relatively similar proper motion of TYC 2036-1173-1, UCAC4 579-051312 and UCAC4 579-051311 are indicative of a trinary star system (especially according to URAT1 astrometry), Gaia DR2 shows that the two brightest members are likely unrelated based on their parallax. Furthermore, UCAC5 astrometry indicates that the faintest member differs significantly in its proper motion from the two others (despite being relatively similar), hence indicating that this star may perhaps be unrelated to the two others. Further study may be needed to assess the true nature of this system, especially in the case of UCAC4 579-051311 in relation to the two others.

Acknowledgments

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| Star | Coordinates (RA+DEC) | PM (RA) | PM (DEC) | Plx (<u>mas</u>) | Sep | PA |
|------|----------------------|---------|----------|--------------------|-------|------|
| A | 154525.06+253740.2 | -9.25 | 11.81 | 1.75 | -- | -- |
| B | 154524.29+253740.3 | -7.50 | 14.29 | 3.44 | 10.6" | 271° |
| C | 154523.74+253740.3 | -- | -- | -- | 17.8" | 270° |

Table 3: Gaia DR2 Astrometry

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