GSC1753-1506: Discovery of a New Binary

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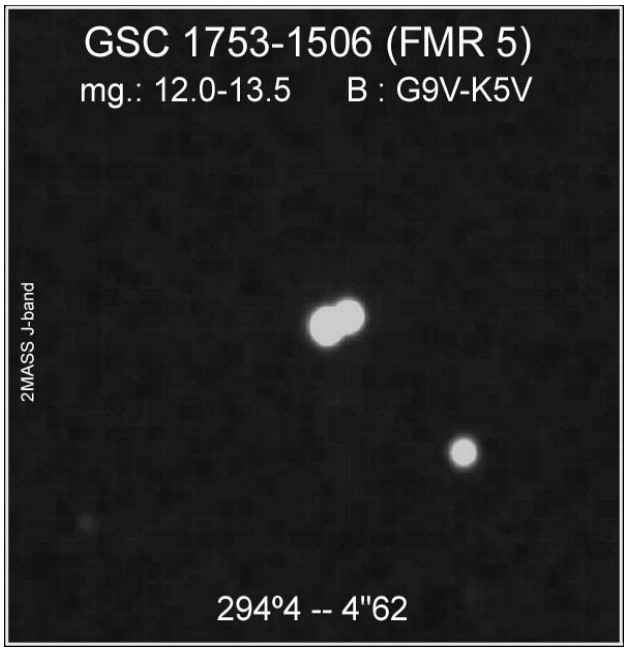
Abstract: Double star amateurs observers can contribute to the double star community searching for new uncataloged binaries, but astrophysical criteria are fundamental to reject optical pairs and not increase the great account of non-astrophysical doubles in WDS. This work reports the discovery by LIADA Double Star Section of a new binary, GSC1753-1506, composed of 12.0 and 13.5 magnitudes stars with an angular separation of 4.62" in direction 294º4. Analyzing 2MASS JHK photometry and Tycho-2 data the binary are composed for G9V and K5V stars located at 172 pc. Several professional criteria were used and GSC1753-1506 is a very strong physical candidate

Introduction

The most expert double star amateurs can contribute to science by measuring double stars. Another contribution more important is to discover new binary systems by searching projects or in an accidental way. Nowadays there are several amateurs that include new pairs of stars in the WDS catalog, but sadly most of them don't use any astrophysical criterion and so many of the new pairs are optical ones with no astrophysical interest. Amateurs can use a lot of professional criterion some easy to use and some not so easy. But there is one criterion that is very easy to use and allows us to reject the majority of optical pairs by consulting the proper motions of the components. Why is this data so important? Because physical pairs have very similar proper motions. Those pairs whose components have dissimilar proper motions are optical. Everybody that reports new discoveries must use one or more astrophysical criterion because we must make an effort to reject all optical pairs in the WDS catalog.



Discovery, infrared photometric and kinematics data.

In a routine study of the double star HJ 635 a close pair was observed near the John Herschel double. This object is listed in the GSC catalog as GSC1753-1506 and it is located at α = 01h 11m 34.8s and δ = +28º 23' 28" in Pisces. It was studied by LIADA and using Aladin and Simbad tools from the Stellar Data Center of Strasburg (France) obtained J, H and K infrared photometry from the Two Micron All Sky Survey (2MASS). See Table 1. Individual optical photometry or proper motions were not found in any catalog. Tycho-2 catalog listed an object with V=11.61 and B-V=+0.61 with proper motion of μ(α) =+0.050"±0.003" and μ(δ) =-0.009"±0.003".

Relative astrometry measure.

We measured relative astrometry from 2MASS J, H and K, CCD images taken by a 1.0 telescope using fv, a FITS viewer and editor tools developed at the High Energy Astrophysics Science Archive Research Center

(HEARSAC) at NASA/GSFC. The results obtained were 294°4 and 4.62" in 1997.831.

Spectral types estimate and deduced V magnitudes.

Photometric data were transformed to the spectral type and, when the stars are very red, to the luminosity class using J-H vs H-K two-colour diagram and several tables that relates photometric data with spectral data used by professionals M.S. Bessell & J.M. Brett (1988) and Gerald E. Kron (1988). Several useful tables are from the "Handbook of Space Astronomy and Astrophysics" of the Harvard University. The process transforms the magnitudes of the problem-star in energy in Jy (1 Jy = 10^{-23} erg * sec^{-1} * cm^2 * Hz^{-1}) and compares the spectral distribution of a component with those of the empirical tables.

When the star is not red enough to obtain the luminosity class using only photometry data, then we must use Reduced Proper Motion Diagrams (Eric M. Jones, 1972; C. A. Nelson, 2002; Salim Salir, 2002). These diagrams relate the observational photometric data and proper motions with a parameter that is characteristic of a population star (dwarfs, giants, sub dwarfs, white dwarfs...).

A preliminary study using 19 components with known spectral types results in a mean difference of 0.5 spectral subclass, and the luminosity class was estimated in the 19 components.

GSC 1753-1506 is composed of G9V and K5V stars (if there is no reddening) with V magnitudes of 12.0 and 13.5 (calculated using J, H and K energy distribution). The reddening could be of 0.05 magnitude in B-V color, so the spectral types could be one subclass hotter.

Are both components bounded gravitationally?

Absolute magnitudes and bolometric corrections are from the "Handbook of Space Astronomy and Astrophysics" of the Harvard University. Spectroscopic distances were calculated, and the distance modulus of +6.3 and +6.2 (about 178 parsecs) for the components indicates that both components are likely to be at the same distances.

Abt (1988) obtained the relation between the mass of the primary and the maximum separation of the components. LIADA estimates masses of 0.83 $M_\odot$ and 0.65 $M_\odot$ using professional references (P. Couteau, 1947; Todd J. Henry, 1993). At a mean distance of 179 pc the projected separation is 854 A.U., and the formulae of Abt give a maximum separation of 1821 A. U. So GSC 1753-1506 could not be an optical pair.

Another professional criterion of value is the relative motion of the system (the difference of the components' proper motions) that for physical pairs is the projected relative orbital motion. There is no other relative astrometry, and the components' proper motions are unknown, but if the relative motion is less than 3 m.a.s. * yr^{-1} then GSC 1753-1506 would be a physical pair.

TABLE I. DATA FOR GSC 1753-1506		
	Primary	Secondary
K	+10.04	+10.54
J-H	+0.40	+0.59
H-K	+0.07	+0.12
V	+12.0	+13.4
Spectra	G9V	K5V
Mv	+5.74	+7.3
Bolometric correction	-0.17	-0.49
Mass (Solar Mass = 1)	0.81	0.65
Distance (parsecs)	179	166

To estimate whether the secondary is physically associated, we calculated the Poissonian probability P, which assumes that for a random star field as bright as or brighter than the primary, the companion would be projected by chance within a radius ρ of the primary. This criterion was first used by John Michell in 1767 as a test for the existence of physical double stars. In 1999, a group of professionals used this method to establish the physical association of companions around several planetary nebulae. LIADA results indicated a very small chance probability of 0.08 %. To obtain a more realistic interpretation LIADA analyzed the P values for a subset of visual double stars studied by us in other observational programs. Against physical and optical pairs about 50% and 3.6% respectively, have values of P less than that for GSC 1753-1506. In a population very rich in optical pairs, the probability that GSC 1753-1506 is a physical pair is 78%. If the number of optical and physical pairs are identical then the probability increases to 93%.

Orbital Parameters.

In an orbit one of the most important data is the semi-major axis. We can calculate the expected semi-major axis, E(a), in arc-seconds, using the work of Paul Couteau (1960). To transform the semi-major axis to A.U. we can use the following simple formula:

$$Projected\ separation\ = a\ /\ \pi$$

Where a is the semi-major axis and π is the parallax of the binary. LIADA considered the mean photometric parallaxes of the components. The photometric parallaxes were calculated using spectral types and luminosity class estimated and the absolute magnitude obtained from several professional references.

The orbital period was calculated using the following formula derived from the Kepler Laws:

$$P = \sqrt{\frac{E(a)^3}{\sum M_{\odot}}}$$

For GSC 1753-1506, E(a)=6.47" that at the distance of the system is 1194 A.U. The approximate orbital period is 34,800 years. Table 2 contains measurements for this binary pair.

TABLE II. BINARY GSC 1753-1506	
θ and ρ	294°4 and 4.62" (1997.831)
Magnitude (spectral types)	12.0 – 13.5
Distance	172 pc
Semi-major axes	6.47" = 1,194 A.U.
Period	34,800 years

Conclusion

Astrometric and photometric data from the 2MASS catalog were used to obtain relative astrometry, spectral types, photometric parallaxes and other astrophysical data for GSC 1753-1506 which was found to be a close pair of weak components. The similar spectrophotometric parallaxes of the components in addition to the results of several professional criteria give us strong evidence that point to a physical association of both components. Nevertheless it is necessary to have more relative astrometric data to confirm the physical nature.

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