The Suspected Binarity of the Nearby Flare Star Gl 424

V. S. Tamazian[1], J. A. Docobo[1], and Y. Y. Balega[2]

[1] Observatorio Astronómico Ramón María Aller, Avenida das Ciencias s/n, Santiago de Compostela, Spain oatamaz, oadoco@usc.es
[2] Special Astrophysical Observatory, N. Arkhyz, Karachai-Cherkasia 369167, Russia balega@sao.ru

Summary. A suspected $0.''132$ companion to the nearby flare star Gl 424 (=SZ UMa) was observed in the course of our speckle interferometry run with the 6m telescope of the SAO (Russia). The distance and magnitude difference ($\Delta V = 3.^m7$) suggest this companion to be a M 4.5 dwarf with a mass of 0.18 $M_\odot$. Rough estimates for the semi-major axis and the dynamical mass of the system lead to a possible orbital period of about 2.5 years. Should its binarity be confirmed, Gl 424 becomes an excellent target for obtaining an accurate orbit on a short time span.

1 Introduction

Multiplicity is an important parameter in the study of formation and dynamical evolution of stars and stellar systems. The largest part of their astrophysical interest is directly related with the knowledge of the binary (or multiple) character of the star.

The binary fraction is rather well determined for solar like stars [1] but much less constrained for M dwarfs. Investigations of a large sample of M dwarfs show its noticeable scatter from 42% [2] and 35% [3] to 26% [4] which are much less than the 57% obtained by Duquennoy and Mayor [1] for G dwarfs. Such a scatter is partly attributable to the uncertain completeness correction needed to account for the influence of the unresolved systems on the mass and luminosity functions.

The nearby flare stars represent an interesting sample almost exclusively comprising young M dwarfs which exhibit, as a rule, a high level of stellar activity [5]. The catalog of Pettersen [6] (limiting distance 25pc) slightly enlarged by [7] comprises 108 stars (23 visual binaries) whose occurrence in binary and multiple systems is not yet specifically studied in detail. The precise knowledge of their distance coupled with a good quality orbit allow to obtain an accurate dynamical mass estimate for these stars.

With the aim 1) to track the orbital motion in binary systems containing at least one flare star and 2) to search for new close companions, we routinely observe a number of flare stars with the speckle interferometry technique.

Gl 424 is a bright ($V = 9.56$) nearby flare star classified in [8] as M0V. It belongs to the handful of low activity flare stars exhibiting H_α in absorption [9]. Abundant photometric data regarding this star can be found in [10]. No change in its radial velocity was detected in [11]. Using the Hipparcos parallax $\pi = 109.9$ mas, a distance $d = 9.10$ pc and a luminosity $M_V = 9.77$ are obtained for this star.

2 Observations

The speckle interferometric observations were carried out with the 6m telescope of the Special Astrophysical Observatory (Russia) with the speckle camera and an intensified 1280x1024 pix CCD coupled with a S-25 photocathode. Usually, this system allows to observe binary components as faint as $15.^m0$ in optical wavelengths with a dynamic range of about $4.^m0 - 5.^m0$. The diffraction limited resolution is about 22mas.

The relative position and magnitude difference Δm is derived from the ensemble averaged power spectrum. A double-slit pupil mask and interferometric binaries with slow orbital motion are used for calibration. More details regarding the observation and reduction procedure can be found in [12] and remain essentially unchanged.

Gl 424 was observed on December 28, 2004 and has shown a sign of a close companion at a distance $0.''132$ along the position angle $334.^\circ0$. The estimated Δm in the red filter centered at 800nm is equal to $3.^m7$ which is close to the detection limit of the speckle camera.

A single previous speckle measurement of Gl 424 was performed at the 3.6m CFHT telescope in 1986 with null detection meaning that the separation at that epoch was less than $0.''04$ [13].

3 Binarity and a rough estimate of the orbital period

To estimate the probability of a chance projection, we applied criteria described in [14, 15] which lead to 1.8×10^{-6} and 9×10^{-7} respectively. Such a low probabilities indicate that the suspected companion should be physically bound to Gl 424. Hereafter, the primary and secondary components will be referred to as Gl 424A and Gl 424B.

Assuming the same distance for both components and taking into account the magnitude difference $\Delta m = 3.^m7$, we obtain $M_V = 13.^m47$ for Gl 424B. Its spectral type (ST) can be estimated through the relation

$$M_V = 0.101(ST)^2 + 0.596(ST) + 8.96 \quad \text{(Henry et al. 1994 [16])}$$

leading to a M4.5 dwarf.

Evidently, the observational data are insufficient to make any certain suggestion regarding the possible orbital motion. Nevertheless, under assumption of a physically bound system, one can make some rough estimates regarding the component's mass, semimajor axis of the orbit and, hence the orbital period − an important datum to be taken into account in future observations.

The mass μ (so designated to distinguish it from the luminosity) can be estimated through empirical relations:

$$\lg(\mu/\mu_\odot) = +0.005239M_V^2 - 0.2326M_V + 1.3785 \text{ (Henry et al. 1999 [17])}$$

$$\lg(\mu/\mu_\odot) = 10^{-3}[0.3 + 1.87M_V + 7.614M_V^2 - 1.698M_V^3 + 0.060958M_V^4] \text{ (Delfosse et al. 2000 [18])}$$

As can be seen from results given in the self-instructive Table 1, the mass sum is found within a range $0.56 - 0.70\ M_{\odot}$.

On the basis of the large samples of binary stars, in [1, 2, 19] several criteria to estimate the semimajor axis a on the basis of the observed angular projected separation ρ'' and parallax π'' were suggested. We followed the relation $a = 1.26\rho''/\pi''$ [2] derived specifically for M dwarfs and yielding $a = 0''.166 = 1.51$ AU for this given case. Then, the mass sum and Kepler's third law lead to an estimate for the orbital period which varies in a rather narrow range 2.2−2.5 yr (see Table 1).

It is worth noting that there are only four more nearby flare stars in visual binary systems with such short periods: HU Del (=AST 2, 1.5yr), V1054 Oph (=KUI 75, 1.7yr), EZ Aqr (=BLA 10, 2.2 yr) and CE Boo (FRT 1A-Ba, 2.4 yr), whereas the next is DT Vir with 14.5 yr.

Thus, should its binarity be confirmed, Gl 424 becomes an excellent target for obtaining an accurate orbit on a short time span. While further observations are feasible even with relatively small telescopes, due to the large magnitude difference between the components a dynamic range of the detecting instrumentation on the order of $5.^m0$ should be an essential requirement.

The increasing number of such systems and a careful comparison of their dynamical and astrophysical properties will provide important clues to many topics concerning the origin, formation and evolution of stars and stellar systems.

Table 1. Mass, semimajor axis and period estimates

Parameter	Henry et al. 1999	Delfosse et al. 2000
Gl 424A mass ($M_{\odot}$)	0.404	0.521
Gl 424B mass ($M_{\odot}$)	0.157	0.184
Mass sum ($M_{\odot}$)	0.561	0.705
a (AU)	1.513	1.513
P (yr)	2.48	2.21

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