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Discovery of the first SX Phoenicis-type pulsating component in the semi-detached Algol-type eclipsing binary in M71

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Abstract. Through the time series CCD photometry to search for pulsating blue straggler stars (BSSs), we discovered a pulsating feature with short periods about 0.03 day and small amplitude about 0.024 mag in the Algol-type eclipsing binary QU Sge. The variable has an orbital period of 3.790818 day and the primary minimum depth of $\Delta V = 1.333$ mag. Eclipsing light curve solution shows that QU Sge has a semi-detached binary configuration with the secondary component totally filling its Roche lobe.

Key words. Globular clusters: individual (M71 = NGC 6838) — — binaries: eclipsing — stars: blue stragglers — stars: variables — stars: individual: QU Sge

1. Introduction

Blue straggler stars (BSSs) are mysterious stars which are bluer and brighter than the main sequence turn-off stars in globular clusters or old open clusters. Since the first BSSs were found in the globular cluster M3 by Sandage (1953), there were many studies to investigate their nature. However, their origin is still controversial. Two primary scenarions for the origin of the BSSs are the single and/or binary star collision in dense clusters, or the mass transfer and/or coalescence in primordial binary systems in sparse clusters and/or in the field (Bailyn 1995; Bailyn & Pinsonneault 1995; Bellazzini et al. 2002; Carney et al. 2001; Ferraro et al. 1999; Sarajedini 1997; Sills & Bailyn 1999).

We present a discovery of a short-periodic pulsating component in the eclipsing binary QU Sge in the globular cluster M71. Coordinates of the variable star are R.A. = $19^h\ 53^m\ 49^s.34$ and Decl. = $+18°45'43''.4$ (J2000.0), respectively. The mean magnitude and color of QU Sge are derived to be $<V> = 15.250$ and $<B> - <V> = 0.445$, respectively. The first observation for eclipsing variability of QU Sge was carried out by Sawyer (1953). She found that the epoch in minimum and period

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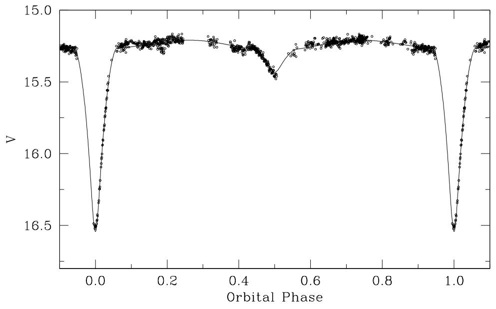

Fig. 1. Orbital V light variations of the variable star QU Sge. The synthetic light curve represented by the solid line was constructed using the Wilson-Devinney (1971) method.

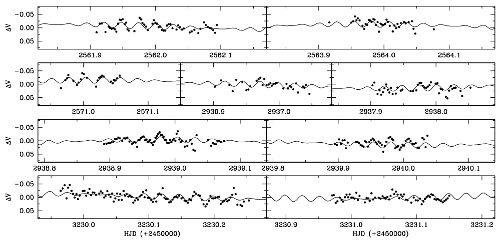

Fig. 2. Pulsational V light curves of the variable star QU Sge. Orbital light variations were subtracted. The synthetic light curves obtained from the multiple frequency analysis are superimposed on the residuals.

of QU Sge are HJD 24533481.78 and 3.7907 day, respectively (Clement et al. 2001). QU Sge is classified as an E type (eclipsing) variable in the General Catalogue of Variable Stars (GCVS).

2. Results and Discussions

Figure 1 shows orbital V light variations of the variable star QU Sge. The spectral type of the primary component is assumed to be A3V (Liller & Tokarz 1981) and that of the secondary is interpreted as G3V or G0III. We tested the Wilson-Devinney code (Wilson & Devinney 1971) for the detached (set to the mode 2) and semi-detached configuration (mode 5), and found that the secondary component fills its Roche lobe for both configurations. Therefore, we suggest that QU Sge is an Algol-type semi-detached eclipsing binary system with the secondary component filling its Roche lobe entirely. Using the Wilson-Devinney method, we derive an orbital period and a primary minimum depth of QU Sge are 3.790818 day and $\Delta V = 1.333$ mag, respectively.

Using residuals after removing the synthetic eclipsing light curve from the data, we examined existence of any other light variation. We performed multiple-frequency analysis of the residuals to detect any periodic signal, for nine nights data with good photometric precision and out-of-eclipse phase. We have detected two frequencies; $f_1 = 35.883$ cycles day^{-1} and $f_2 = 39.867$ cycles day^{-1}. Maximum peak-to-peak amplitude of the pulsational component is 0.024 mag in V band. If QU Sge is a member of M71 as deduced from the study of proper motion (Geffert & Maintz 2000; Cudworth 1985), it is the first SX Phoenicis-type (Pop. II) pulsating component in semi-detached Algol-type eclipsing binaries. This supports that hypothesis that the origin of BSSs in globular clusters may be the mass transfer between two components in a binary system.

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