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Magnetic activity and orbital period variation of the eclipsing binary KV Gem

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HIGHLIGHTS

- We present new CCD BVRI light curves of KV Gem in 2010 and 2011.
- Photometric solutions of KV Gem are obtained and starspot parameters are also derived.
- KV Gem exists a cyclic variation overlaying a continuous period decrease.
- This cyclic variation maybe caused by the light-time effect or magnetic cycle.

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ABSTRACT

This paper presents new CCD *BVRI* light curves of **a** neglected eclipsing binary KV Gem. Our new light curves were obtained in 2010 and 2011 at the Xinglong station of the National Astronomical Observatories, China. By analyzing all available light minimum times, we derived an update ephemeris and found there existed a cyclic variation overlaying a continuous period decrease. This kind of cyclic variation may probably be attributed to the light-time effect via the presence of an unseen third body or magnetic activity cycle. The long-term period decrease suggests that KV Gem is undergoing a mass transfer from the secondary component to the primary component at a rate of $3.4(0.3) \times (10^{-7}$ $M_\odot$/year for period decrease and a third body (10.3 ± 0.2 years), and $5.5(0.6) \times 10^{-7}$ $M_\odot$/year for decrease and magnetic cycle (8.8 ± 0.1 years). By analyzing the light curves in 2011, photometric solutions and starspots parameters of the system are obtained using Wilson–Devinney program. Based on the photometric solution in 2011, we still could use the spot model to explain successfully our light curves in 2010 and three published light curves. Comparing the starspot longitudes and factors, KV Gem are variable on a long time scale of about years. For the data of KV Gem, the brightness vary with time around phases 0, 0.25, 0.5, and 0.75, which means that there is a possible photospheric active evolution. More data are needed to monitor to detect stellar cycle of KV Gem. For chromospheric activity of KV Gem, we found strong absorption in the observed H_β, H_γ, and Ca II H & K spectra, and no obvious emission.

1. Introduction

Near-contact binary is a key evolutionary stage for the formation and evolution of a close binary. They are very interesting targets, especially near contact eclipsing binary. By analyzing photometric light curves (LCs) and spectroscopic spectra, we could obtained orbital parameters of eclipsing binary, and discuss photospheric starspot and chromospheric activities. For many near contact eclipsing binaries, they display long-term variations (period increase or period decrease or/and period cyclic variation...) of orbital periods (Qian, 2002; Zhu and Qian, 2006; Hoffman et al., 2006; Coughlin et al., 2008). The long continuous period increase or decrease may result from mass transfer between components or stellar magnetic winds. For thermal relaxation oscillation models (Lucy, 1976; Flannery, 1976; Robertson and Eggleton, 1977; Kaluzny, 1985; Hilditch et al., 1988; Shaw, 1994; etc), the mass transfer might cause the weak-contact binary to evolve into either a deeper-contact configuration or a broken-contact configuration. Recently, a new theory of contact binary formation come into being (Stępień, 2006; Eker et al., 2007) based on magnetized stellar wind. They present a new method for evolution of contact binaries from detached systems. Sometime the variation of the orbital period show periodicity (Hoffman et al., 2006; etc). The physical mechanism for orbital period cyclic variation might be a third companion,

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Table 1
The observational log.

Star name or ID	coordinate(Ra;Dec 2000)	Mag_B	Mag_V	Mag_J	Mag_H	References
KV Gem(GSC01330-01213)	06:47:12.6;15:43:35	12.4	12.16	10.663	10.355	1,2,3
TYC 1330-119-1	06:47:00.8;15:46:06	12.03	11.78			3
GSC01330-00101	06:47:05.4;15:43:33	13.6	12.9	12	11.8	4

Reference: 1. Samus et al. (2003); 2. Gettel et al. (2006); 3. Hog et al. (2000); 4. Cutri et al. (2003).

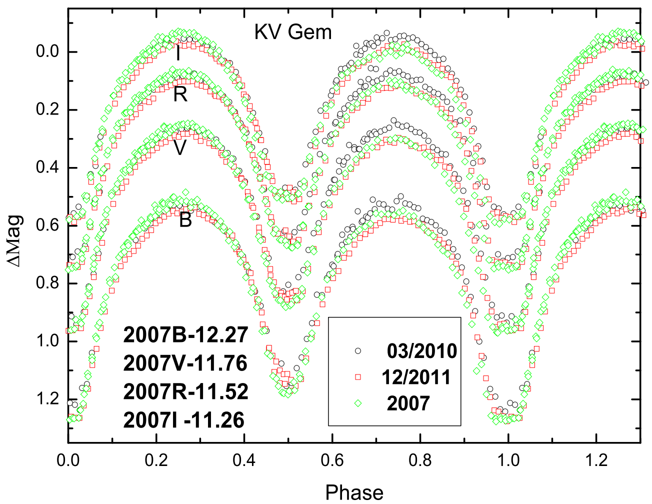

Fig. 1. B, V, R, and I light curves of KV Gem. Squares (□) indicate Dec. 2011, circles (○)-Mar 2010 and Diamond (2007 – data published by Coughlin (2010).

Table 2
Our new times of minimum of KV Gem.

HJD	Error	Filter	Type
2455282.12891	0.00075	B	primary
2455282.12984	0.00031	V	primary
2455282.12956	0.00039	R	primary
2455282.12924	0.00031	I	primary
2455284.10265	0.00035	B	Secondary
2455284.10210	0.00034	V	Secondary
2455284.10226	0.00054	R	Secondary
2455284.10201	0.00069	I	Secondary
2455910.07940	0.0002	B	Secondary
2455910.07950	0.0002	V	Secondary
2455910.07940	0.0001	R	Secondary
2455910.07945	0.0001	I	Secondary
2455910.25770	0.0002	B	primary
2455910.2579	0.0002	V	primary
2455910.25780	0.0003	R	primary
2455910.25750	0.0002	I	primary

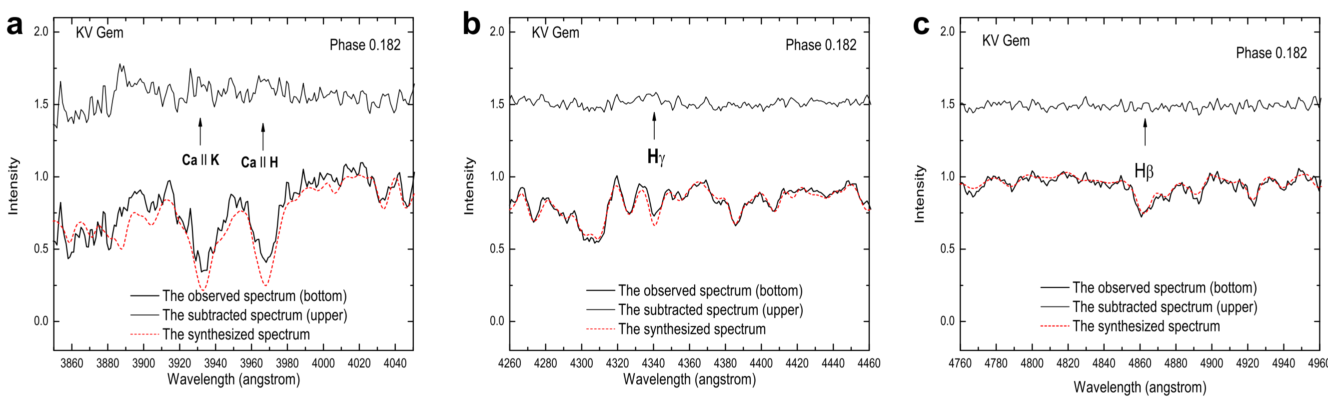

Fig. 2. The observed, synthesized, and subtracted spectra for the Ca II H & K, H beta and H gamma lines of KV Gem. The dotted lines represent the synthesized spectra and the upper spectra are the subtracted spectra.

or magnetic cycle (Applegate, 1992; Lanza et al., 1998; etc). KV Gem is an interesting eclipsing binary to discuss photospheric and chromospheric activity, and period variation.

KV Gem was first designated as a variable star by Kukarkin et al. (1968). Later, it was classified as the shortest period RR Lyrae ($p = 0.2185467$), by the general catalogue of variable star (Kholopov et al., 1985). In 1991, Schmidt (1991) found that KV Gem seemed to be an eclipsing binary with period of 0.43713 days. Recently, it was definitively re-confirmed as an eclipsing binary based on the first accurate multi-color light curves, and refined the period as 0.358 days (Coughlin, 2010). They also suggest that there might be a quasi-sinusoidal trend in the O–C diagram. At the same time, they also derived the orbital and spot parameters of KV Gem by modeling the light curve.

In this paper, we present our new B, V, R, and I LCs of KV Gem and analyze them using the 2003 version of Wilson–Devinney (WD) code (Wilson and Devinney, 1971; Wilson, 1990, 1994; Wilson and Van Hamme, 2004). Moreover, we accumulated all available times of light minimum and discussed the period change in detail for the first time.

2. New CCD photometric and spectroscopic observations of KV Gem

The new photometric observations were made during two observational runs (Mar. 26 and 28, 2010, and Dec. 14, 2011) with the 85-cm telescope of Xinglong station of the National Astronomical Observatories of China (NAOC). The photometer was equipped with a 1024 × 1024 pixel CCD and the standard Johnson–Cousin–Bessell *BVRI* filters (Zhou et al., 2009). The observations of KV Gem were made in B, V, R, and I passbands, and all observed CCD images were reduced by means of the IRAF[1] Package in the

[1] IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.