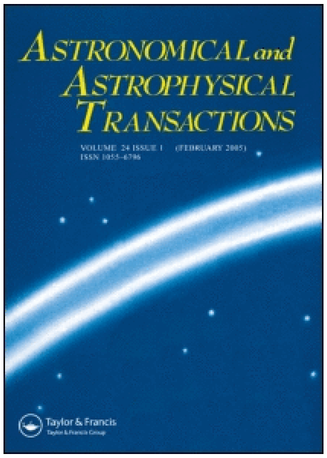

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

RX Cas revisited

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Online Publication Date: 01 February 2007
To cite this Article: Pustylnik, I., Kalv, P. and Harvig, V. (2007) 'RX Cas revisited', Astronomical & Astrophysical Transactions, 26:1, 31 - 34
To link to this article: DOI: 10.1080/10556790701300595
URL: http://dx.doi.org/10.1080/10556790701300595

Astronomical and Astrophysical Transactions
Vol. 26, Nos. 1–3, February–June 2007, 31–34

Taylor & Francis
Taylor & Francis Group

RX Cas revisited

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(Received 26 January 2007)

Between 1969 and 1993 a number of *UBVR* light curves of the long-period W Ser-type interacting binary RX Cas ($P_{\rm orb} = 32.328$ days) were obtained at Tallinn Observatory. The results of earlier observations, the interpretation of the light curves as well as the investigation of the nature of invisible primary component, intrinsic variability and its period ($P_{\rm intr} = 516.06$ days) were summarized by Kalv (and also discussed by Martynov). In recent years, new solutions of the radial velocity curves as well as of the synthetic light curves of RX Cas have been obtained. This enables the physical parameters of the components to be determined more accurately and the rate of mass exchange between the components and the initial parameters of the progenitor to be estimated with better precision.

Keywords: Stars; Binaries; Eclipsing stars; RX Cas

RX Cas belongs to a small group of W Ser-type binaries which according to our current knowledge are caught in a state of high-rate mass loss and mass transfer. The other best-studied members of the W Ser group are SX Cas, W Crucis, V367 Cygni, β Lyrae and W Ser itself. A common feature for this group is the presence of rich ultraviolet emission line spectra coming from higher ionization levels than can be expected from the effective temperatures of the stellar components.

The early stage of studies of RX Cas was summarized by Dmitri Yakovlevich Martynov [1, 2] who was the first to propose the quantitative model of RX Cas and to study in detail the effect of apsidal motion in this system, estimating the total period of apsidal motion as $\Pi = 29\,000 \pm 4\,000$ years. Kalv [3] found a reliable period $P = 516.06$ days of the intrinsic variability in RX Cas. Additional *UBVR* light curves of RX Cas were obtained at Tallinn Observatory in the observational period following the publication by Kalv [3] of the comprehensive analysis of the data consisting of the earlier observations obtained between 1969 and 1979 (see also [4, 5]). New R light curves [6] are shown in figure 1. The orbital phases were calculated with a value for the orbital period of $P = 32.327\,39$ days. In figure 2, the $O - C$ diagram is shown covering the total period of photoelectric photometry of RX Cas at Tallinn Observatory. Note that our orbital period is slightly longer than the value of $P = 32.3238$ days given by Kreiner *et al.* [7] but the trend (secular lengthening of the period) is the same. From the value $\mathrm{d}P/P \approx 10^{-7}$

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Astronomical and Astrophysical Transactions
ISSN 1055-6796 print/ISSN 1476-3540 online © 2007 Taylor & Francis
http://www.tandf.co.uk/journals
DOI: 10.1080/10556790701300595

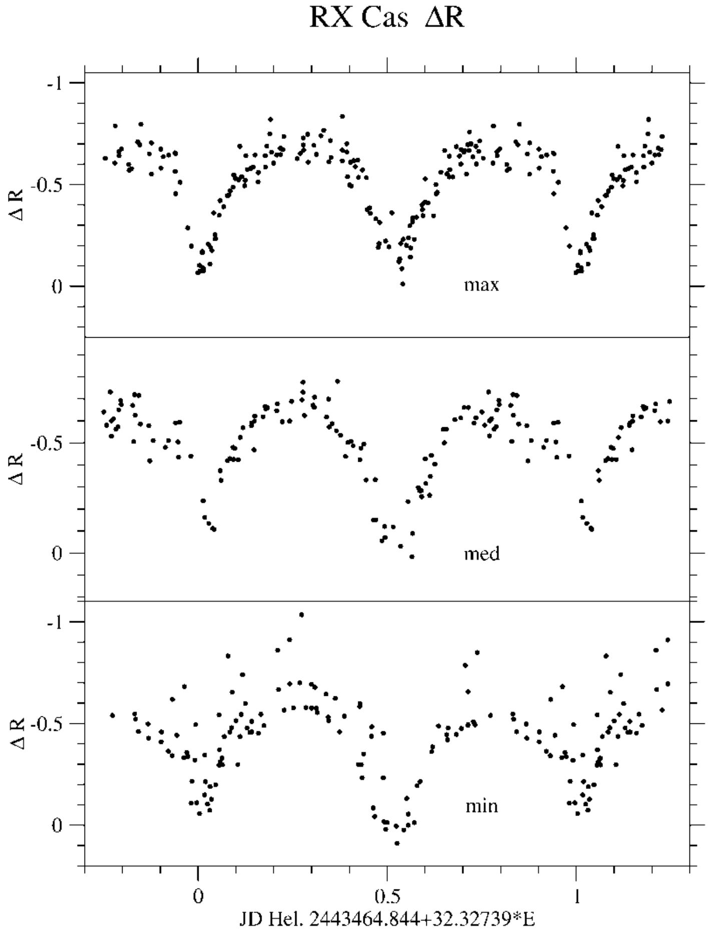

Figure 1. Light curve of RX Cas in the *R* band obtained at Tallinn Observatory in1969–1993. Inscriptions max, med and min denote respectively the maximum, medium and minimum levels of intrinsic variability.

and assuming conservative mass transfer in RX Cas when the former primary, more massive component filled in its critical Roche lobe, the rate of mass transfer can be estimated, with the result $\mathrm{d}m \approx 10^{-6} M_\odot$ year^{-1}. The physical parameters of RX Cas components according to Andersen *et al.* [8] are $m_1 = (5.8 \pm 0.5)m_\odot$, $m_2 = (1.8 \pm 0.4)m_\odot$, $R_1 = 2.5R_\odot$, $R_2 = (23.5 \pm 1.2)R_\odot$, $T_{ef2} = 4600 \pm 300$ K, $d = 570 \pm 100$ pc and the magnitude of the secondary component $Mv = -0.8 \pm 0.3$.

Using this updated information on the physical and orbital parameters of RX Cas as well as the estimate of the mass loss from the system, we may attempt to restore the earlier evolutionary history of RX Cas and the nature of the progenitors. We used an approach described in detail by Pustynski and Pustylnik [9]. We calculate the evolution of orbit of a binary assuming that the progenitor of the former primary component (more massive star) filled in its critical Roche lobe when the former during its nuclear evolution was approaching the tip of RGB (case B). We used the computer code package sse.f (Swift Stellar Evolutionary Code) (for details see [10]) to follow the evolution of the primary component for different initial stellar masses and metallicities until the donor approached its critical Roche lobe for the adopted mass ratio $q = m_2/m_1$ of the components and initial value d of the semimajor axis of the orbit. In the sse.f code output file, log L, log R and log $T_{\rm eff}$ values, and also the core mass $m_{\rm c}$ and mass

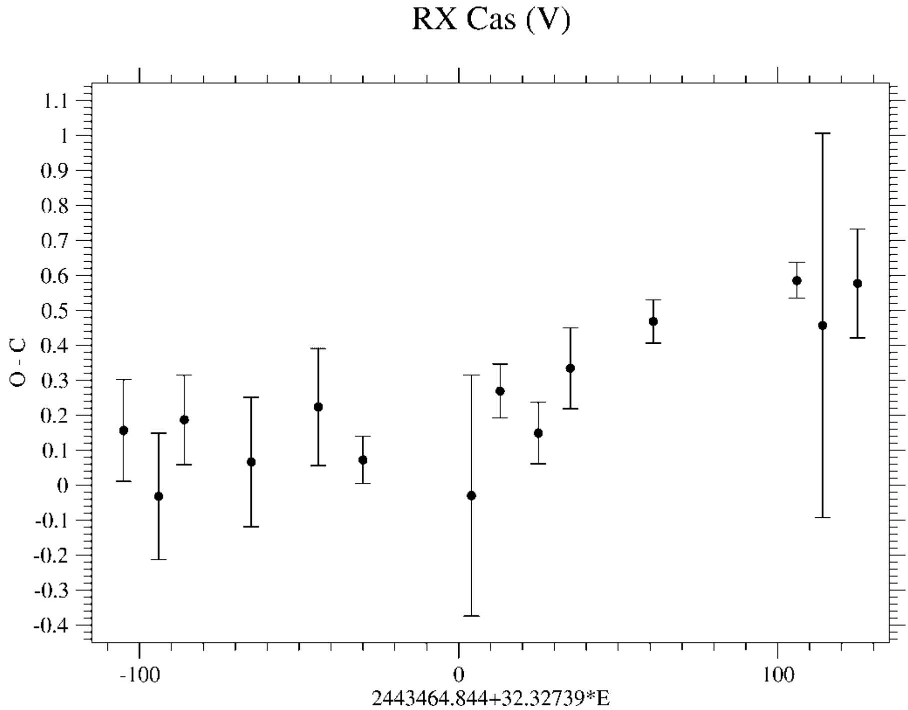

Figure 2. *O–C* diagram based on observations made at Tallinn Observatory in 1969–1993.

loss rate dm, as functions of the physical evolutionary time from the zero-age main sequence, are found. Once the donor fills in its critical Roche lobe, subsequent evolution depends on the relation between R_1 and R_{Roche}. The subsequent period change is found from the mass loss rate as $\mathrm{d}P/P = (-2dm/m) + 3dm_2(m_2 - m_1)/(m_2 + m_1) + 3K$. The term K takes into account an additional angular moment loss from the system by matter corotated to the Alfvén radius R_{A} and $m = m_2 + m_1$ (for details see [9]). Calculations are made for various sets of the initial parameters in order to clarify how the binary evolution depends on the starting characteristics of the system. We investigate the evolution of the period and the semimajor axis with time for different values of parameters characterizing the system to reveal the factors influencing to the greatest extent the orbit shrinkage and close binary formation. Using this approach we find the following plausible initial physical and orbital parameters for the progenitor of RX Cas: $m_1 = 7.0m_\odot$, $m_2 = 5.0m_\odot$, $d = 345R_\odot$, $K = 2.7$ (where m_1 and m_2 are masses of the primary and the secondary components, respectively, d is the initial separation and K is the relative Alfvén corotation radius in units of the radius of the donor). The resulting system that emerged would have the following parameters when its orbital period decreases to $P = 32.327\,38$ days: $m_1 = 5.9m_\odot$, $m_2 = 3.7m_\odot$ and $d = 89R_\odot$. The primary arrives at this stage with $\log L = 3.45L_\odot$.

Acknowledgement

The authors of the current investigation gratefully acknowledge support from Estonian Science Foundation grant 5760.

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