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S 10947 Aql ≡ RX J2009.8+1557: A probable RS CVn star which sometimes stops its eclipses

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As part of our programme of investigating the optical long-term behaviour of selected ROSAT sources (e.g. Richter *et al.* 1995), we discovered a new variable star as the likely optical counterpart of RX J2009.8+1557. In the B band it is variable between $13\overset{\mathrm{m}}{.}4$ and $14\overset{\mathrm{m}}{.}8$. It was given the preliminary designation S 10947 Aql. This object is identical with GSC 0161801655 and USNO-catalogue entry U1050_17035117 with USNO-coordinates:

$$\mathrm{R.A.} = 20^{\mathrm{h}}09^{\mathrm{m}}51\overset{\mathrm{s}}{.}43,\ \mathrm{Dec.} = +15^\circ 57' 34\overset{''}{.}2.$$

(equinox 2000.0), in agreement with our measurement on the digitized Palomar Sky Survey (see Fig. 1).

Because of the small difference to the best-fit X-ray position (see below) of only $\sim 5''$ (far below the X-ray position error) and the lack of any other optical objects brighter than 19 mag within the X-ray error circle, we are quite certain about the identification of RX J2009.8+1557 with S 10947 Aql.

RX J2009.8+1557 was detected during the ROSAT all-sky survey in 1990 at a count rate of 0.019 ± 0.005 cts/s with a likelihood of detection of 12.4 (corresponding to about 4σ confidence). With a total of only 9 counts collected during the total exposure time of 495 sec this source is below the brightness limit of the 1 RXS catalogue. Nonetheless, these few photons supply both a well-defined position of RA (2000.0) $= 20^{\mathrm{h}}09^{\mathrm{m}}51\overset{\mathrm{s}}{.}9$, Decl. (2000.0) $= +15^\circ 57' 35''$ with an error radius of $30''$ as well as hardness ratios HR1 $= 0.70 \pm 0.32$, HR2 $= 0.52 \pm 0.34$ suggesting a hard X-ray spectrum. No ROSAT pointing exists for this sky area.

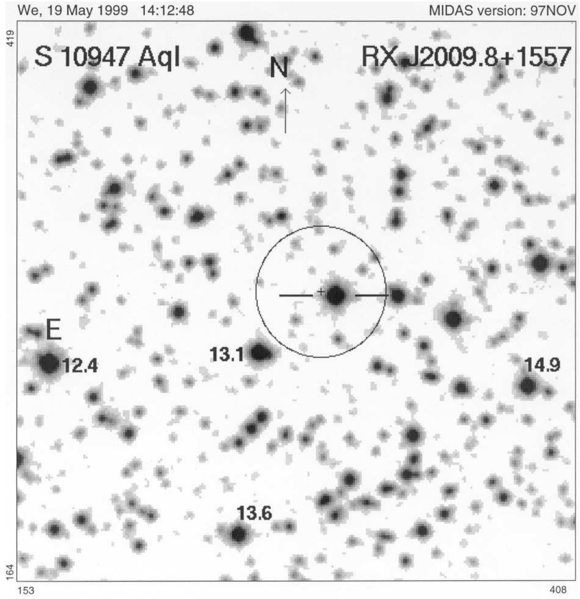

Fig. 1 A 4'.3 by 4'.3 part of the digitized sky-survey image (based on the red passband plate SF04843 taken on 25 Sep 1992) with the X-ray error circle of the ROSAT all-sky survey position (large circle; 30″ radius) overplotted. S 10947 Aql is marked by two heavy dashes. The numbers next to four other bright stars are B band magnitudes of the comparison stars used for deriving the light curve of S 10947 Aql (see Figs. 2 and 3). They were derived by differential connection to comparison stars of WZ Sge (Khruzina & Shugarov 1991).

A total of 744 archival plates taken between 1934 and 1995 with the Sonneberg astrographs (400 mm, 170 mm and 140 mm) were used for the investigation of the long-term behaviour of S 10947 Aql. Unfortunately, the object is invisible on all plates of the Sonneberg sky patrol (limiting magnitude 14^{m}).

Spectroscopic observations of S 10947 Aql do not exist, but the kind of brightness changes together with the detected X-ray emission seem to indicate that it is a chromospherically active binary of the RS Canum Venaticorum (≡ RS CVn) type:

- occasional brightness humps which can be recognized and followed over several months to years, with a cycle length of about $P_h = 8\overset{d}{.}628$ (on the average) and an amplitude of $\lesssim 0.5$ mag (migrating waves);
- eclipsing minima with a mean period of $P_o = 8\overset{d}{.}6294$.

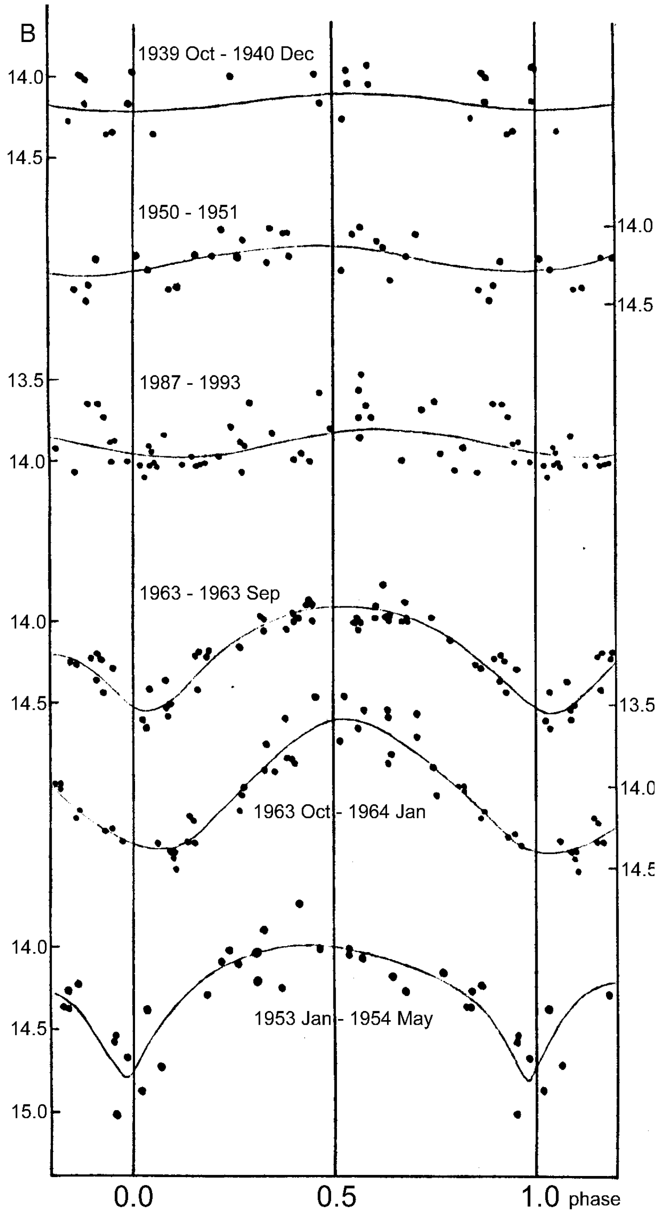

Fig. 2 Some examples of light-curves without eclipses (upper half) and with eclipses (lower half). Data taken over several months (time span is indicated on the right hand side) are folded over P_h.

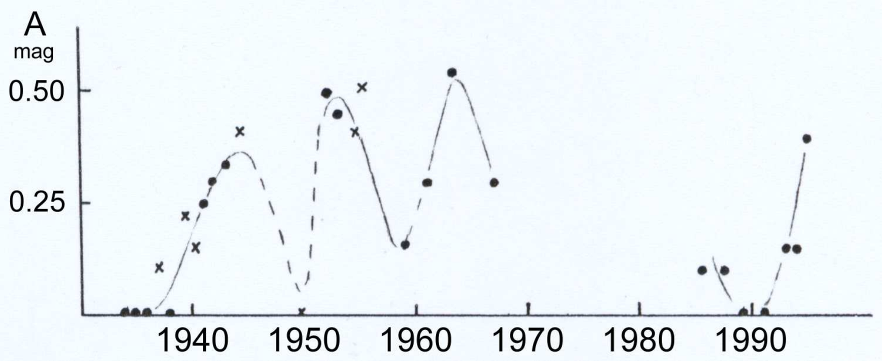

Fig. 3 Time variation of the eclipsing amplitude. The time axis is in years, and crosses denote uncertain measurements.

According to the classical interpretation of RS CVn stars, the brightness changes can be interpreted solely by starspot activities in a binary system (e.g. Geyer 1976). But until now it was not yet possible to unambiguously explain the physical processes in RS CVn systems. This is because photoelectric and spectroscopic observations are not available to a sufficient extent since the phenomenon was discovered by Hall (1972). Some interesting properties in the eclipsing light curves of our newly discovered object may contribute to a better understanding of the RS CVn systems:

1. During the entire time of observation (60 years), the period P_o has been increasing from $8\overset{d}{.}6289$ in 1935 to $8\overset{d}{.}6300$ in 1990. A similar behaviour is also observed in some other RS CVn systems. This may indicate that some RS CVn systems are in a state of very fast binary evolution (enhanced mass exchange between the components).
2. Another peculiarity is the apparent disappearance of the eclipse minima from time to time (see Figs. 2 and 3). Though it may be partly caused by overlapping of the minima with the maxima of the migrating waves, it strengthens the assumption that it is not the companion itself which causes the eclipses, but rather circumstellar matter or an accretion disk, variable in size and/or brightness. This supports earlier statements by Hall & Ramsey (1992) that extended matter in RS CVn systems may play a greater role than hitherto assumed. To give a definite decision, a dense series of observations over a time interval of several years is required.

This work demonstrates the importance of plate archives where many still unknown secrets and information are hidden. Detailed spectroscopic observations are urgently needed to further the understanding of this enigmatic source S 10947 Aql.

Acknowledgements

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