# EXOSAT AND IUE OBSERVATIONS OF THE SYMBIOTIC BINARY R AQUARII DURING MAXIMUM AND MINIMUM

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ABSTRACT. Coordinated IUE and EXOSAT observations of the symbiotic Mira R Aqr, made in June and December 1985, at phases 0.0 and 0.5 of the Mira light curve, are discussed. A weak X-ray flux has been for the first time unambiguously detected without any significant change with the Mira light curve. Also the UV spectrum of the central object has not varied, while the presence of high ionization lines (NV and HeII) in the spectrum of the jet-like feature is confirmed. The data are discussed in the light of a model in which the jet is preexisting material illuminated by the recently increased X and UV radiation from the inner edge of the accretion disk around the degenerate companion of the Mira primary.

## 1. Introduction

R Aqr is a well known Mira variable showing a very peculiar composite spectrum, typical of a symbiotic star, with prominent emission lines and a strong UV excess. The star is surrounded by a filamentary oval nebula of about 2 arcmin in extent, which has probably been produced during two major ejections, 185 and 640 years ago (Solf and Ulrich 1985). The inner part of the nebulosity is elongated at right angles with respect to the filamentary structure, and is variable in brightness and shape. In fact, a "spike" or "jet" was first observed in 1977 (Wallerstein and Greenstein 1980, Herbig 1980), which was not present before. This feature was later studied in details at radio wavelengths by Sopka et al. (1982), and in the UV with IUE by Kafatos et al. (1986), who found a recent increase of the excitation of the "jet", which is presently "hotter" in the UV than the unresolved central object.

Also the central object is peculiar, not only for its prominent emission line spectrum, but also for the Mira light curve, showing large irregular variations, mainly a kind of long term

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"modulation" of the amplitude, which has been attributed to a very eccentric orbital motion of a binary system with a period of about 44 years (Willson et al. 1981). Tidal effects at periastron could produce intense ejection of matter.

For its many peculiarities, giving in particular evidence for violent phenomena, and its relative nearness, R Aqr is certainly an ideal target for X-ray observations. The star was in fact observed with the Einstein Observatory on 21 June 1980 with IPC, and a marginal detection was claimed by Jura and Helfand (1984) at a 3 sigma level. However, a detailed reexamination of the IPC data, using the last revised data processing at CFA, led us to the conclusion that the claimed detection is probably only a background fluctuation.

## 2. EXOSAT and IUE Observations.

R Aqr was observed with the Low Energy detector of EXOSAT, using the Thin Lexan filter on 14 June 1985, when the star was near maximum of the Mira light curve. The observations were repeated on 24 December 1985, at Mira phase 0.5. A weak X-ray flux was detected in both cases at a 8-10 sigma level (Viotti et al. 1985, 1986, Baratta et al. 1985). After correction for the background, the count rate was 5.4 and 4.6 $10^{-3}$ $s^{-1}$ for the two epochs respectively.

IUE observations of R Aqr were obtained on 17 June and 23 December 1985, very close to the EXOSAT observations. The observed spectra are shown in Figure 1. Although the two observations were made during two very different luminosity phases of the Mira, the ultraviolet appears nearly the same. This result and the absence of significant variation of the X-ray flux confirm that the hot ionizing source is distinct from the cool pulsating giant, as found also in the case of Mira itself (Reimers and Cassatella 1985). The spectrum of the jet-feature observed in December is very similar to that of R Aqr except for the presence of the high ionization lines of NV and HeII, that are much weaker or absent in the UV spectra of R Aqr. Thus the jet appears hotter than the central object (cf. Kafatos et al. 1986).

## 3. A model for R Aquarii

The weakness of the X-ray flux from R Aqr could be intrinsic, or the result of significant interstellar or circumstellar extinction. A large interstellar extinction of E(B-V)=0.6 was for instance suggested by Kaler (1981) to explain the Hα/Hβ ratio in the spectrum of the star and the nebula. But such a strong extinction is not supported by the UV spectrum especially near the 2200 A region. On the contrary we think that the interstellar extinction is low, and that the X-ray flux is intrinsically weak. Assuming logNH=20.2, a black body temperature of 200000 K, and a distance of 300 pc, we derive an X-ray luminosity of 2x10+32 erg s-1 in the 0.02-2 keV range. Such a flux would be just below the upper limit for the HEAO-2 observations. We may thus exclude a much larger X-ray flux of R Aqr 5 years before the EXOSAT observations.

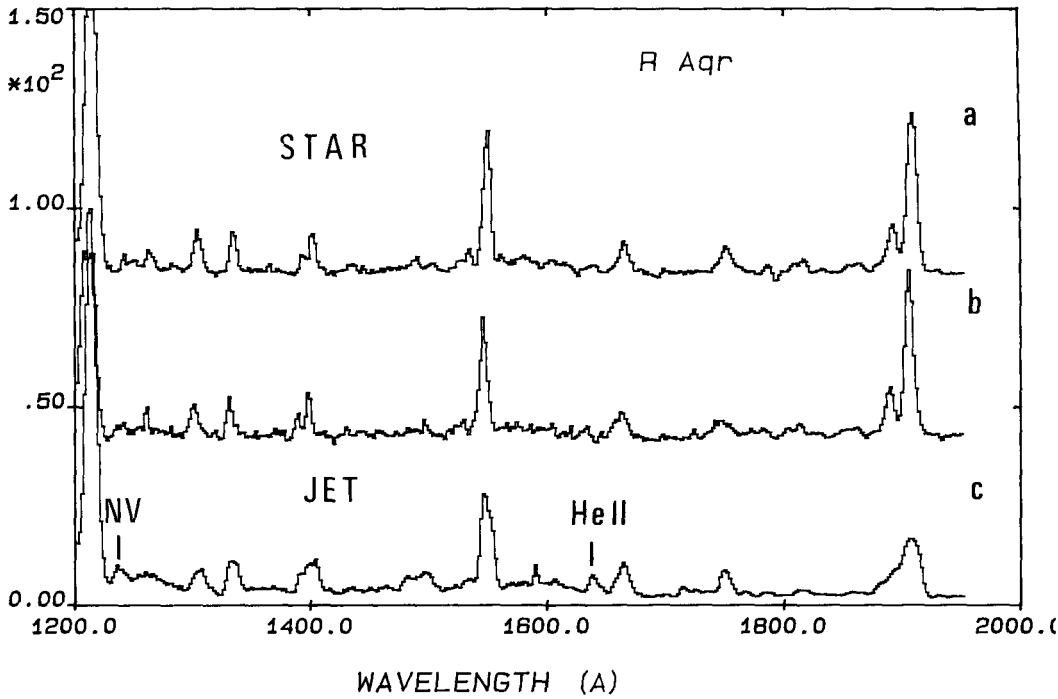


Figure 1. The low resolution ultraviolet spectrum of R Aqr on 17 June (a) and 23 December 1985 (b) and of its jet on 23 December 1985 (c). Ordinates are fluxes in $10^{-14}$ erg $cm^{-2}$ $s^{-1}$ with a constant vertical shift.

As discussed above, high temperature spectral features, such as NV 1240 A and HeII 1640 A, have been identified in the IUE spectrum of the jet, while these lines are weak or absent in the UV spectrum of the central star. This strongly suggests that X-rays are coming not from R Aqr but from the jet (cf. Kafatos et al. 1986).

A possible explanation is that an intense (but not directly observed) X-ray flux was produced near the companion of the Mira primary, possibly at the boundary layer of an accretion disk. X-ray are only emerging in directions out of the orbital plane, where the large amount of gas and dust is completely absorbing the radiation. A fraction of the X-rays is intercepted by aggregations of matter ejected during previous phases, which are heated and partly scatter the UV and X-ray photons. Thus the recent appearence of the jet was not a real ejection of matter, but rather illumination of preexisting matter by the suddenly increased rate of ionizing photons from the central source.

If this outburst is associated to the passages at periastron of the binary, we should expect a secular variation of the X-ray flux, most probably a gradual weakening during the next years. This is left to future observations of this interesting object.

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