A CORRELATION BETWEEN WATER MASER EMISSION AND THE VISUAL LIGHT CURVE OF RX BOOTIS

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Abstract

We investigate the emission from the 22.2 GHz maser line of water, and compare it to the visual light curve for the semi regular variable star RX Boo. There appears to be a correlation between the maser emission and light curve, however, the correlation is not as clear as for regular Mira variables. The water emission appears over a broad velocity range, and separate features appear to react to the changing light with different time delays.

1. Introduction

RX Bootis is a semi regular variable star classified as SRb. It is a red giant with a photographic magnitude range of 8.6 to 11.3 and spectral class ranging from M6.5 to M8. SRb stars usually have spectral classes of K, M, C, or S. They have a regular period for a while, then stop varying temporarily, and, later resume variation, but with a changed period.

2. Observations

We observed RX Boo approximately once per month from JD 2446800 to JD 2448000 for the emission of the 22.2 GHz water line with the 120-foot radio telescope of the Haystack Observatory (Figure 1). We plotted the integrated area under each spectrum as a function of time in Figure 2. Visual data were obtained from the AAVSO for the same period (Mattei 1991)(Figure 3).

Between the JD 2447000 and 2447200, the light curve drops by about one magnitude (≈2.5x in flux); the maser emission decreased by a similar factor between JD 2447500 and 2447620, apparently responding to the visual brightness. These changes can be seen in Figures 2 and 3 as well as in the strength of the individual features shown in Figure 4. One can see that the strongest emission feature has an antenna temperature of about 30° K in the beginning, but by JD 2448000 is only about 10° K. This decrease may be even larger since there was some improvement to the Haystack Observatory telescope during the period of the observations. To facilitate the discussion of the individual features, we have arbitrarily assigned numbers to the most prominent features as labeled at the top of Figure 1.

By closely examining the spectral changes, one can see how the features at different velocities appear to change in intensity. Particularly, this intensity change can be seen in the strongest feature, feature 6 from now on, and in feature 3 the feature with slightly lower radial velocity that suddenly appears, grows large, and then decreases again. The relative intensity of these two features has not always been so. A spectrum taken in 1983 by Lane *et al.* (1987) shows feature 3 and feature 6 reversed in intensity.

Feature 6, the clearest example of the decrease in maser energy which, like the light curve, drops off by about 2.5 times in flux, indicates that the radio emission is being affected by the light emission. However, it appears that feature 6 follows the light curve with a lag of about 60 days. Feature 4 is similar to feature 6 in its lag. This may indicate that the two are at similar distances from the source that is exciting them, i.e., the star itself. Feature 5 followed the light curve, but with an even greater time lag from the visible, possibly indicating that it is farther out in the circumstellar shell than the other two features. The feature that had been around in 1983 and then disappeared, feature 3, suddenly reappeared in this time period about 1-2 months after the light decreased. The time delay for each feature was estimated by overlaying the light curve with the plot of antenna temperature versus Julian day.

We noticed that the precise velocities of each feature seemed to change slightly. This is an odd occurrence, because it indicates that the clouds that are capable of masing are shifting within the circumstellar shell. We plotted the velocity variations versus Julian day to determine if there is an obvious pattern; no such pattern was found. We conclude, therefore, that what we had arbitrarily called a single feature is actually several masers at close velocities whose intensities are summing up to give what appears to be a single maser.

3. Conclusion

We have found that there appears to be a correlation between the light curve and the water maser emission, although the maser emission is delayed in comparison to the light curve. However, each feature, which represents a different velocity emission, seems to be following at its own pace. There is no single delay. We are continuing to monitor the water maser emission from RX Boo, and further studies may more precisely define the location of the different masers in the shell and the correlation of these to the light curve. This could lead to a better understanding of the pumping mechanism of masers.

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References

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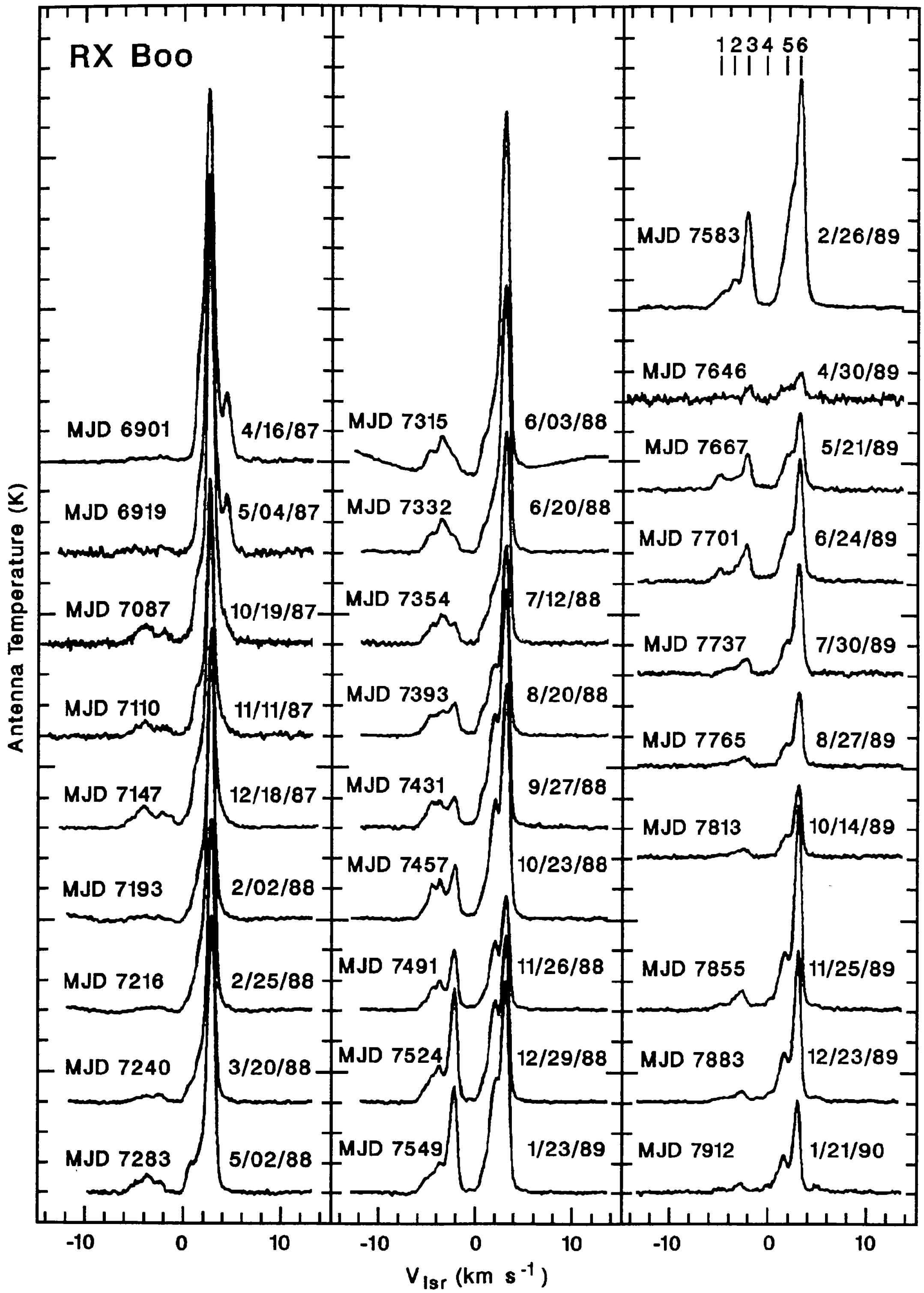

Figure 1: A series of water spectra at 22.2 GHz from the circumstellar material around RX Boo. The antenna temperature is plotted on the y-axis versus the radial velocity on the x-axis.

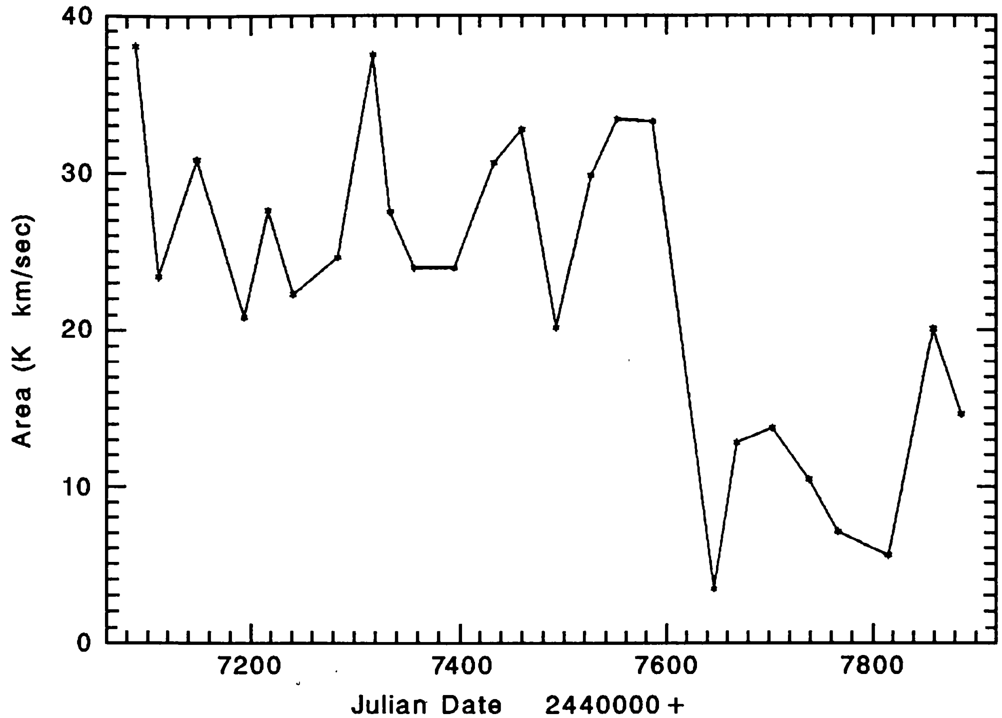

Figure 2: The integrated area under each water maser spectrum versus Julian day for RX Boo.

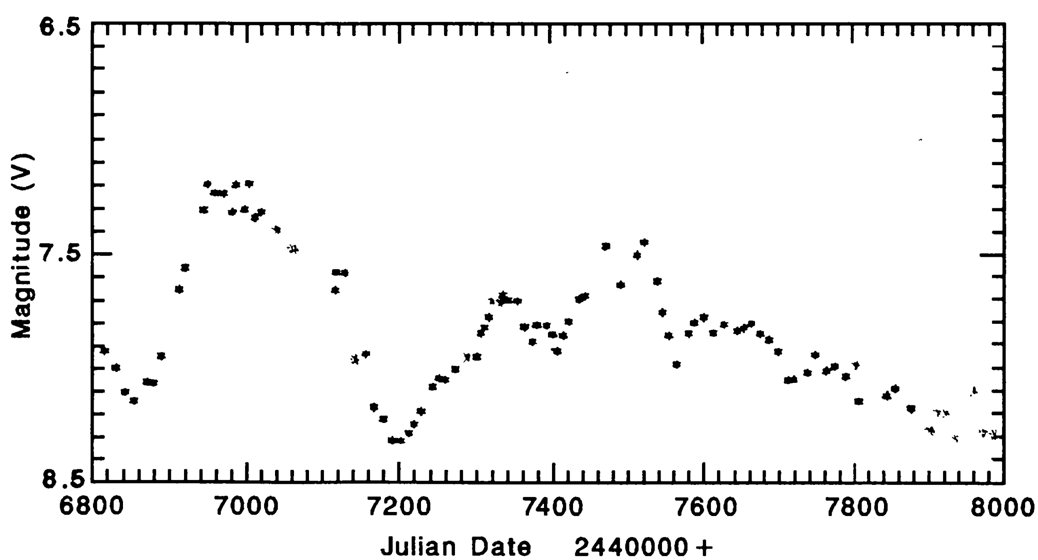

Figure 3: The AAVSO light curve for RX Boo.

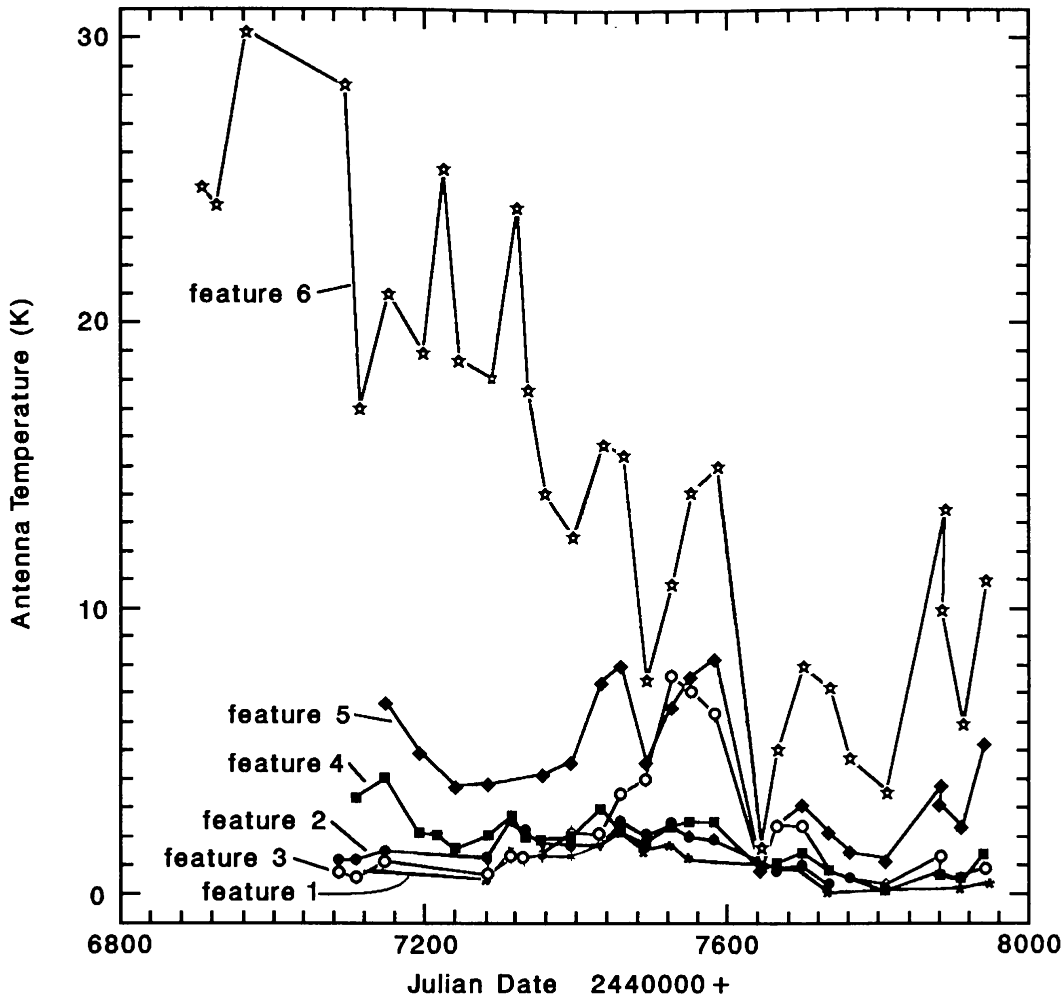

Figure 4: The antenna temperature of individual features in the water maser spectra of RX Boo versus Julian day.