# J-Net VLBI Monitoring Observation of the Semi-regular Variable R Crateris - Results

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**We have monitored and then imaged the Water Vapor Masers of the semi-regular variable star R Crateris with the Japan VLBI Network (J-Net) at 22 MHz, for nearly one month spaced epochs.**

**As the results of this sensitive observation we could detect shifts on the VLSR of each maser spot and also we could detect the Proper Motion of the maser spots.**

**From the proper motion of the maser spots we could made a spectrum-like profile and the verify that the distance to the star is 170 pc and not 300 pc. as reported by others. On the other hand with this tool we were able to measure the proper motion of the circumstellar envelope.**

**Finally, applying the standard expanding shell model to our data, a spherical shell can be plotted around the star.**

**Masers velocity structure are good tracers of stellar envelopes kinematics. The results obtained will help to understand the physical conditions around the stars.**

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## Introduction

Semi-regulars like R Crt are strongly variable on time and the study of the circumstellar envelope became difficult because of the complexity on the behavior of masers within the shell. Expansion velocity of shells is variable because different parts of the shell, expands at different velocity, that means that the shell within water masers are not isotropic at all.

Our target, R Crateris is a semi-regular variable of SRb type and spectral classification M7, the optical period is 160 days (Kholopov et al. 1987) that varies from 9.8 to 11.2 mag. Water maser was first detected by Squeren et al 1979, and after SiO masers by Dickinson et al. 1991, CO lines by Khane and Jura 1994. Also reports of 321 and 325 GHz water vapor masers have been done by Yates et al. 1995.

Monitoring and imaging the maser distribution well lead us to measure the movement of each spot on each epoch, in tree dimensions. On the line of sight direction and on the plain of the sky. This inter epoch observation measurement is reported here.

## The Observations

We used the Japanese VLBI Network (J-Net) that comprises of four antenna, the longest baseline is of 1300 km from the Mizusawa and Kagoshima stations and east west baseline from Nobeyama to Kashima station. The last station belongs to the Kashima Communications Research Laboratory and the remaining tree belongs to the National Astronomical Observatory of Japan (NAO-J).

The data was recorded on K4 tapes using the VSOP terminal and after, the correlation process was done at the Mitaka FX Correlator of the (NAO-J). For the data reduction we used the reduction software AIPS of the NRO.

The observations were scheduled according to the table below.

Table 1.

| Experiment Name | Epoch (1998) | Stations | Obs. Time (hr) |
|---|---|---|---|
| j98090a | March 31 st | MKNO | 10 |
| j98116a | April 26 th | MKNO | 10 |
| j98148a | May 28 th | MKNO | 9 |
| j98170b | June 19 th | MKNO | 8 |

(M) Mizusawa, (K) Kagoshima, (N) Nobeyama, (O) Kashima stations.

## Results

In the direction of the line of sight, the J-Net systems allowed us to measure with high accuracy the velocity of each maser spot, the accuracy is better than 0.2 milli arc seconds. From the maximum and minimum velocity of the maser spots we determined the system velocity and expansion velocity of the circumstellar shell, see figure 1.

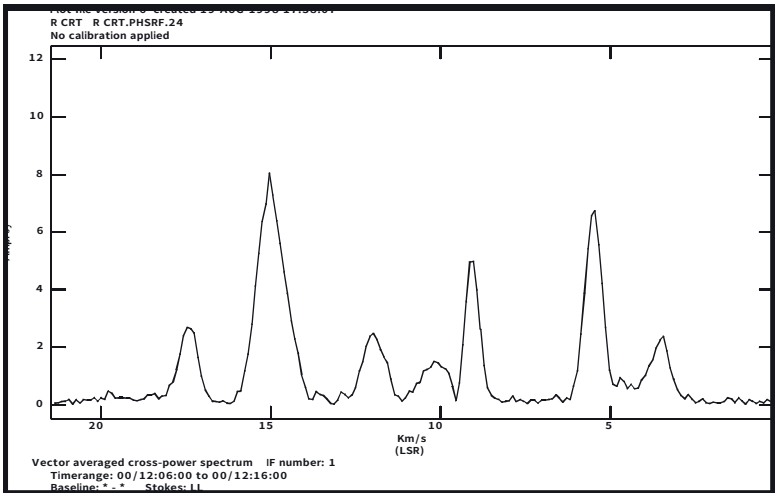



Fig. 1
R Crateris cross power spectrum profile got from the first epoch the maximum spot velocity is 19.02 km/s and the minimum 2.83 km/s, then the expansion velocity is 8.1 km/s and the system velocity 10.9 km/s. A typical double peaked profile for evolved stars.

From the power spectrum profile the system velocity and expansion velocity are consistent with other reports. The circumstellar shell around R Crt is moving with a velocity of 10.9 km/s on the line of sight direction, Bowers and Johnston reported the system velocity of 10.8 km/s, the expansion velocity estimated is 8.1 km/s while from Szymczack et al 1999, the velocity is 7.9 km/s, our measurement is consistent.

Once imaged all the epoch maser spots and comparing the velocity between each epoch, we can notice the velocity shifts of each maser on the line of sight direction, shifts are positive or negative as in figure 2.

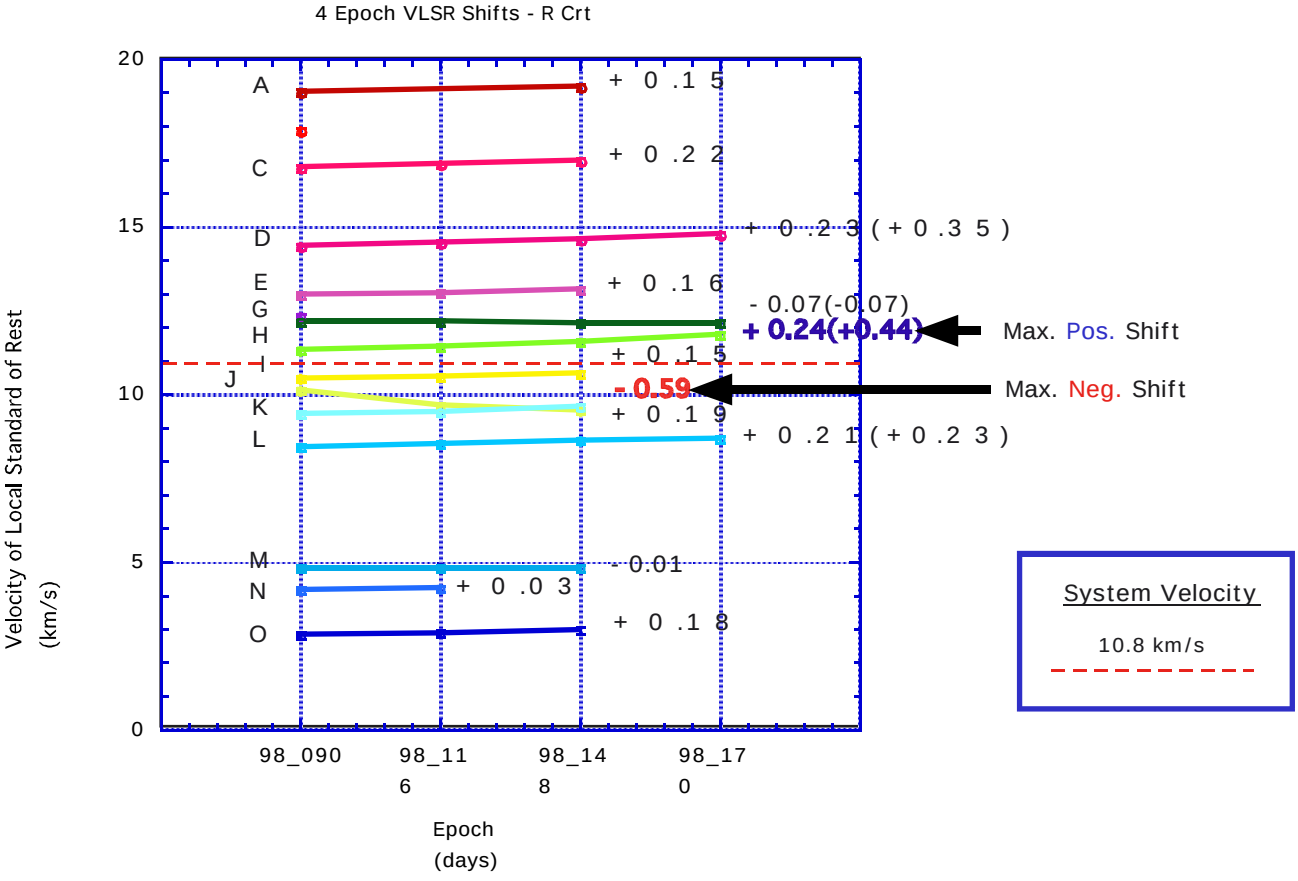



Fig. 2. Maser spots are shifting between epochs, around the system velocity (10.9 km/s) the most shifted maser can be noted.

On the plain of the sky, the Proper Motion of the masers were detected and combining with the line of sight information we made the figure 3, displacement vectors are represented by cones.

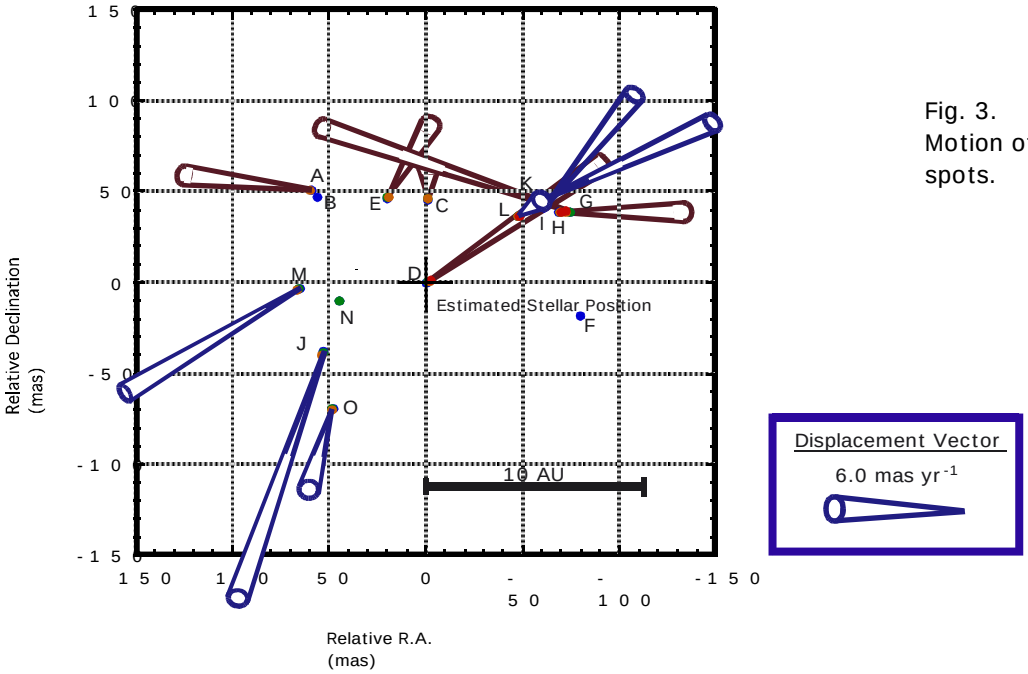
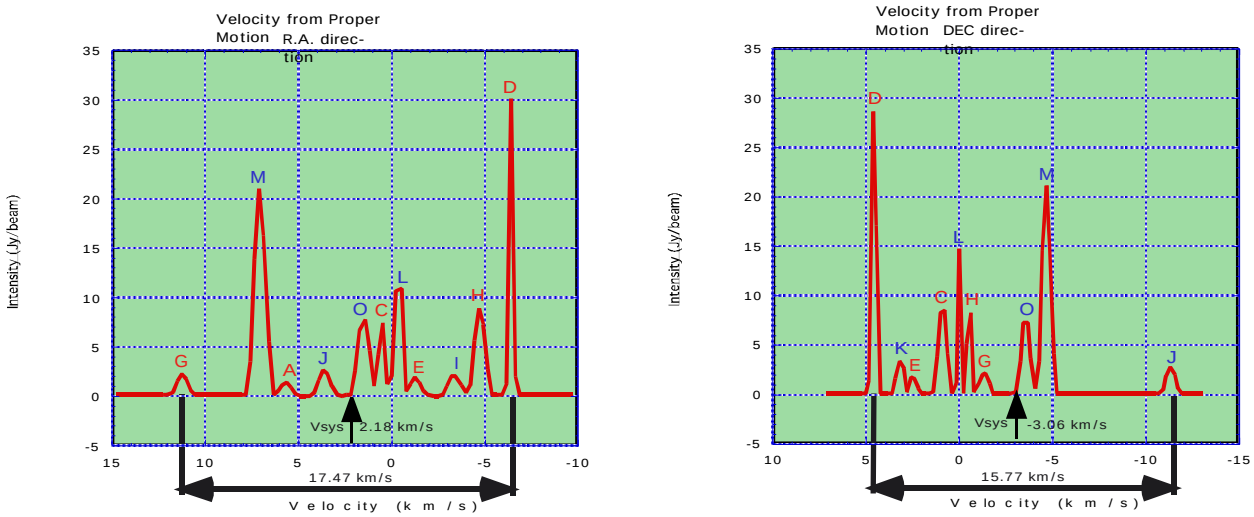



Fig. 3. Proper Motion of maser spots.

Deriving from the proper motion displacement velocities, we made a spectrum-like profile from the R.A. and DEC directions. Here we were able to get valuable information about the circumstellar shell. Verify the distance to the star, calculate the proper motion of the shell and so on. This tool will be useful for this kind of observations. See figure 4.




System Velocity: 4.66 + 0.59 mas yr $^{-1}$
Distance : 215 + 27 pc

Fig. 4. Profiles in R.A. and DEC directions, also a typical double peaked profile can be seen.

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