PERIODICITIES OF MASER EMISSION FROM VARIABLE STARS

Sara A. Maene
Whitin Observatory
Wellesley College
Wellesley, MA 02181

Received: December 19, 1991

Abstract

Continued observations of radio emissions from Mira variables show periodicities similar to observed visual periodicities.

1. Introduction

Radio emission comes from clouds of water molecules surrounding a variable star. A molecule in this cloud is excited into a metastable rotational energy state by the energy emitted by the star. From this level, the molecule may drop into a lower energy level, emitting radiation in the process. If a photon of an energy corresponding to the de-excitation energy of the molecule should hit the molecule, the molecule will de-excite and emit two photons, both of energies corresponding to the molecule's de-excitation energy. These photons may go on to de-excite two more molecules, which may de-excite four in their turn. Thus, the original photon is amplified by a factor of two with each interaction, and we call the source a maser (which is an acronym for "Microwave Amplification by Stimulated Emission of Radiation"). The maser gives rise to a large amount of long-wavelength radiation from one place, the magnitude of which we observe using radio telescopes.

2. Observations

During the summer of 1991, I worked with Dr. Priscilla Benson of Wellesley College on continuing observations of masers for an ongoing project being carried out by Drs. Benson and Irene Little-Marenin, and which concentrates on monitoring maser emission at both visible and radio wavelengths and correlating it with optical light curves. For our analysis, we used radio observations made at Haystack Observatory, and visual data from the AAVSO (Mattei 1991). This visual data was augmented as necessary by observations made with the Wellesley College CCD camera on our 24-inch telescope.

The information gained from maser observations has many applications. For example, we can find the velocity at which the maser is retreating from or approaching us, by observing the Doppler displacement of the observed spectral lines from those obtained in laboratory experiments. Since the emission travels at light-speed, we can state that

$$(\lambda\,(\text{observed}) - \lambda\,(\text{laboratory}))/\lambda\,(\text{laboratory}) = (\text{maser velocity})/c \qquad (1)$$

where c is the speed of light, and maser velocity is the velocity of the maser feature.

We have also monitored the intensity of the emission. Figure 1 shows our maser data for the Mira variable R Ceti, ranging over a period of three years. (Since the wavelength of emission is linearly related to the maser's velocity and the antenna temperature is similarly related to the intensity of the emission, this plot can also be considered as representing a plot of flux as a function of wavelength.) This study is an extension of the one on R Ceti previously published by Blais *et al.* R Ceti shows one feature, which varies in intensity over time. A comparison of this data with the AAVSO observations of R Ceti for this period (Figure 2) shows periodicity of intensity at both visual and radio wavelengths. Closer inspection reveals that the periods of both sets of data are similar; the maser data shows similar relative peaks and dips in intensity to those in the visual data, except that it displays a slight phase lag behind the visual data.

The data obtained from the Mira variable W Hydrae (Figure 3) shows two features, which seem to vary out of phase with each other. We have not yet obtained enough data to determine the phases of these features, or to compare the phase of each feature with that of the other. When compared with the visual data of the same time period (Figure 4), the maser data seems to show the beginnings of a periodicity, possibly similar to that of the visual data.

3. Conclusion

We hope that continued observations of masers will shed light on the details of the more complex maser features, and perhaps give clues as to the nature of the masering mechanism.

I would like to thank Dr. Priscilla Benson, my advisor, who guided me through my research; Wellesley College, for funding the research; and the members of the AAVSO, for their visual observations that have provided much insight into the workings of masers.

References

Blais, K. A., Attridge, J. M., Little-Marenin, I., and Benson, P. J. 1988, *J. Amer. Assoc. Var. Star Obs.,* 17, 115.

Mattei, J.A. 1991, observations from the AAVSO international data base, private communication (to P. Benson).

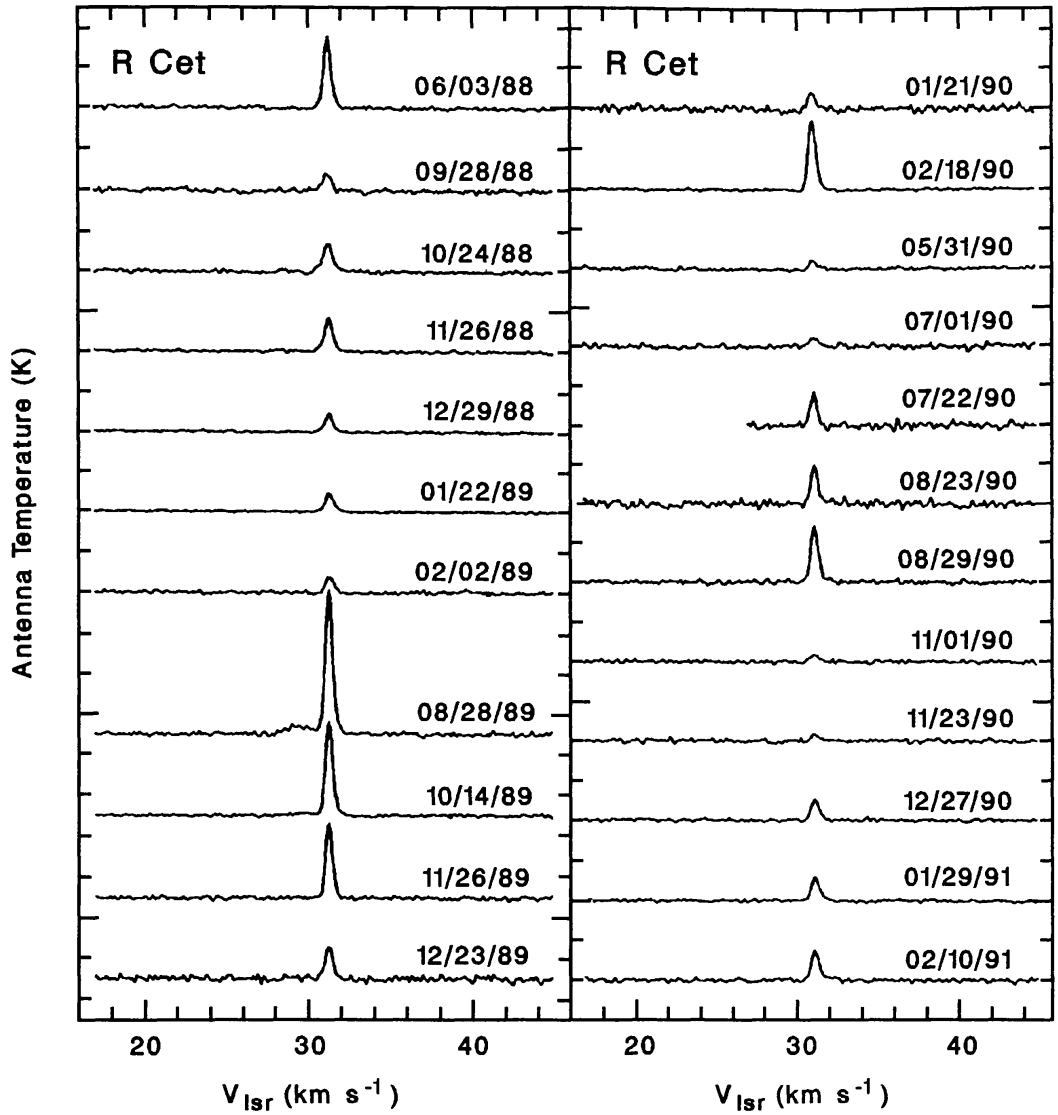

Figure 1. Radio emission flux for the Mira variable R Ceti. V_{lsr} is the maser velocity.

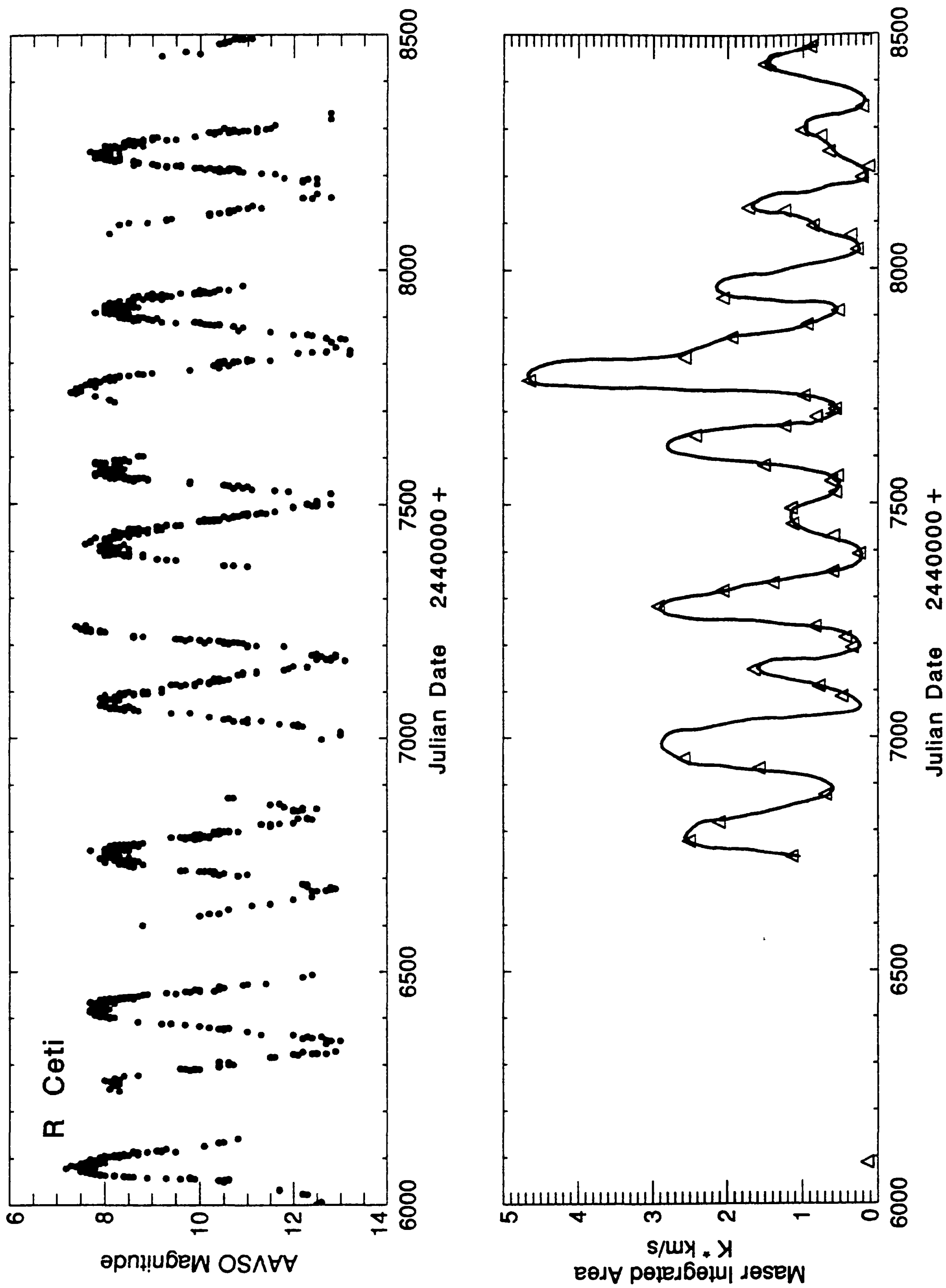

Figure 2. AAVSO visual observations and radio emission for R Ceti, plotted vs. Julian Day.

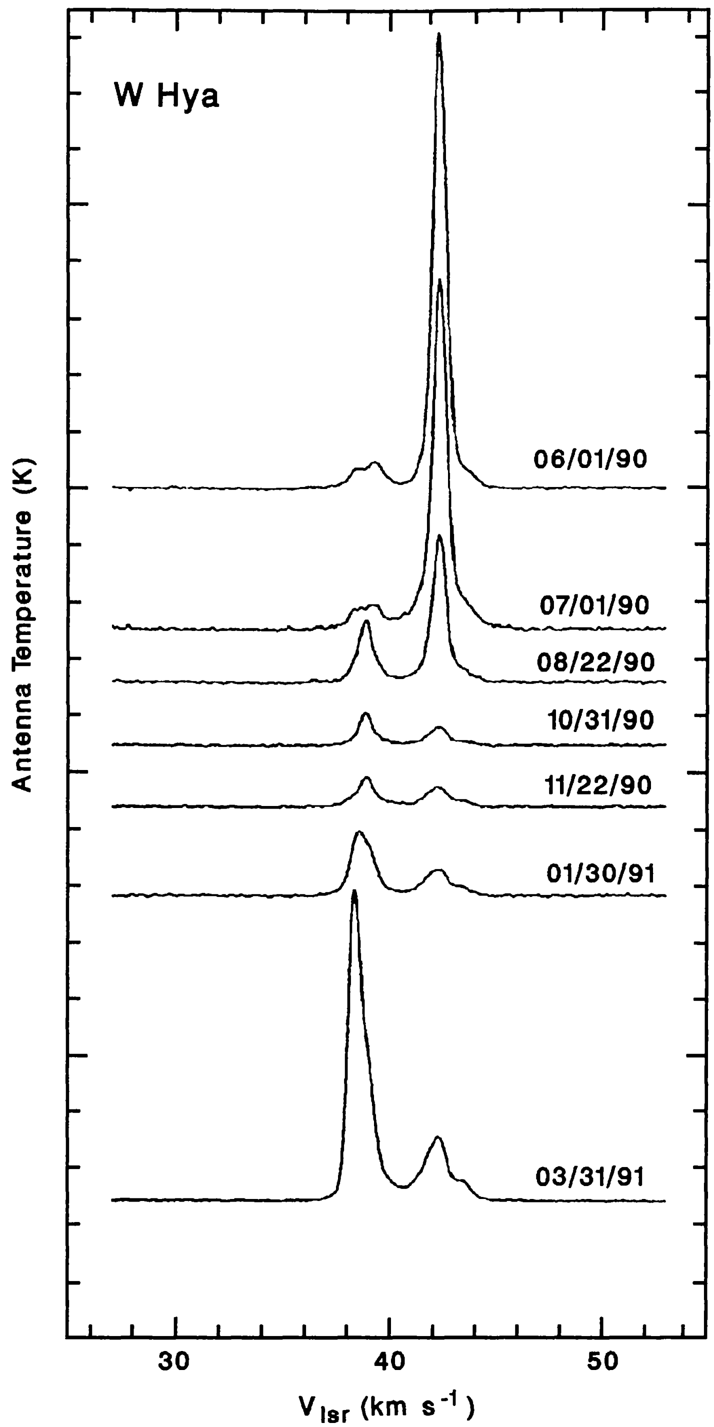

Figure 3. Radio emission flux for the Mira variable W Hydrae.

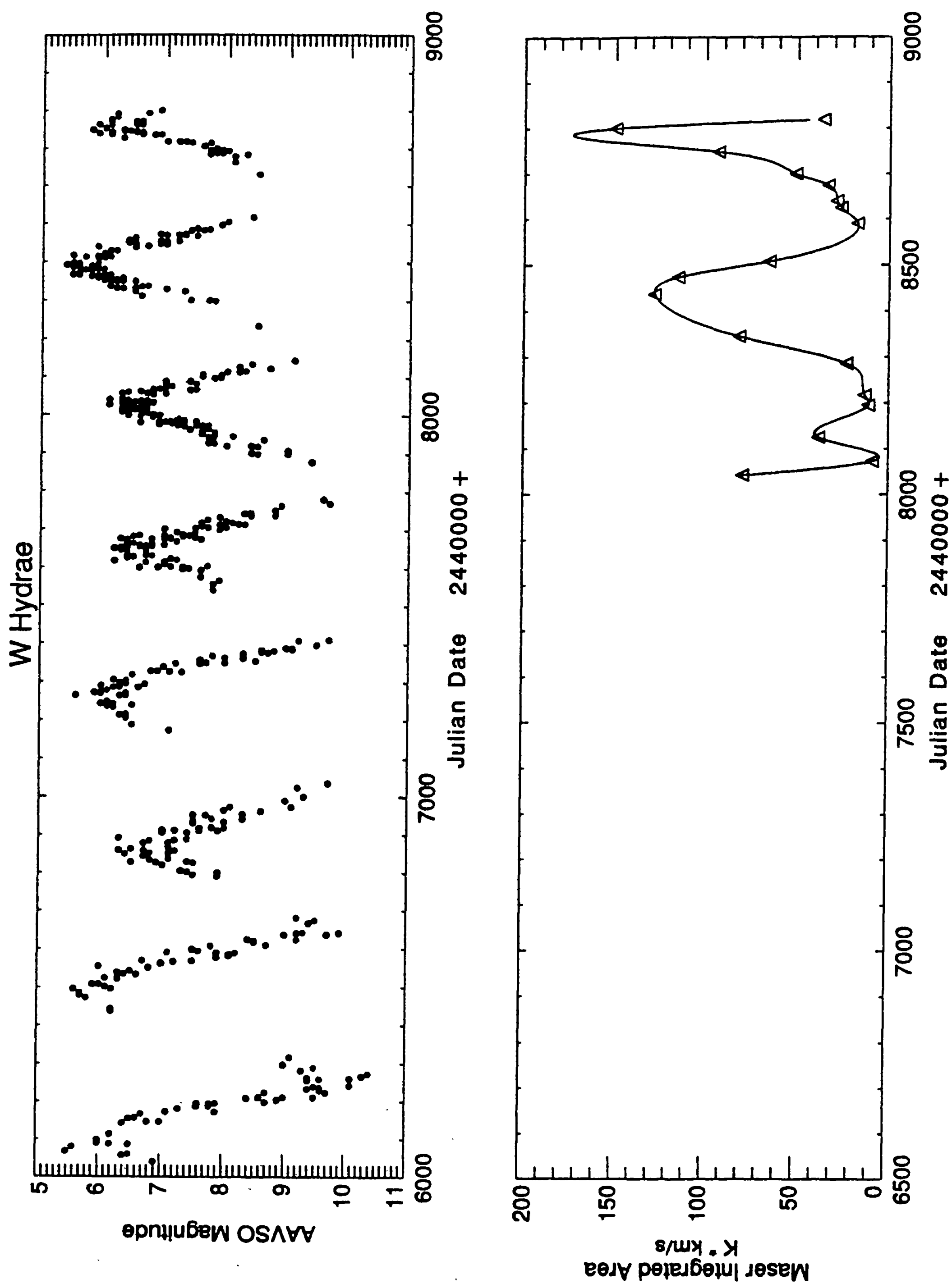

Figure 4. AAVSO visual observations and radio emission for W Hydrae, plotted vs. Julian Day.