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OH EMISSION IN THE DIRECTION OF TV Gem AND BI Cyg

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ABSTRACT

OH maser main-line emission at 1665 MHz has been detected in the direction of two late-type supergiants, TV Gem (M1Iab) and BI Cyg (M3Iab), with the 43-m telescope and 18-cm receiver at NRAO-Green Bank. Detection of two new OH maser sources here is particularly interesting in view of the relatively small number of late-type supergiants that are known as molecular radio sources or associated in close proximity with OH emission clouds. The infrared, ultraviolet, and radio properties of these stars are discussed briefly.

I. INTRODUCTION

Observations show the 1665-MHz OH main line in emission is the direction of supergiant stars TV Gem (M1Iab) and BI Cyg (M3Iab). The luminous M supergiant TV Gem is a very complex and interesting object that has unexpected UV continuum radiation which was detected in the range 1200–3200 Å by the *International Ultraviolet Explorer* (Michalitsianos *et al.* 1980). The UV continuum in TV Gem is attributed to a hot companion star. The absence of strong UV emission lines suggests that the companion is an object having high temperature and possibly high effective surface gravity, although a number of absorption features possibly attributed to Si IV (1391 Å) and C IV (1548 Å/1550 Å) indicates that an early B-type star could be responsible for the observed UV radiation. Infrared emission observed in TV Gem by Gehrz and Woolf (1971) indicates that a cool circumstellar shell of silicate grains surrounds the supergiant. BI Cyg is also a red supergiant (M3Iab) which exhibits mass-loss characteristics (Gehrz and Woolf 1971).

A number of large-scale OH sky surveys have been conducted over the last decade. These surveys have shown that OH emission may be associated with late spectral type stars and in particular M-type giant variable (Miras). Also among this group are approximately seven M supergiants (Baudry *et al.* 1977; Mutel *et al.* 1979). This paper presents the possible addition of two stars, TV Gem and BI Cyg, to this list.

II. OBSERVATIONS

These radio observations were obtained in August 1979 using the 43-m telescope of the National Radio Astronomy Observatory* in Green Bank, West Virginia. The measurements were made at the prime focus with the 18-cm cooled receiver with a system temperature of approximately 60–70 K. The aperture efficiency was approximately 0.54, giving $S/T_A \approx 3.6\ \mathrm{Jy\ K^{-1}}$. The 384-channel autocorrelation receiver was used in two sections of 192 channels to observe orthogonal linear polarizations which were combined to obtain the total unpolarized flux. The receiver was operated in a frequency-switched mode using upper and lower sidebands, thus tripling the velocity coverage. The bandwidth of each section was 0.31 MHz, resulting in a frequency resolution of 1.6 kHz or 0.3 km $\mathrm{s^{-1}}$.

III. RESULTS AND DISCUSSION

The observations were made as part of a general study of stars that exhibit composite spectra over a wide range of wavelength regions. These stars were initially searched for the OH satellite emission line at 1612 MHz, as this emission is typically the strongest OH emission in sources with large infrared fluxes. In order to test the validity of this strategy, some sources were observed at the main-line frequencies. During such observations 1665 and 1667 OH main-line emission was observed in the direction of the supergiant star TV Gem and 1665 emission in the direction of BI Cyg. Time did not permit measurements in the satellite lines for these sources nor at 1667 MHz for BI Cyg. The receiver frequencies were offset to test the validity of the weak spectral lines. The spectral features appeared to shift by an amount equal to the displacement of the receiver frequency and thus supports these detections as real and not an artifact of the receiver system. The combined spectra of the summation of all observations of TV Gem and BI Cyg for 1665 MHz are presented in Figs. 1–3. A Hanning smoothing function has been applied which reduces the resolution to approximately 0.6 km $\mathrm{s^{-1}}$. The dates of observations and the effective on-line, on-source integration time is given in Table I.

Since the half-power beamwidth of the telescope is 18 arcmin, the assignment of the emission to the two supergiant stars can only be tentative until higher-resolution detections can be made. Hydroxyl ion emission has been

*The National Radio Astronomy Observatory is operated by Associated Universities, Inc., under contract with the National Science Foundation.

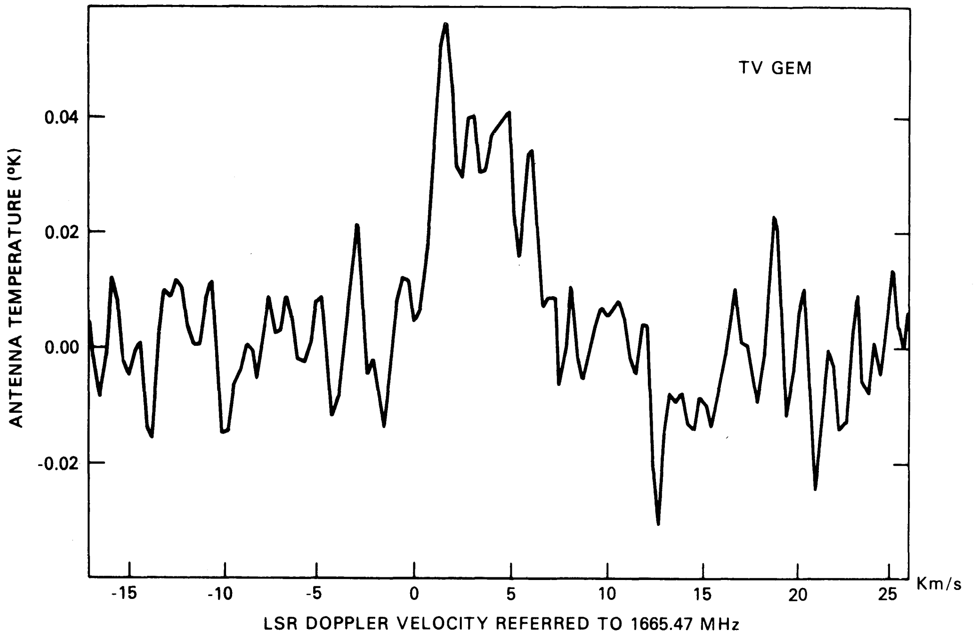

FIG. 1. Main-line frequency observations of TV Gem at 1665.47 MHz for which all data have been averaged together.

often detected in the atmospheres of late-type stars, but only a handful of these stars are supergiants (most being M-type giants). Supergiant stars in general do not seem to have OH radiation (Bowers 1975; Bowers and Kerr 1978; Baudry *et al.* 1977). Of the seven supergiants observed to have OH emission only IRC+10420 (Mutel *et al.* 1979) at F8 appears to have an earlier spectral type than TV Gem at M1; whereas BI Cyg at M3 seems somewhat more typical.

In earlier work (Wilson and Barrett 1972), OH supergiants were observed to have two strong 1612-MHz emission features, excess IR emission, and H_2O emission. Later observations (Baudry *et al.* 1977; Mutel *et al.* 1979) have added OH supergiants which show deviations from these characteristics. In particular the main-line 1665-MHz emission for S Per is stronger than for the 1612-MHz satellite line; the 1612-MHz emission was not detected in AH Sco with no clear double-peak

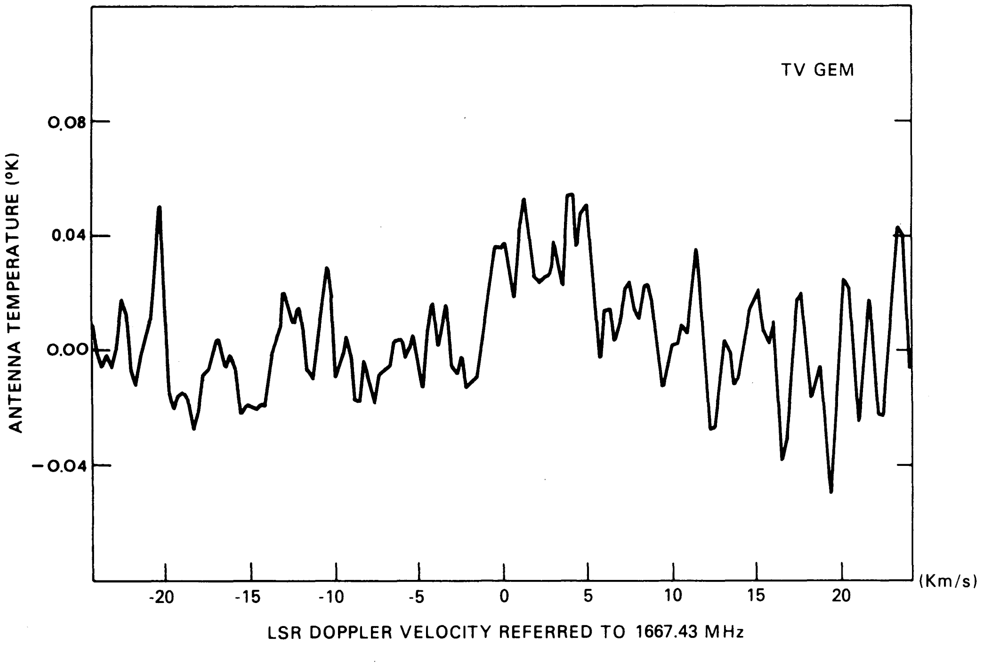

FIG. 2. TV Gem showing less pronounced emission at 1667.43 MHz than at 1665.47 MHz, where the data shown represent the composite of all individual frequency scans obtained at this frequency.

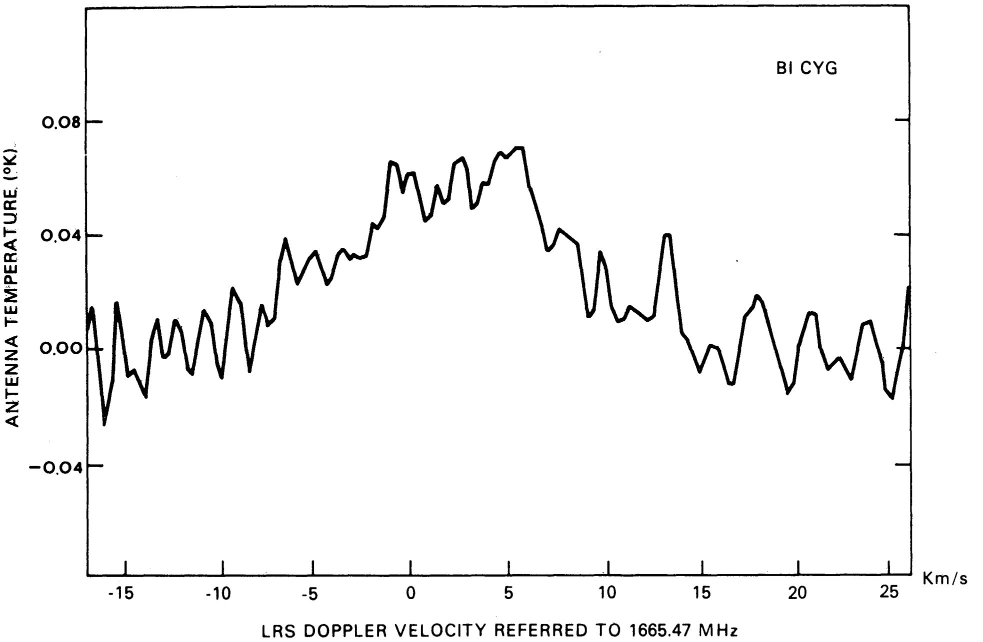

FIG. 3. BI Cyg observations at 1665.47 MHz suggest a broader emission feature than observed in TV Gem.

distribution for the 1665-MHz feature; and H_2O line emission was not detected for IRC+10420. For our observations, only the OH main-line emission was attempted and it is not possible to fully discuss TV Gem or BI Cyg in these terms. However, TV Gem (Bowers 1975) and BI Cyg (Wilson and Barrett 1972) have shown no detectable 1612-MHz emission at a lower-sensitivity level previously. Both stars do show infrared excess, and the mass-loss rates derived (Gehrz and Woolf 1971) suggest a silicate circumstellar shell which would greatly influence the OH observations.

The BI Cyg spectral feature is very similar to that of AH Sco, as there is no clear evidence of a double-peaked distribution over the broad feature. The TV Gem spectral feature is narrower and resembles one component of a double-peak distribution as observed in the other supergiants. This might result from the second peak being below the detection limit. This would support the OH emission radial velocity being at approximately 1 km s^{-1} instead of the stellar velocity of 17 km s^{-1}.

IV. SUMMARY

OH emission in the direction of TV Gem has been detected at 1665/1667 MHz and in the direction of BI Cyg at 1665 MHz. This increases the number of OH supergiants to nine and further expands the diversity of these objects.

TABLE I. Molecular OH observing program.

Date	Frequency (MHz)	Effective integration time (min)
	TV Gem	
8-20-79	1665	32.5
8-21-79	1665	110.0
		142.5
8-22-79	1667	67.5
	BI Cyg	
8-20-79	1665	42.5
8-21-79	1665	102.5
		145.0

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