Molecular Hydrogen in the Circumstellar Shells of Carbon Stars

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The S-branch lines of molecular hydrogen were detected in 2.0–2.4 μm carbon-star spectra by Johnson et al. (1983, *ApJ*, 270, L63). We subsequently detected strong S-branch lines in the 2 μm infrared spectra of M-, S-, and C-type long-period variables. In long-period variables, the H_2 lines show very strong phase-dependent changes in velocity, strength, and line profile, with the H_2 line strength greatest near minimum light. The strength of the H_2 lines also depends on the visual amplitude of the variable. Analysis of the H_2 line profiles shows that the H_2 line is formed both in the photosphere and in an extended, non-photospheric (non-pulsating) region (or regions) of the stellar atmosphere.

In the case of the obscured carbon stars, the photospheric 2 μm spectrum has been nearly completely filled in by thermal emission from circumstellar dust. Our modeling of the circumstellar envelope of IRC +10216 indicated that the expanding circumstellar H_2 S(1) line should be detectable with a depth of a percent or so. We also felt that observations of this line would shed light on the origin of the non-photospheric H_2 profiles seen in non-obscured stars. We undertook very high signal-to-noise 2 μm spectroscopy of IRC +10216 to observe the H_2 S(1) line. However, the observations reveal that at the few percent level, the photospheric spectrum of IRC +10216 is present in the 2.12 μm spectrum. This greatly complicates the analysis. Limits on the mass-loss rate will be discussed.

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