

CH⁺ AND CH EMISSION FROM THE RED RECTANGLE

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Using the 3.5 meter telescope at the Apache Point Observatory, we have observed the 0 - 0, 1 - 0, 0 - 1, 1 - 2, and 2 - 1 bands of the $\tilde{A}^1\Pi \rightarrow \tilde{X}^1\Sigma^+$ transition (origin at 4238 Å) of CH⁺ and the 0 - 0 band of the $\tilde{A}^2\Delta \rightarrow \tilde{X}^2\Pi$ transition (4307 Å) of CH in emission from HD 44179, the central star of the Red Rectangle. The 0 - 0 band emission of CH⁺ was reported earlier,^a but all other emission bands are new.

The CH⁺ emission lines are observed up to the $Q(7)$ and the $P(6)$ lines demonstrating population of CH⁺ up to at least $J = 6$ in the ground state. Since CH⁺ has a large dipole moment (1.656 D,^b 1.804 D^c) the spontaneous emission of the $J = 6 \rightarrow 5$ rotational transition at 165.96 cm⁻¹ is fast (the Einstein coefficient $A = 1.81 \text{ s}^{-1}$, 2.15 s⁻¹). In order to populate up to the $J = 6$ level, CH⁺ must be in an environment with a high density on the order of 10⁹ cm⁻³. It has to be a cloud of H atoms since H₂ will immediately react with CH⁺ to produce CH₂⁺. Existence of such a high density H I cloud is remarkable.

The observed CH emission, on the other hand, is limited to the $R_2(1/2)$, $R_1(3/2)$ and $R_1(5/2)$ lines all of which can be reached from the lowest two levels in the ground state that are separated by only 17.9 cm⁻¹ and spontaneous emission between them is slow. This clearly demonstrates that CH⁺ and CH exist in entirely different regions of the cloud surrounding HD 44179. A more detailed analysis will be given.

^aS. P. Balm and M. Jura, *A&A* **261** L25 (1992)

^bF. R. Ornellas and F. B. C. Machado, *J. Chem. Phys.* **84** 1296 (1986)

^cH. Sun and K. F. Freed, *J. Chem. Phys.* **88** 2659 (1988)