First astronomical detection of the \( \text{CF}^+ \) ion

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Abstract. We report the first astronomical detection of the CF\(^+\) (fluoromethylidyridium) ion, obtained by recent observations of its \( J = 1 - 0 \) (102.6 GHz), \( J = 2 - 1 \) (205.2 GHz), and \( J = 3 - 2 \) (307.7 GHz) pure rotational emissions toward the Orion Bar. Our search for CF\(^+\) was carried out using the IRAM 30m and APEX 12m telescopes – was motivated by recent theoretical models that predict CF\(^+\) abundances of a few \( \times 10^{-10} \) in UV-irradiated molecular regions where C\(^+\) is present. The measurements confirm the predictions. They provide support for our current theories of interstellar fluorine chemistry, which suggest that hydrogen fluoride should be ubiquitous in interstellar gas clouds.

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neutral diatomic hydride, and is the only such molecule to be more strongly bound than molecular hydrogen. Fluorine is therefore the only element in the periodic table to have a neutral atom that reacts exothermically with H$_2$. As Zhu et al. (2002) have shown, the reaction is expected to be fairly rapid even in cold molecular clouds.

(2) Hydrogen fluoride is the dominant reservoir of fluorine nuclei (solar abundance: $n_F/n_H \sim 3 \times 10^{-8}$) in the gas phase, even near cloud surfaces. Beneath the surface of a UV-illuminated cloud, HF forms precisely where hydrogen becomes molecular, and long before carbon gets incorporated into CO.

(3) Hydrogen fluoride is destroyed primarily by photodissociation and by reaction with C$^+$ to form CF$^+$. There is a substantial region where C$^+$ and HF overlap, and it is in this region where the CF$^+$ abundance is largest, accounting for a few percent of the total fluorine nuclei. The total predicted CF$^+$ column density is $\sim 10^{12}\text{ cm}^{-2}$ over a wide range of physical conditions.

To summarize, we have obtained the first astronomical detection of the CF$^+$ ion, toward the Orion Bar. This observation supports a theoretical model that predicts large abundances of HF close to cloud surfaces where the C$^+$ abundance is high, and it suggests that Herschel and SOFIA will detect widespread absorption by the $J = 1 - 0$ transition of HF in diffuse clouds along lines-of-sight to far-infrared continuum sources.

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References