First detection of the Methyldiene cation (CH\(^+\))
fundamental rotational line
with the Herschel/SPIRE FTS

(on behalf of the ISM SPIRE consortium)


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Methylidyne cation CH⁺

- One of the first molecules/radicals discovered in the visible 70 years ago (Douglas & Herzberg 1941), shortly after the methylidyne (CH) radical (Swings & Rosenfeld 1937).

- CH⁺ far-IR detections reported the J=2-1 to 4-3 transitions in the NGC7027 PDR (ISO-LWS / Cernicharo et al. 1997). ^13CH⁺(J=1-0) reported from the ground (Falgarone et al. 2005)
Production of \( \text{CH}^+ \)

- \( \text{CH}^+ \) is commonly detected in the visible and found to correlate with rotationally excited \( \text{H}_2 \)

\[
\text{C}^+ + \text{H}_2 \rightarrow \text{CH}^+ + \text{H} \quad (0.4\text{eV barrier or 4600K})
\]
Overcoming barriers for CH$^+$

Several routes examined:

- **UV pumping**
  
  Lambert & Danks, 1986

- The diffuse medium flux seems too weak for that

- The H2 profiles widths indicate a warm component

Gry et al., 2002

Lacour et al., 2005
Overcoming barriers for CH$^+$

Several routes examined:

- Shocks

- Expected velocity shifts between different species that are not observed (multiple shocks or intrinsic velocities dispersion among species)

Draine & Katz, 1986

Gredel 1997
Overcoming barriers for CH$^+$

Several routes examined:

- Turbulence
  (suggested in articles as a consequence of observed hot H2 not UV pumped)

TDR

Godard et al., 2009
SPIRE/FTS : CH$^+$ towards HII regions

Res $\sim$ 780 km/s, $\Delta \tau$ obs. = 0.05 $\Rightarrow$ $\Delta v \sim$ 40 km/s
CH$^+$ towards HII regions
CH$^+$ with SPIRE FTS in Orion Bar

Frequency (GHz)

[Graph showing frequency vs. brightness with peaks labeled Carbon Monoxide and Carbon, Carbon Monoxide, and Methylidyne Ion.]

Orion Bar © ESA and the SPIRE consortium
CH$^+$ and CH with SPIRE FTS in Orion Bar
CH$^+$ in Orion

Lis et al, 1998
CH$^+$ in Orion Bar

1.9 - 3.8 x 10$^{12}$ cm$^{-2}$ (50-200K)

5.5 - 11 x 10$^{12}$ cm$^{-2}$ (50-200K)
CH$^+$ in Orion Bar

Pellegrini et al, 2009
Orion PDR modelling

\[ C^+ + H_2^* \rightarrow CH^+ + H \]

Hierl et al. 1997

\[ C^+ + H_2 \rightarrow CH^+ + H \]
(0.4eV barrier or 4600K)

Meudon PDR Code: LePetit et al. 2006, Agundez et al. 2010, Habart et al. 2010
Work in progress…

- PDR Modeling including detailed physical param for CH+ to examine the excitation (in the rotational levels)

Waelkens et al., 1992

Balms et al., 1993
These data represent only few min int time, a fully sampled map will be investigated.

Should be associated to HIFI data

P1.03 PRISMAS Observations of the Methylidyne Ion (CH+) coupling Turbulence and Chemistry Falgarone, E.; et al.

P1.05 Herschel/HIFI Observations of the Methylidyne Ion CH+ in DR21 Gerin, M.; et al.

SPIRE FTS and HIFI complementary (wavelength coverage, mapping, HR obs.)

Naylor et al., 2010, A&A special issue
Orion PDR modeling

Meudon PDR Code: LePetit et al. 2006, Habart et al. 2010
Orion : CH on the Bar