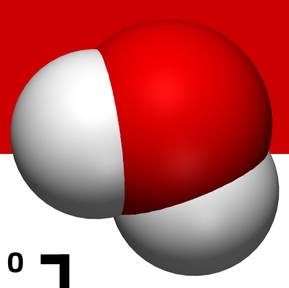
CO-Dark H_2 Gas is not Dark Anymore

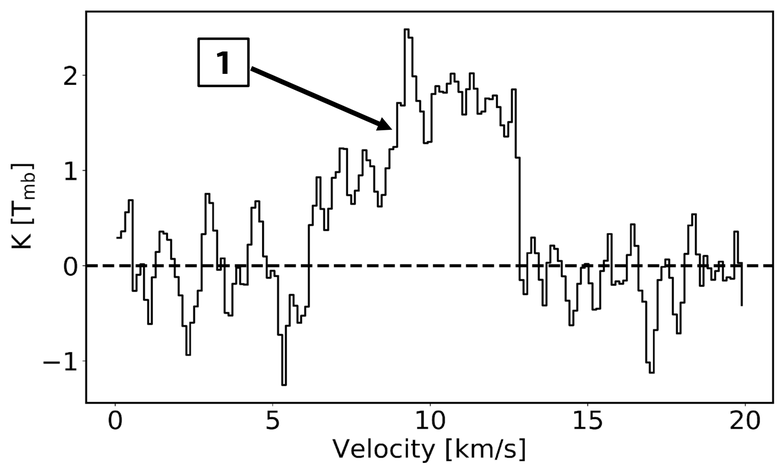
Ümit Kavak[1,2], Russell F. Shipman[2,1], Floris F. S. van der Tak[2,1], Alexander G. G. M. Tielens[3]

[1]Kapteyn Astronomical Institute, University of Groningen, The Netherlands
[2]SRON Netherlands Institute for Space Research, Groningen, The Netherlands
[3]Leiden Observatory, Leiden, The Netherlands



INTRODUCTION

The hydrogen fluoride (HF) molecule is seen in absorption in the ISM along many lines of sight and probing a variety of ISM conditions. It is surprisingly observed in emission toward the Orion Bar which is an interface between the ionized region around the Orion Trapezium stars and the Orion Molecular Cloud.



HF J = 1-0 line (1232.476 GHz or 243.2 μm) emission toward the Orion Bar.

TRAPEZIUM STARS

Thermal excitation?

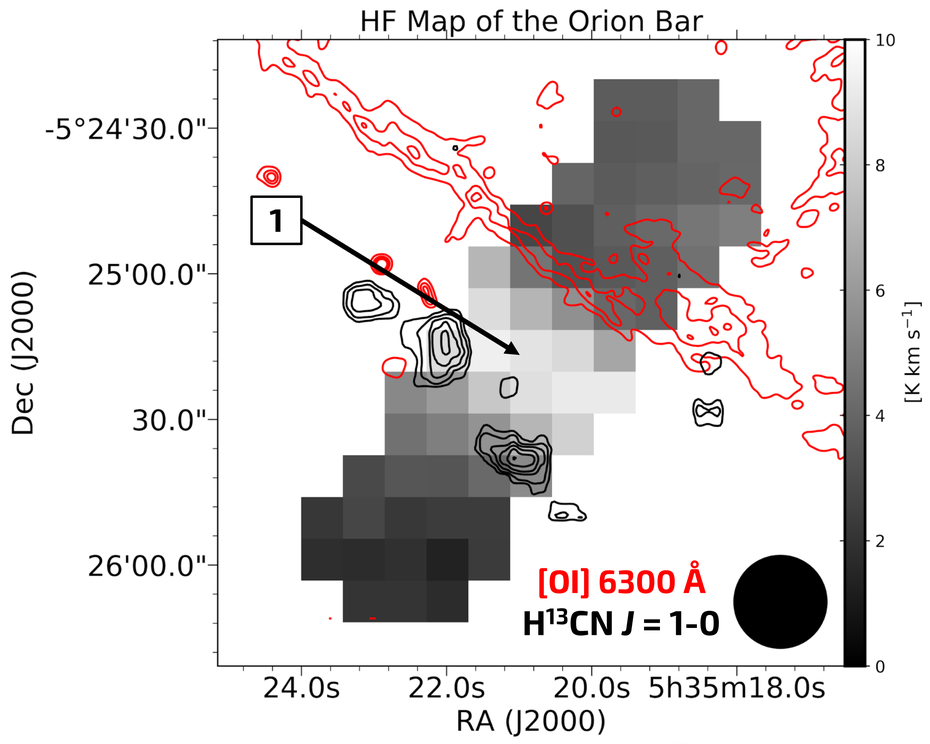
Dust?

Chemical pumping?

All/none of them?

OBSERVATIONS & MODELS

We use Herschel/HIFI maps of the HF emission across the Orion Bar combined with non-LTE radiative transfer modelling to investigate the emission.



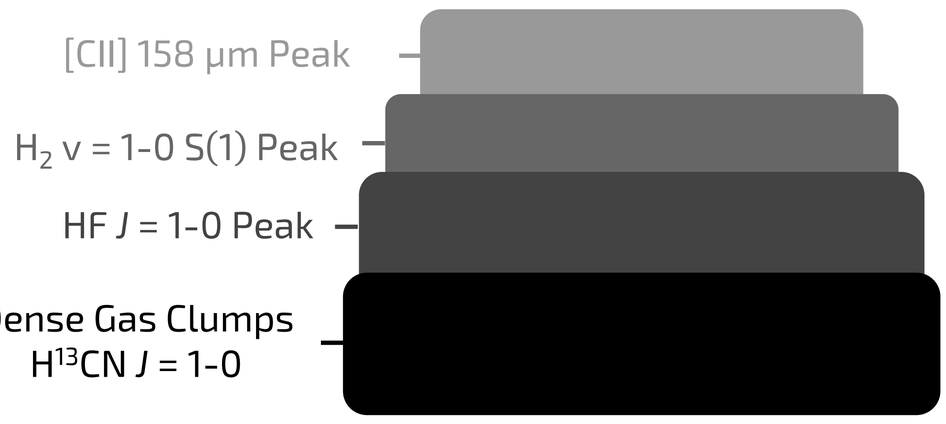
IONIZED (HII) REGION

[OI] 6300 Å ~ 100 arcsec

HF ~ 134.7 arcsec

Photodissociation Region (PDR)

[OI] 6300 Å (Ionization Front)



QUESTION?

Why is the HF line observed in emission?

$H_2 + F \rightarrow HF + H$ (Exothermic)

HF is dominant fluorine gas reservoir

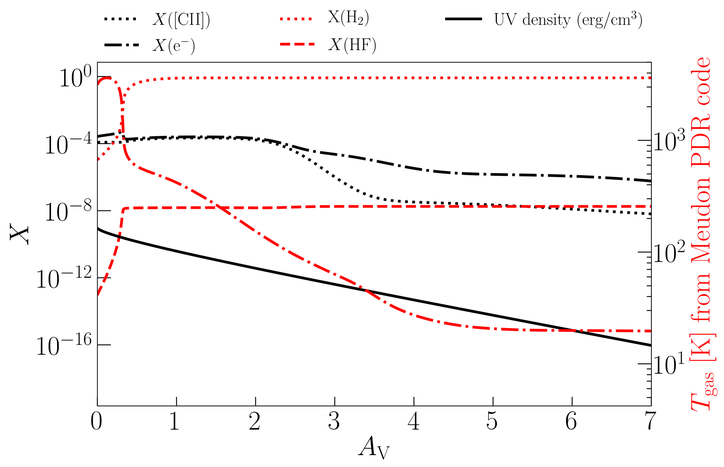
Therefore, HF is ***surrogate tracer*** of H_2 within the diffuse ISM.

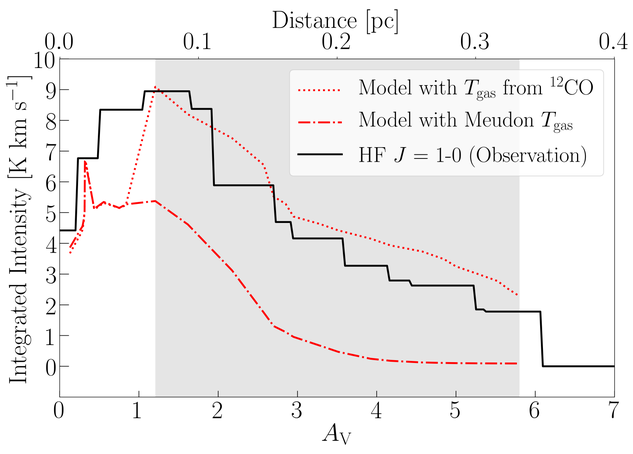
The Orion Bar is the only Galactic example of HF in emission!

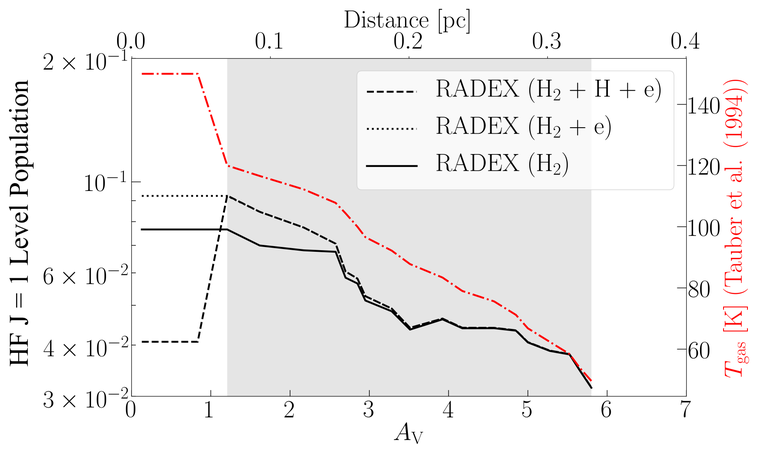
PDR: ORION BAR

THE CHEMISTRY AND EXCITATION OF HF J = 1-0

- *The gas temperature from ^{12}CO observations for the range of 1.2-6.*
- X(HF) increases between 0 < A_V < 1 when atomic H is converted into H_2.
- Atomic H is ineffective after A_V = 1.2
- The drop in the HF intensity is due to drop in the gas temperature.







RESULTS

- The bulk of the HF emission emerges from the CO-dark H_2 gas that separates the ionization front from the molecular gas deeper in the Orion Bar.
- The excitation of HF is caused by H_2 gas with a minor contribution of free electrons (15%) in the interclump gas (10^5 cm^{-3}).
- The collisional excitation of HF is insensitive to the H-to-H2 conversion in the Orion Bar.

ORION MOLECULAR CLOUD

HF J = 1-0 traces CO-Dark H_2 clouds

Submitted in A&A

Scan Quick Response Code and get your copy!

Scan me

university of groningen

SRON Netherlands Institute for Space Research

Universiteit Leiden Leiden Observatory

CELEBRATING THE FIRST 40 YEARS OF *Alexander Tielens'* CONTRIBUTION TO SCIENCE