UNIVERSITÉ de Cergy-Pontoise

l'Observatoire de Paris

LERMA

Laboratoire d'Étude du Rayonnement et de la Matière en Astrophysique

Sticking of molecular hydrogen on icy grains:

Beam temperature dependence

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(UMR 8112 of the CNRS)

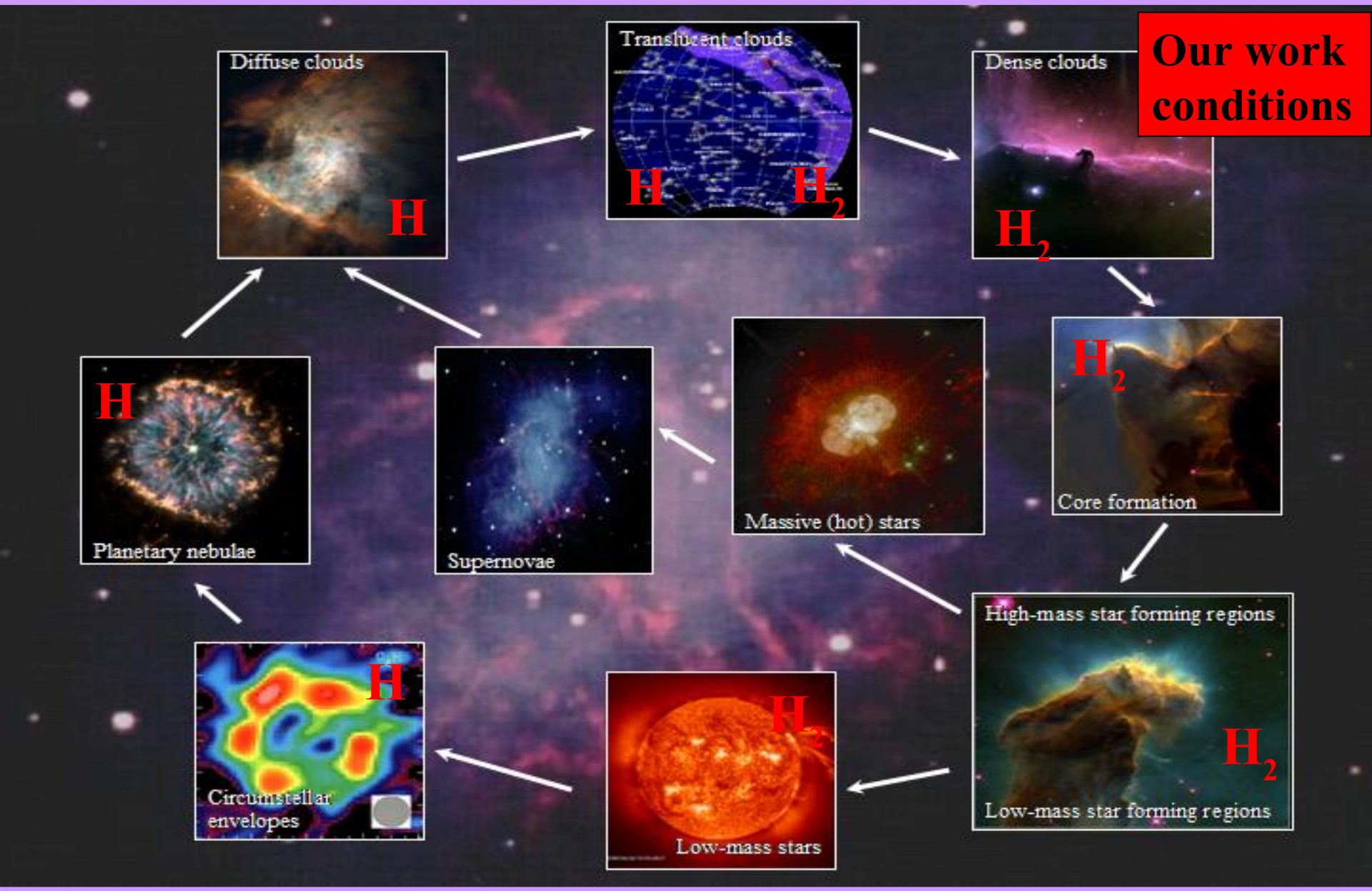
Réunion Plénière du GDR ARCHES

La Londe Les Maures, du 4 au 7 Mai 2009

Outline

- Introduction
- Experimental set-up – FORMOLISM
- Sticking of molecular H_2 and D_2
- Perspectives and future works

Introduction – Life cycle of a star



Introduction – Diffuse & molecular clouds

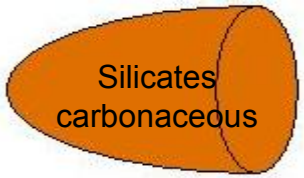
InterStellar Medium (ISM):

- **Composition: (in mass)** **Gas (99%) in which 90% hydrogen**
  Dust (1%)

- **Diffuse clouds:**

H

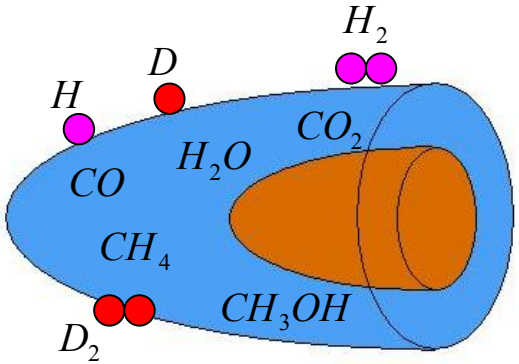
+ Dust forms: Silicates & or carbonaceous grains
+ Gas density ~ 50 cm^{-3}
+ T_{Gas} = 50 – 100 K
+ T_{grain} ~ 20 K



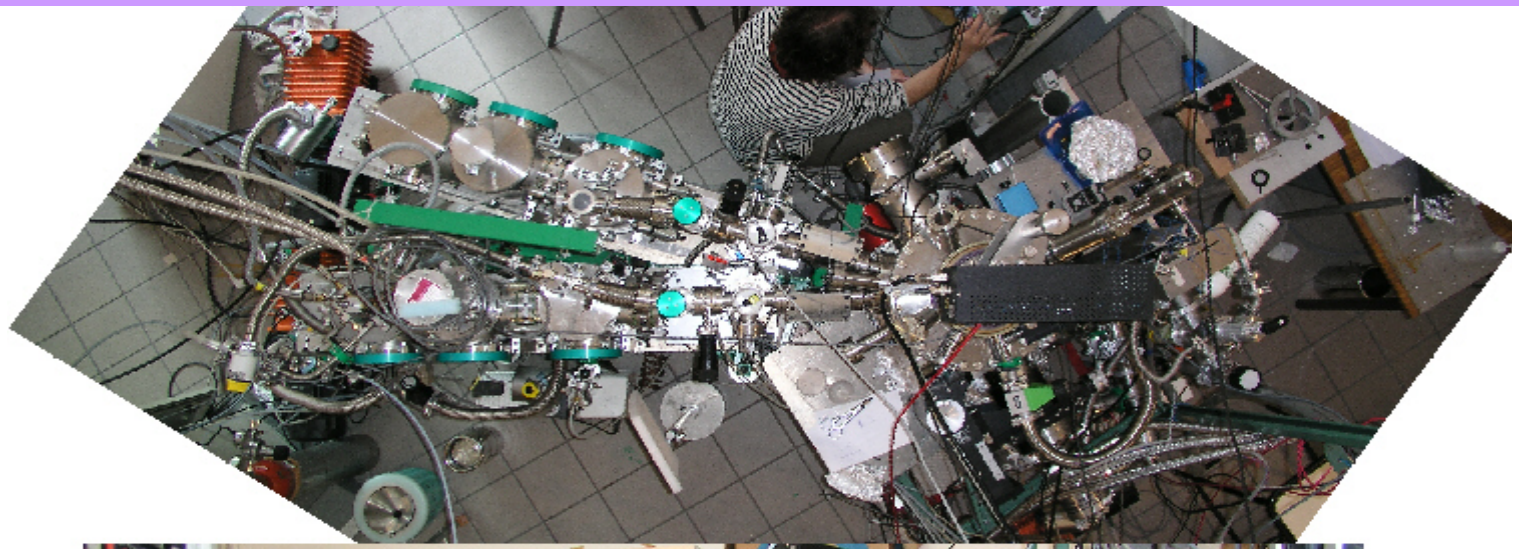
- **Molecular (dense) clouds: (Our work conditions)**

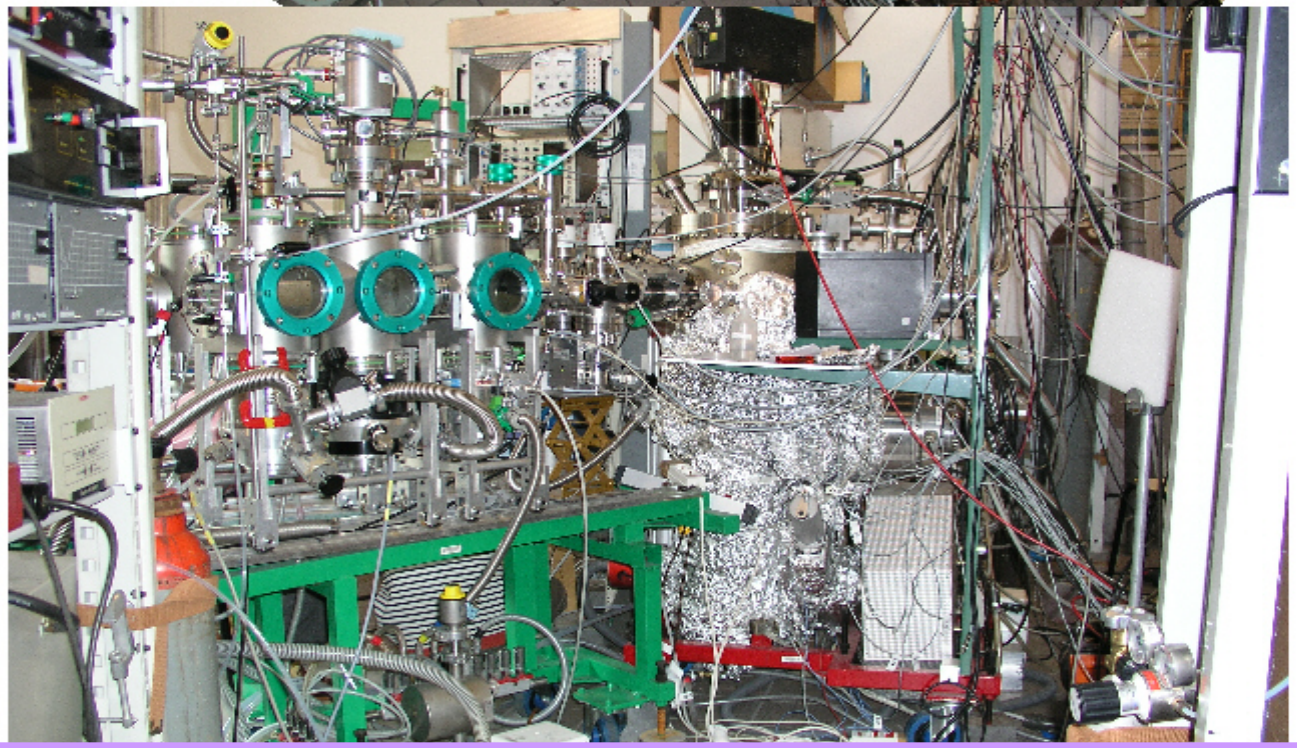
H_2

+ **Dust covered with icy mantles**
+ Gas density ~ 10^2 – 10^6 cm^{-3}
+ T_{Gas} ~ T_{grain} = 10 K

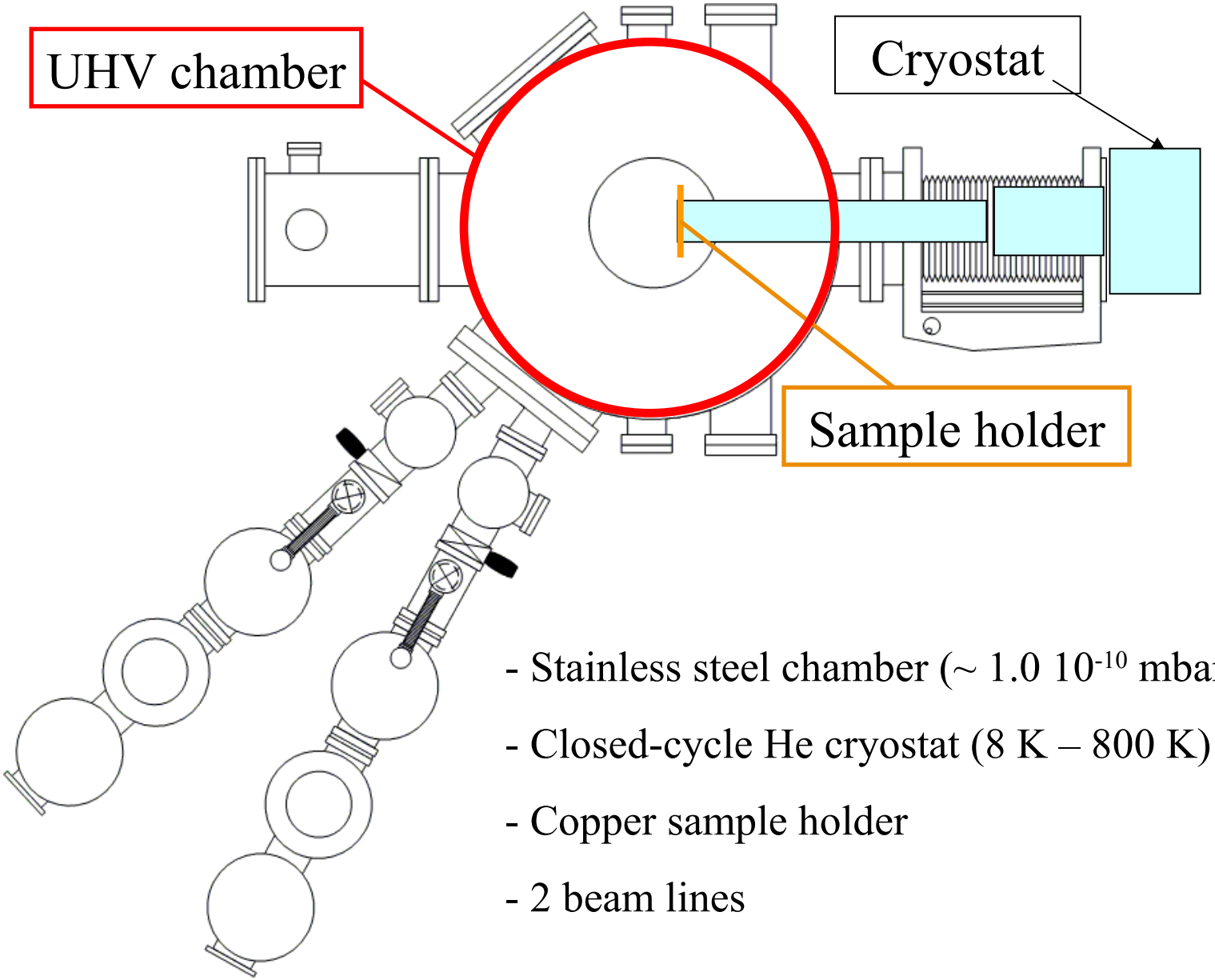


FORMOLISM



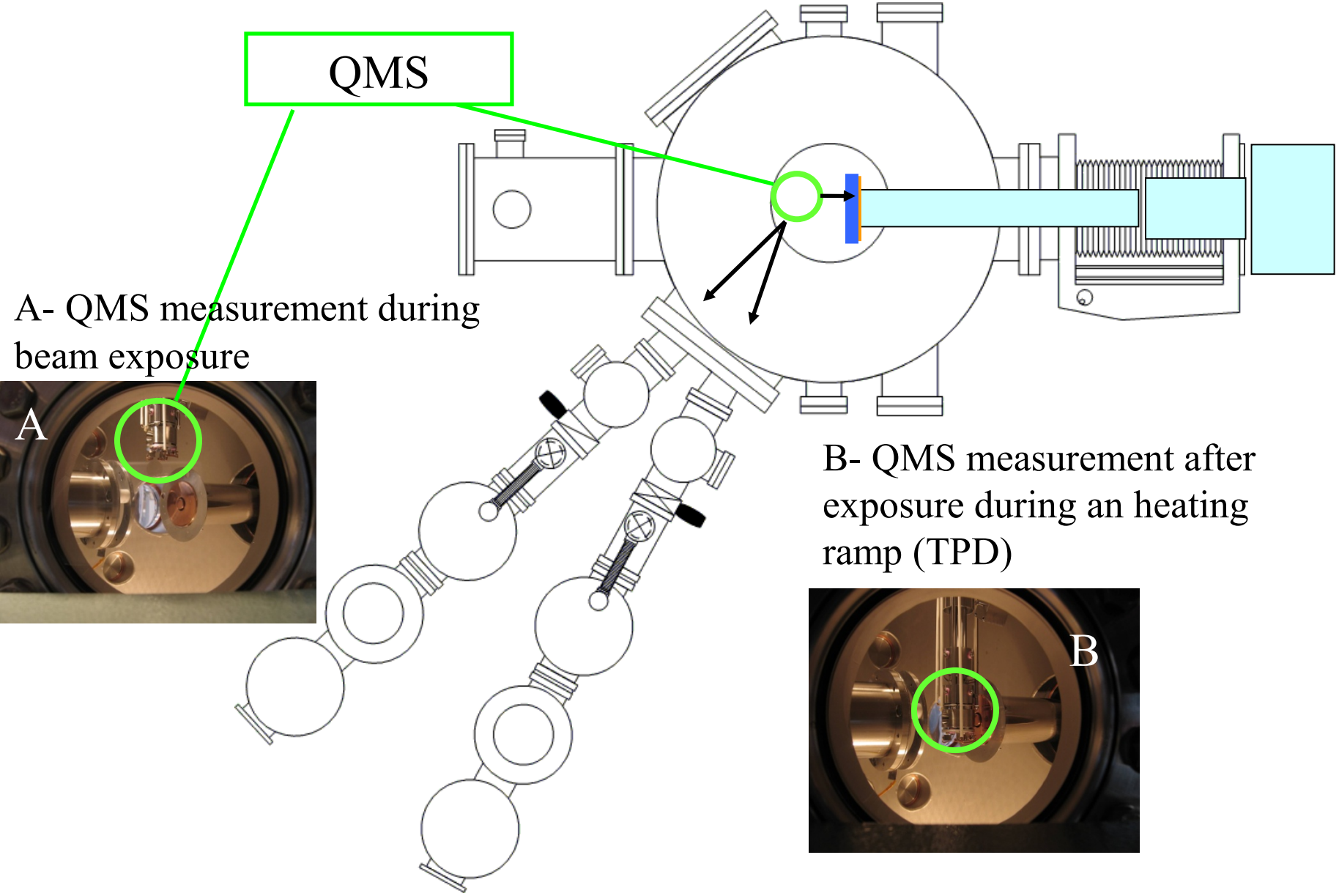


FORMOLISM

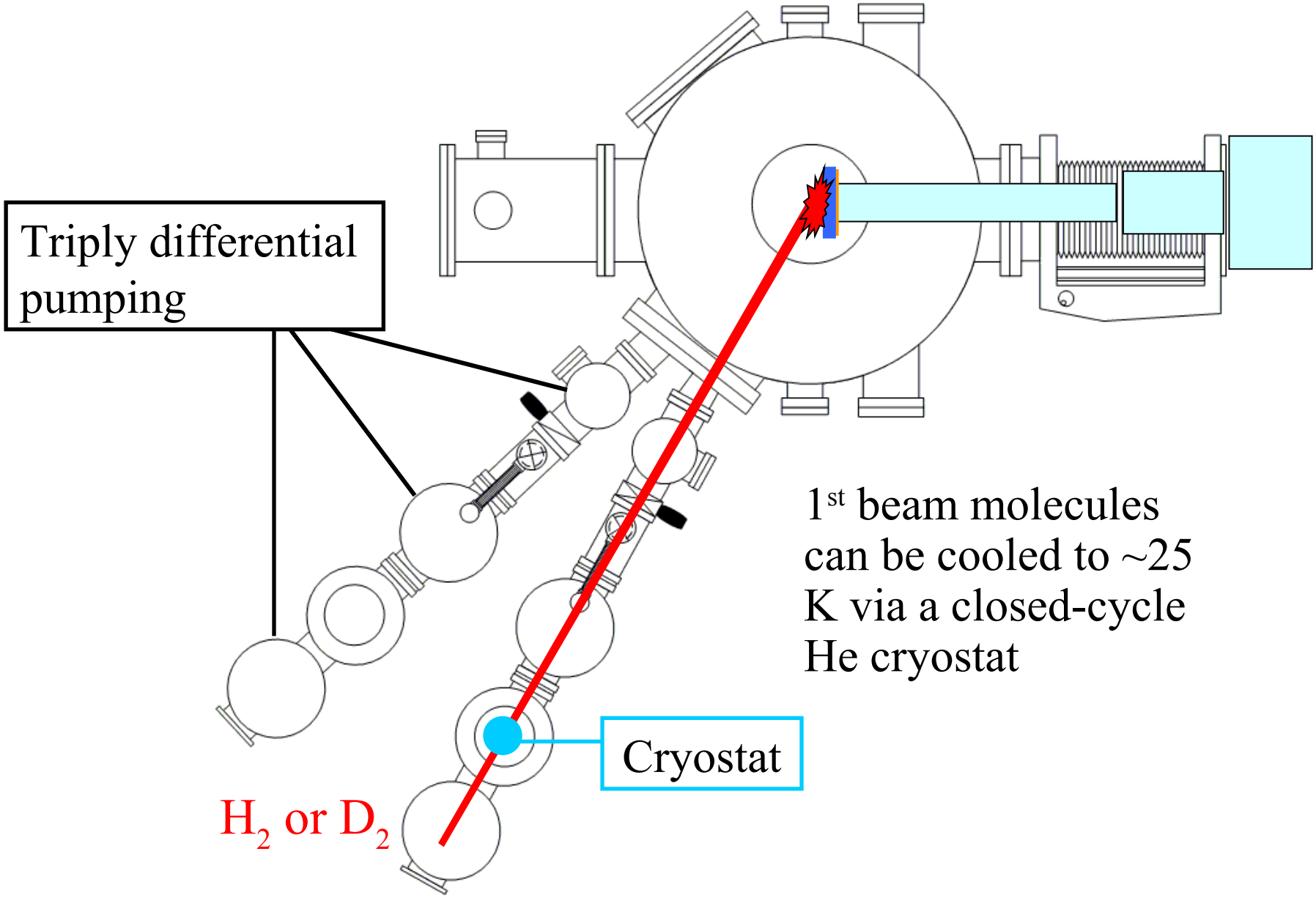


- Stainless steel chamber (~ 1.0 10^{-10} mbar)
- Closed-cycle He cryostat (8 K – 800 K)
- Copper sample holder
- 2 beam lines

FORMOLISM


QMS
A- QMS measurement during beam exposure
A
B- QMS measurement after exposure during an heating ramp (TPD)
B

FORMOLISM


Triply differential pumping
1st beam molecules can be cooled to ~25 K via a closed-cycle He cryostat
Cryostat
H2 or D2

Sticking of molecular hydrogen

Aims

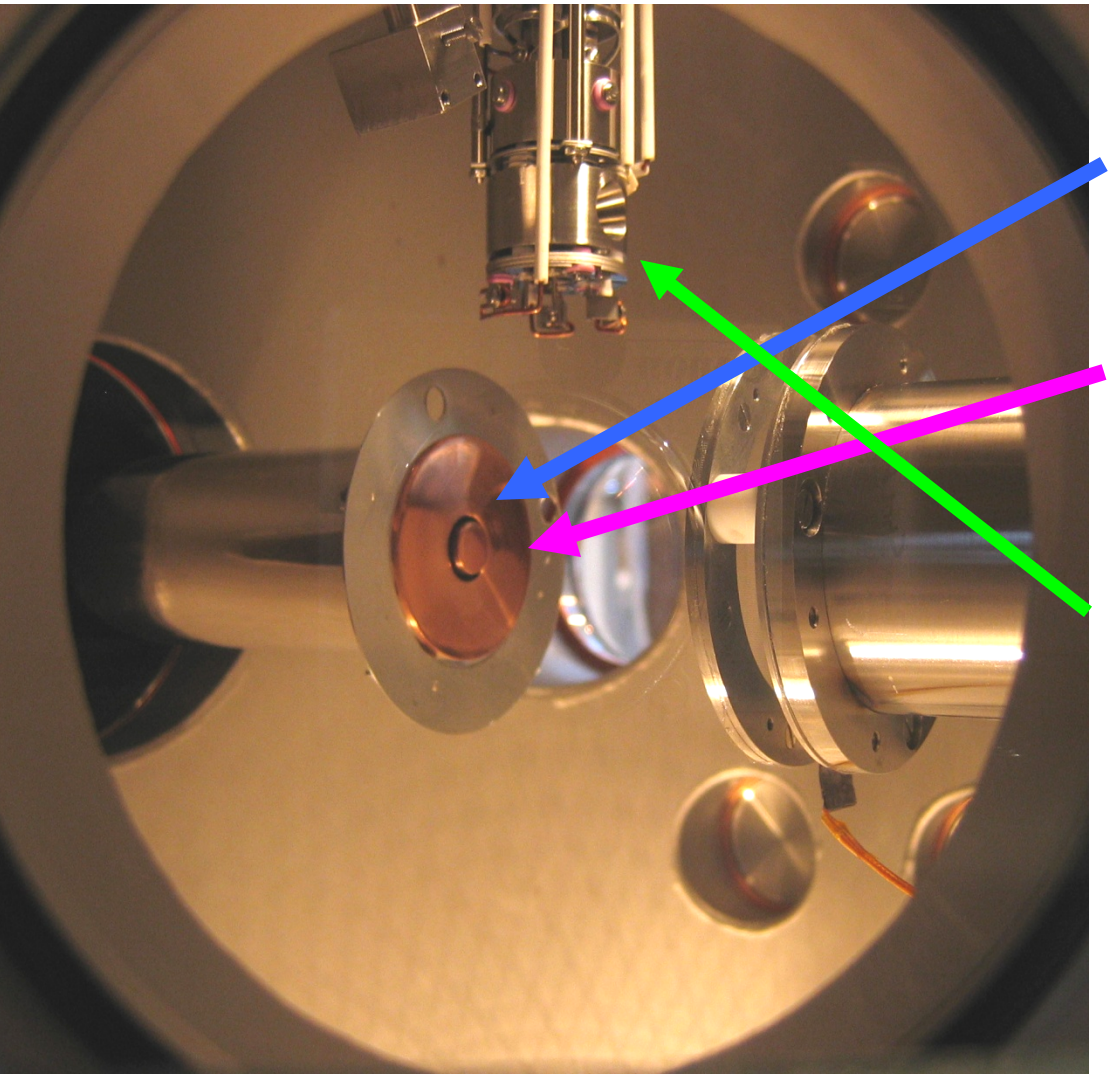
* H_2 most abundant in dense clouds

* enhances sticking of other species (Govers et al. 1980; Amiaud et al. 2007)

* isotopic segregation (Dulieu et al 2005, Chem. Phys. Let.)

* understand the sticking of H and the formation of H_2

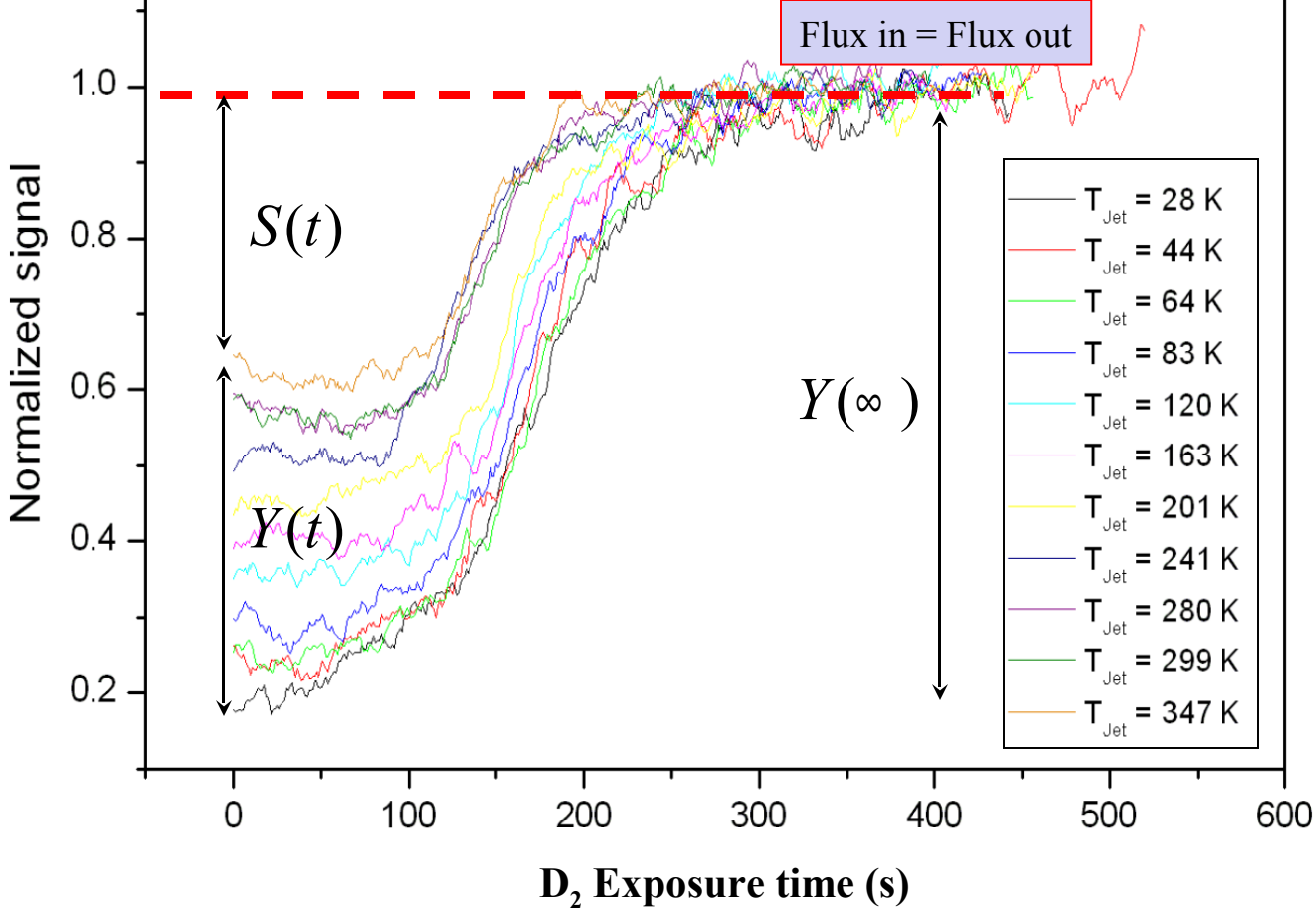
Procedures



1 – 100 ML of np ice (Ts = 10 K)

2 – D_2 (or H_2) beam
(T_b held in 30 – 350 K)

3 – Monitor (real time) the residual partial pressure of D_2



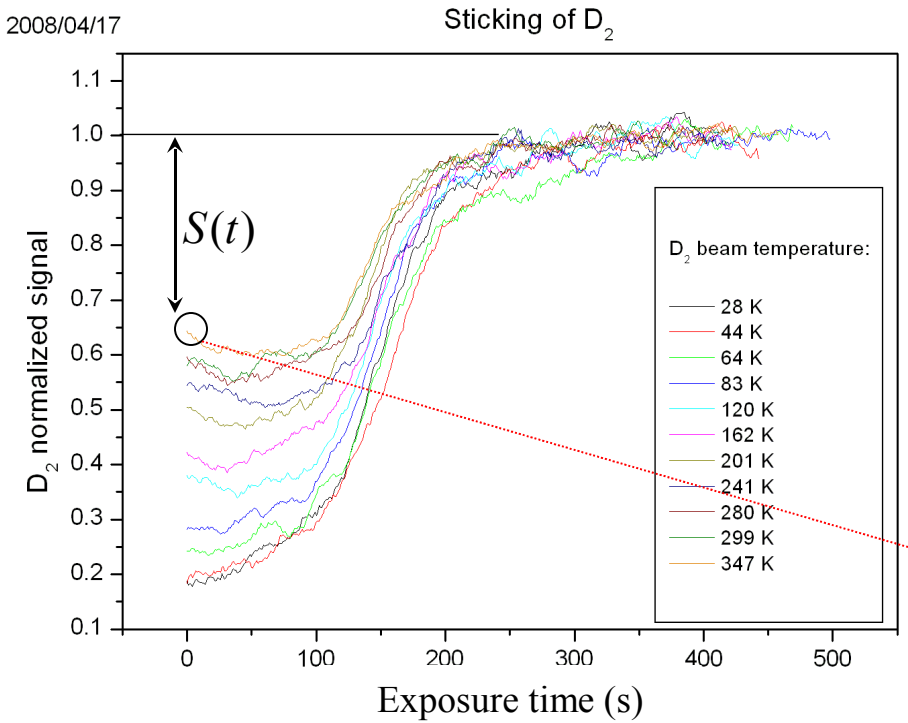
Absolute sticking coefficient:

$$S(t=0) = \frac{Y(\infty) - Y(t=0)}{Y(\infty)}$$

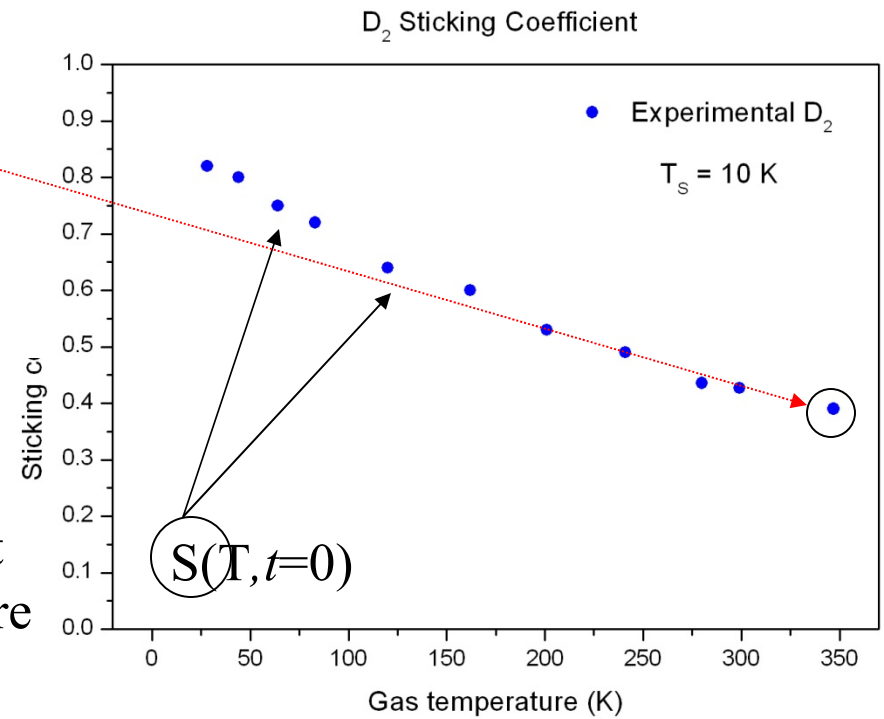
Amiaud et al. J. Chem. Phys. 127, 4709 (2007)

Matar et al. (In preparation)

Sticking of molecular hydrogen



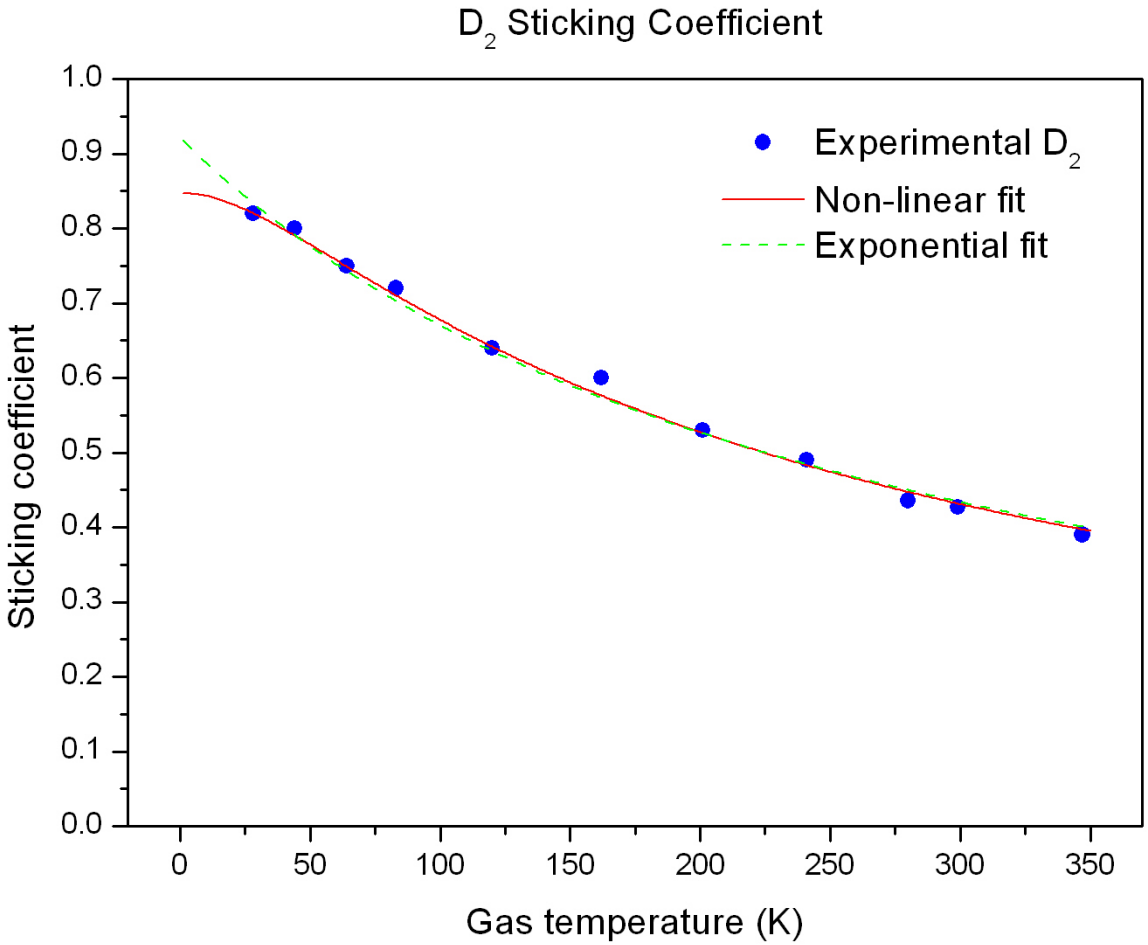
Variation of the sticking coefficient as a function of the exposure time



Variation of the sticking coefficient as a function of the beam temperature

Matar et al. (In preparation)

Sticking of molecular hydrogen

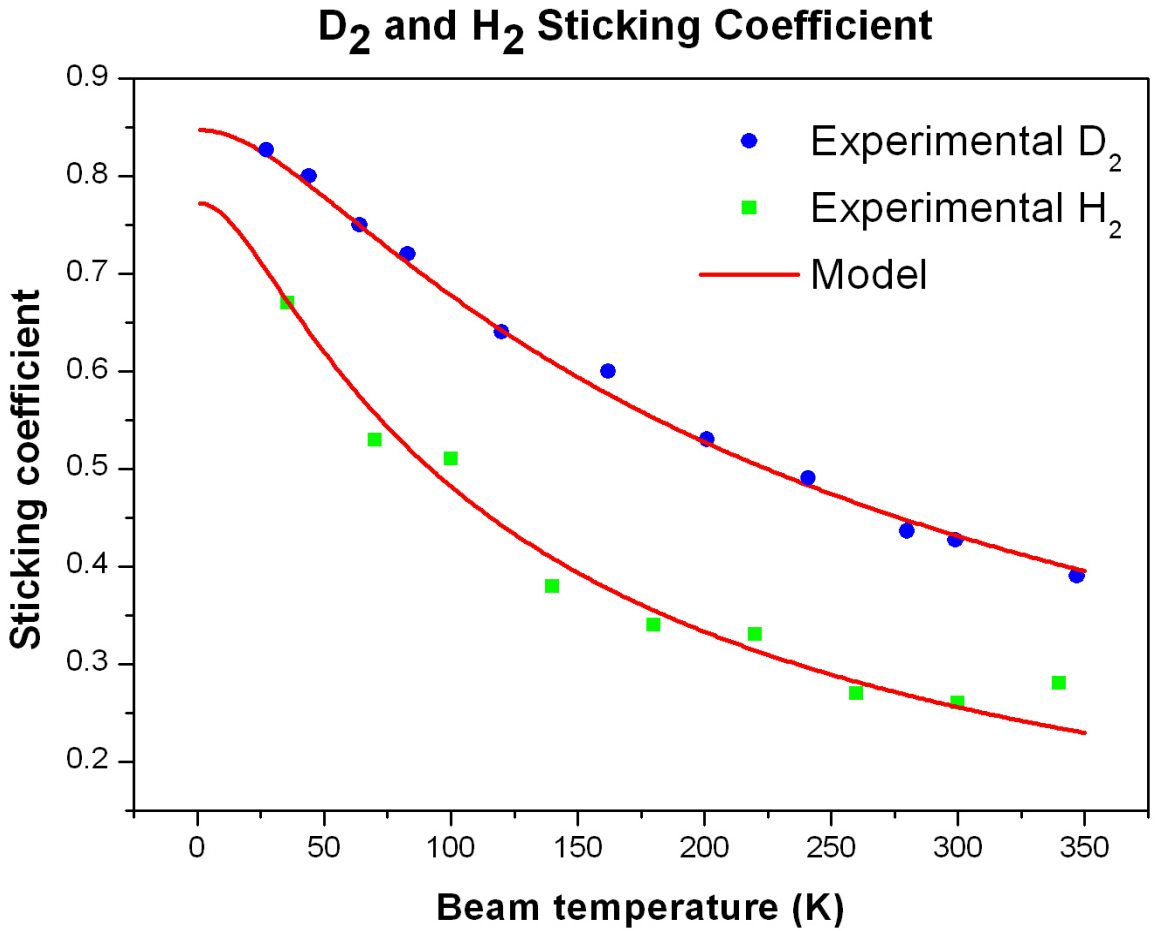


$$F(x) = \frac{1}{1+x^4}$$

$$F(x) = e^{-x^2}$$

$$S(T_S, G, T_G) = S_0(T_S, G)\int_0^{\infty} e^{-u} F\left(\sqrt{\frac{T_G}{T_0(m)}}u\right)du$$

Matar et al. (In preparation)



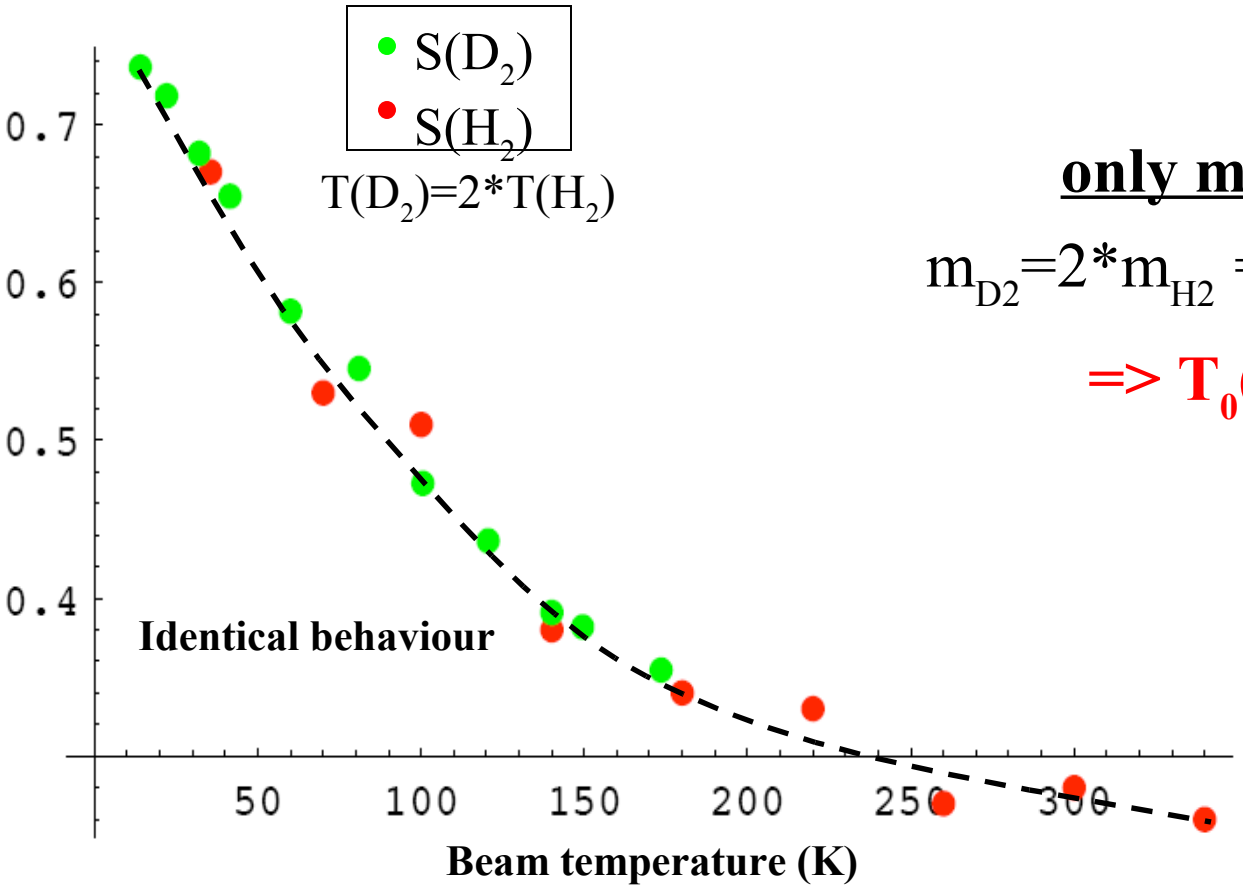
Experimental findings

under dense cloud conditions ($T_{Gas} \sim T_{grain} = 10$ K)

$S(D_2)$= 84% and $S(H_2)$ = 75%

Matar et al.
(In preparation)

Sticking of molecular hydrogen



<u>only mass dependence</u>

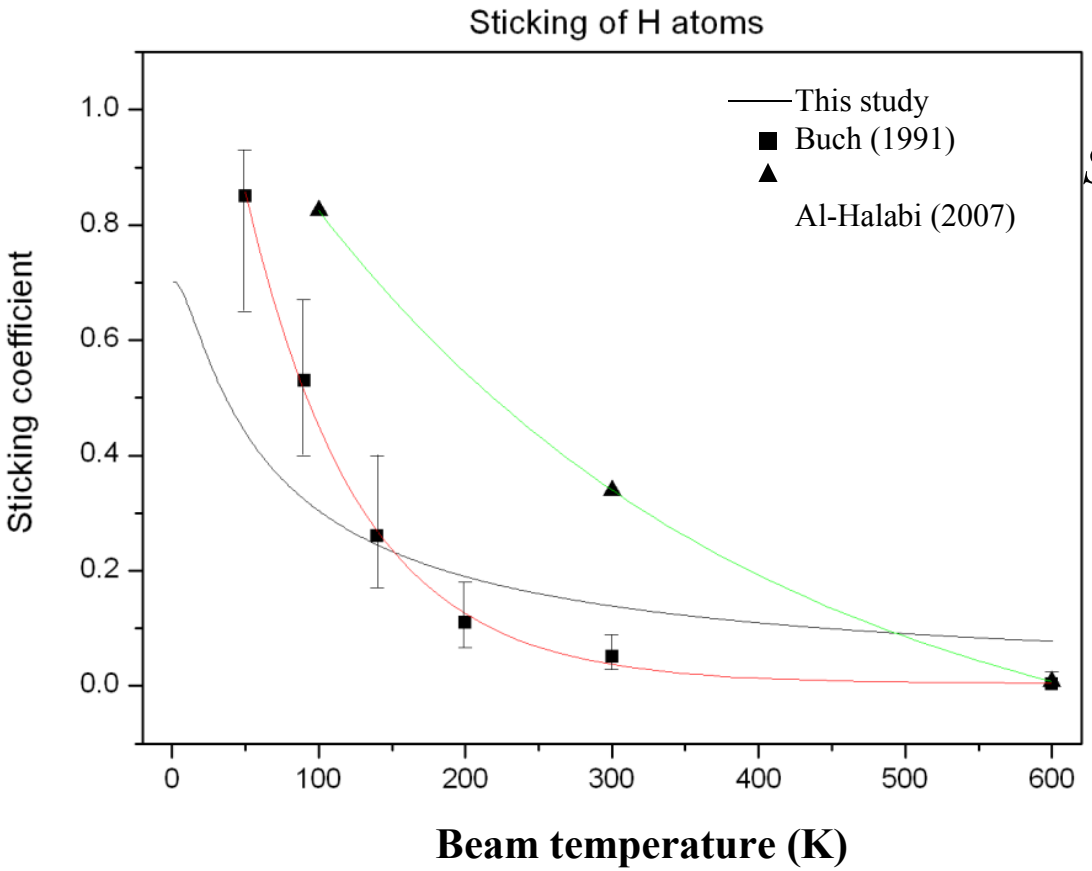
$m_{D2}=2*m_{H2} \Rightarrow T_0(D_2)=2*T_0(H_2)$

$\Rightarrow T_0(H) = T_0(H_2)/2$

Matar et al. (In preparation)

Comparison with others

Extrapolation of S(H) from S(H2)



Comparison

S(H) = *60% (Matar et al.)*
= *97%* (Al-Halabi 2007)
= *~100%* (Buch & Zhang 1991)

under dense cloud conditions
(T_{Gas}~T_{grain}=10 K)

Matar et al. (In preparation)

Future works

- **Experiments on the sticking of atomic hydrogen**

- **Improvement of the model to find the cause of the discrepancy in the values.**

- **Include grain-surface potentials, polarisability effects, etc.**

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THANK YOU