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# Velocity measurements of a cooled atomic hydrogen beam

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## ABSTRACT

We have analysed the velocity distribution of atomic hydrogen cooled down to liquid helium temperatures. Different geometries and different materials have been tested for the dissociator and the nozzle.

## 1) The test bench

Fig. 1 shows a schematic view of our test bench. The atomic beam produced by the nozzle is analyzed by a velocity selector [1]. A quadrupole mass spectrometer is used as a detector, allowing separate analysis of molecular and atomic velocity distributions.

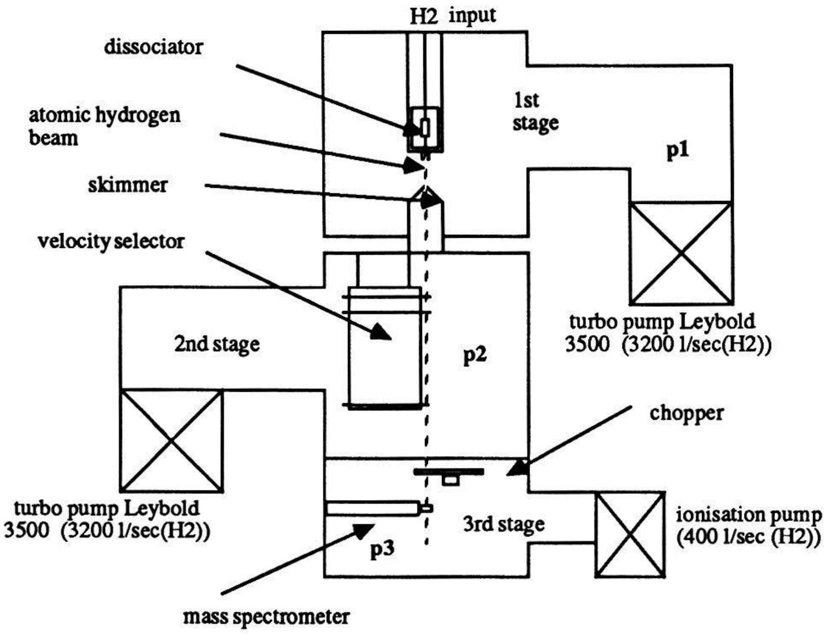


**Fig. 1** Schematic diagram of the test bench

## 2) The dissociator

We have used three different geometries for the dissociator (see Fig. 2).In the cases a) and b) the discharge is powered by a 27MHz generator. The power dissipation is about 150 W. In the case c), we use a microwave cavity at 2.54 GHz and the discharge is at room temperature. Hydrogen purified by a palladium filter is admitted into the dissociator at a pressure between 0.2 - 1 Torr (without adding vapour). There are two independant cooling circuits , one for the nozzle alone and one for the accommodator ( and the dissociator in a) and b) ).

In geometry a), the discharge became very unstable at lower temperature. Most measurements were done with geometry b). Geometry c) is the easiest to handle.
The following materials were tried:

- sapphire and pyrex for the dissociator
- sapphire for the accommodator
- sapphire, pyrex and pure aluminium (99.999%) for the nozzle.

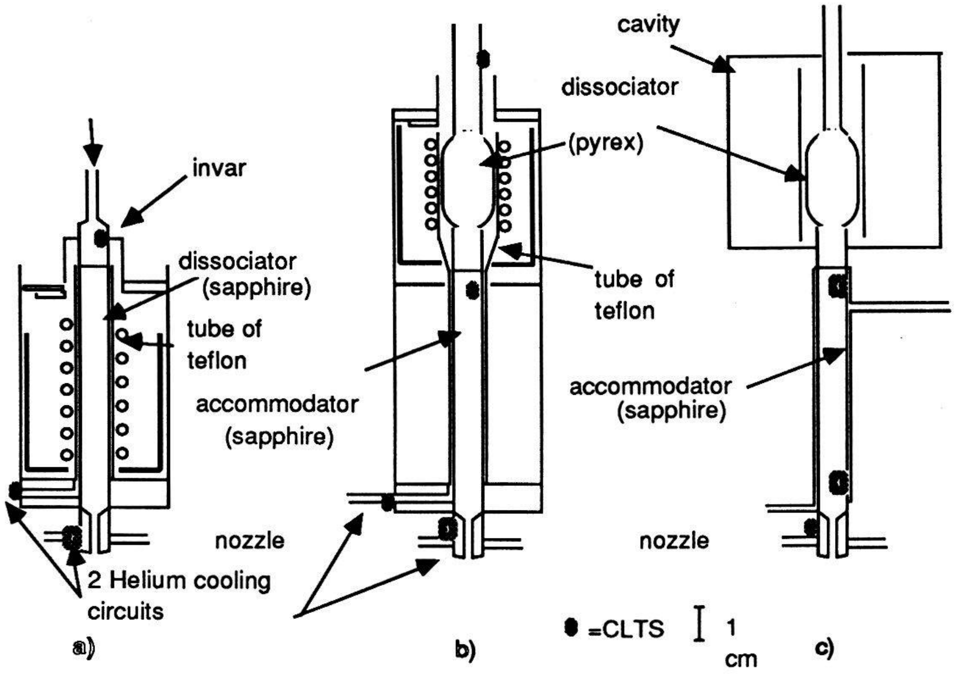
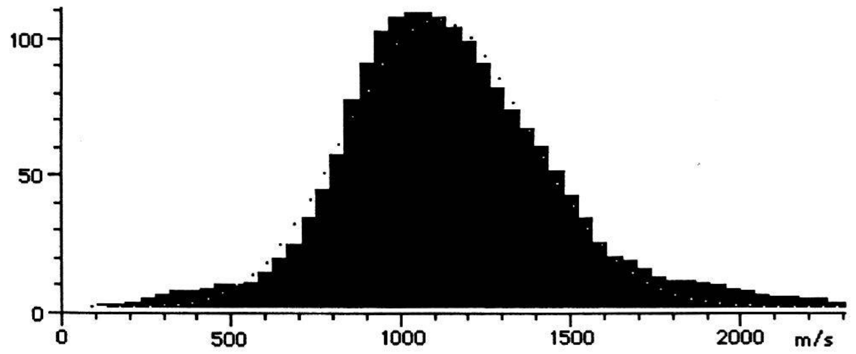


**Fig. 2** Dissociator geometries

The Fig. 3 gives an example of a measured velocity distribution . The parameters were the following: temperature of the nozzle : 10K , temperature of the dissociator : 164K , power :150W , gas flow : 0.5 torr l/sec

We have made a fit with a supersonic distribution : $f(V) \ \alpha \ V^3 \exp(-( V - V_{drift})^2/(2kT/m))$



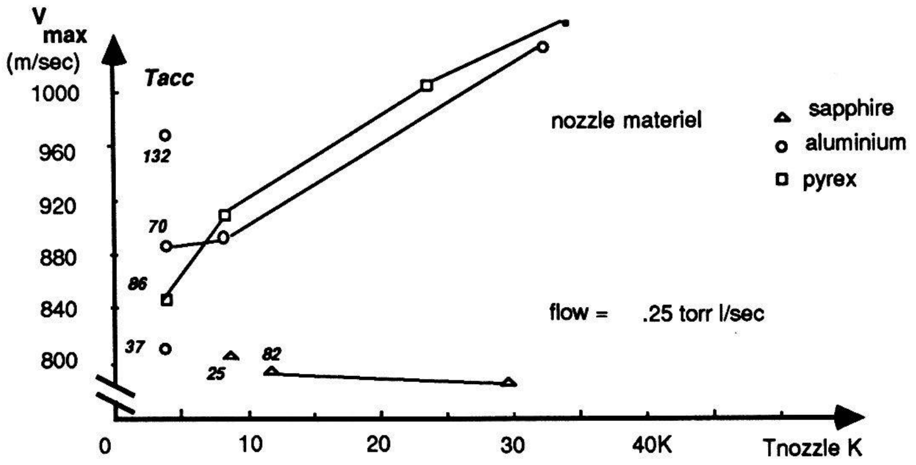
$V_{drift}$ = 858 m/s T = 11.1 K $V_{max}$ = 1035 m/s Mach number = 2.7

**Fig. 3** Example of a velocity distribution

3) <u>Results:</u>

1. The Fig. 4 shows the influence of the nozzle material on the most probable velocity. The sapphire nozzle gives the lowest velocity for a given nozzle temperature, which may be due to the high thermal conductivity of this material in our temperature range. On the other hand, one would expect a more pronounced difference between Pyrex and aluminium.

2. The Fig 5 shows ***the effect of the material on the recombination***. With the same geometry , we are changing only the material of the surface of the nozzle. The sapphire is a good surface from room temperature down to 5K, while the aluminium has a high recombination rate above about 70K.



Tacc = temperature of the accommodator (geometry b) )
**Fig. 4:** most probable velocity

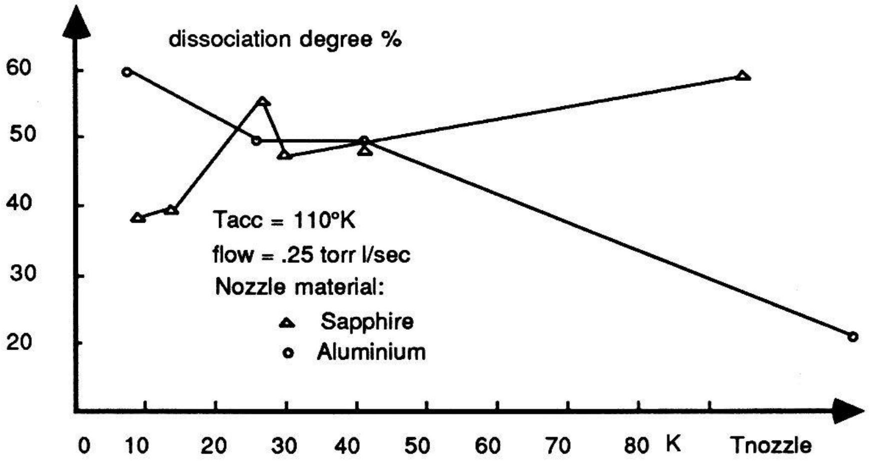


**Fig. 5** Dissociation degree for various nozzle materials (geometry 2 b)

Fig. 6 shows the dissociation degree as function of hydrogen flow and accommodator temperature.

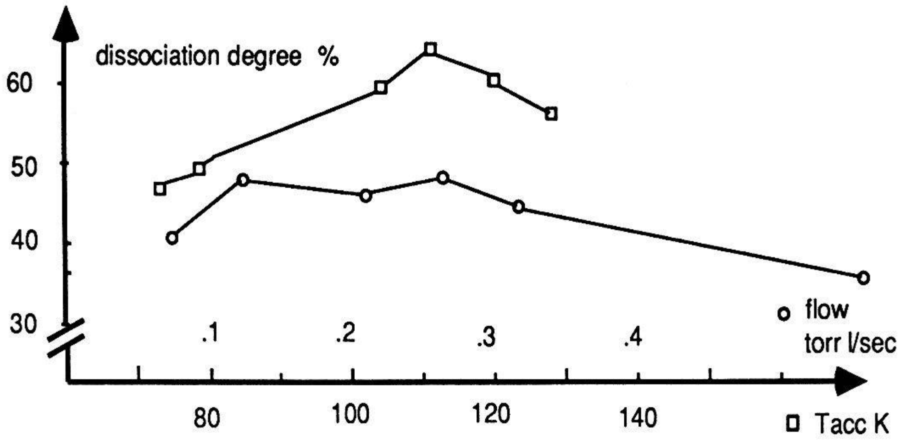


**Fig. 6** Dissociation degree (geometry fig 2 b , nozzle material: sapphire)

3. At the pressure where we are working we can see a ***moderate supersonic effect*** [2] :

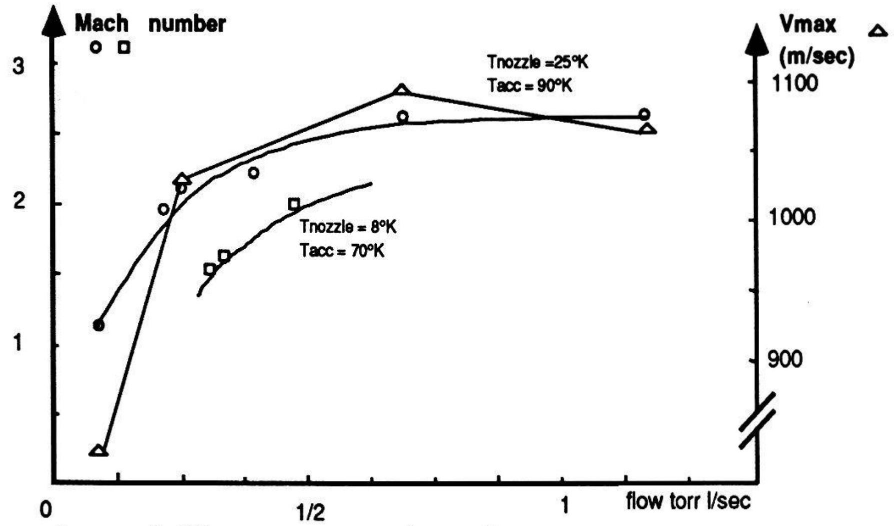


**Fig. 7** Mach number and Vmax versus gas input flow

4. ***Influence of the diffusion.*** We observe a steady decrease in beam intensity with decreasing nozzle temperature, the input gas flow remaining constant. The curve in Fig.8 has been obtained by multiplying the $H_2$ density as mesured by the mass spectrometer with the mean velocity. This intensity reduction may be due to the scattering of the cold molecules on the room temperature background gas.

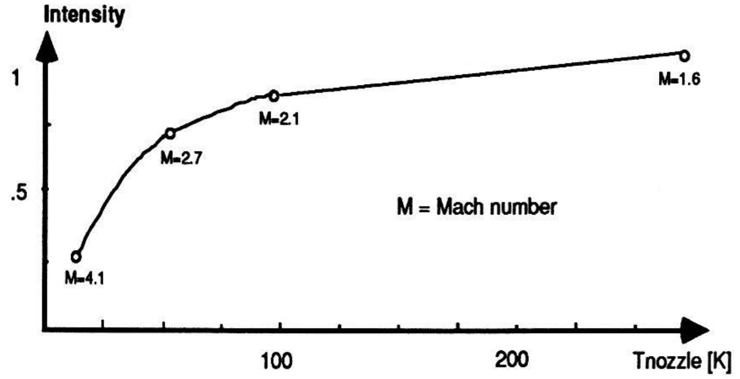


**Fig. 8** Effect of the diffusion

**4) Conclusions:** we have measured mean velocities comparable to those found by other groups [3][4] ,we find very similar velocity distributions. More measurements will be made in particular in the temperature range below 30K in order to clarify the influence of nozzle material and input gas composition on the dissociation degree.

**5) Acknowledgement:** we would like to thank the Institut für Strahlen und Kernphysik of the Bonn University for making availabel to us their velocity selector .

## 6) References:

[1] H.G. Mathews, PhD thesis, University of Bonn (1979)
[2] Peter P. Wegener 1974 , molecular beams and low density gasdynamics - Dekker New York
[3] A.Hershcovitch, A.Kponou and T.O.Niinikoski , this workshop
[4] P.A. Schmeltzbach, W. Grüebler , this workshop.

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See also rapporteur's report, Session (J), E. Huttel.