**lecture 28.10.2010**

we had in the last week:

- few more remarks on cluster physics
- atomic physics: history
- Doppler-reduced spectroscopy
- preparation of atomic beams part I

today:

- preparation of atomic beams II: thermodynamics
  blackboard script and ppt

# preparation of supersonic atomic beams

## by adiabatic jet expansion

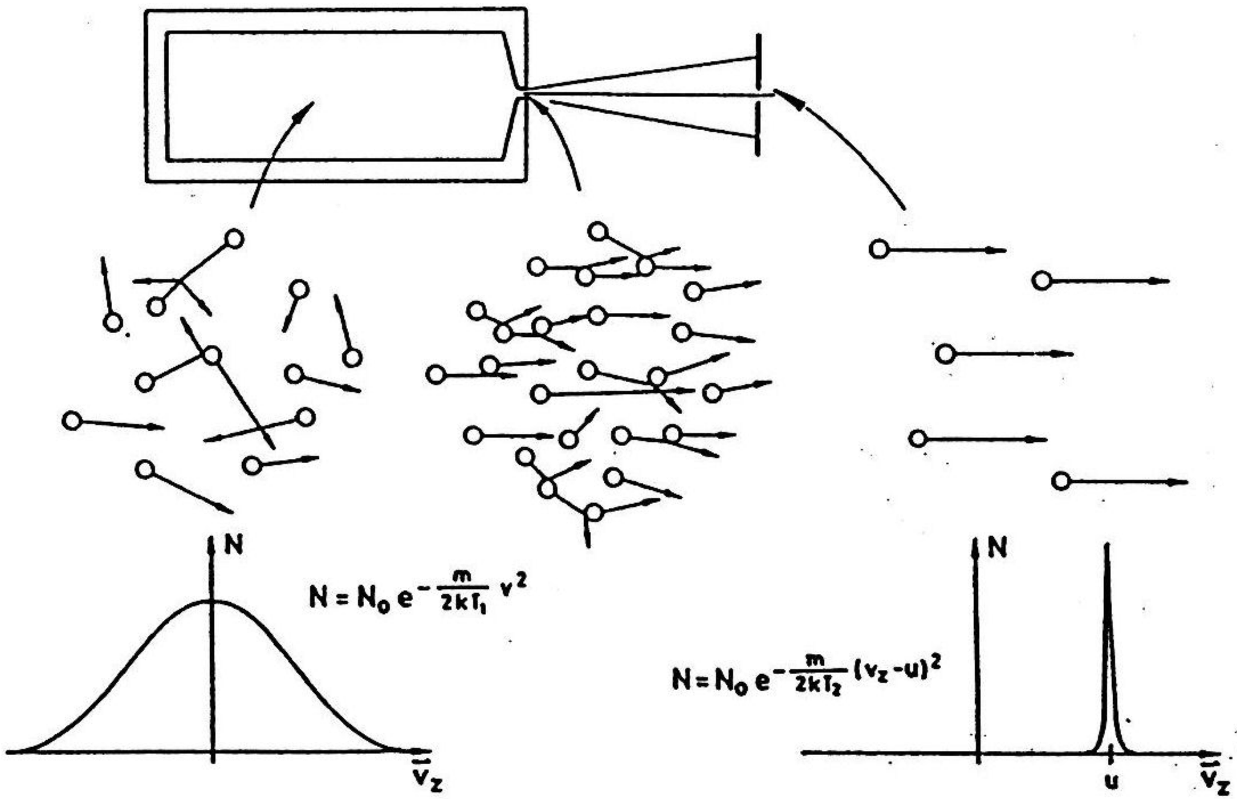
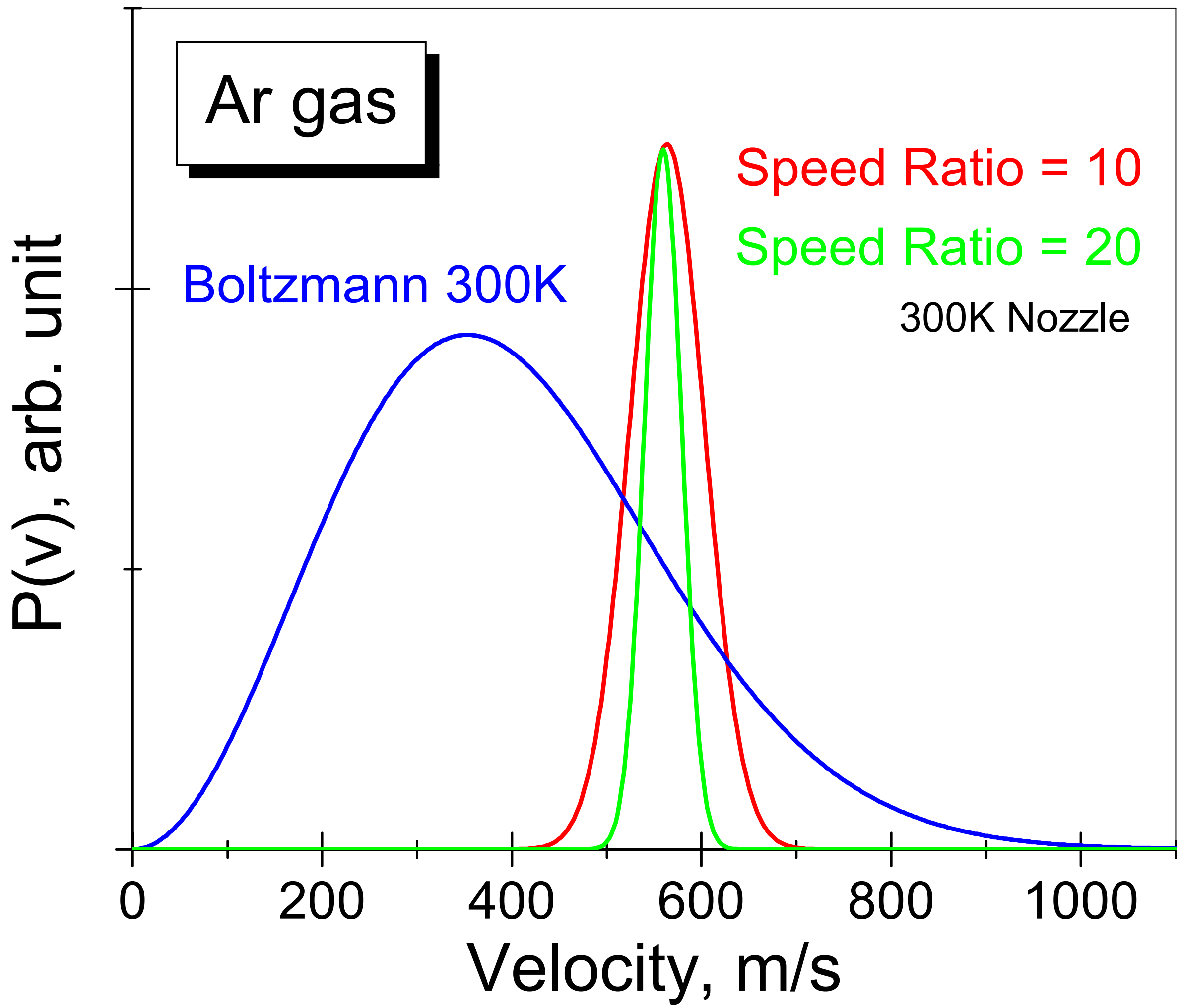
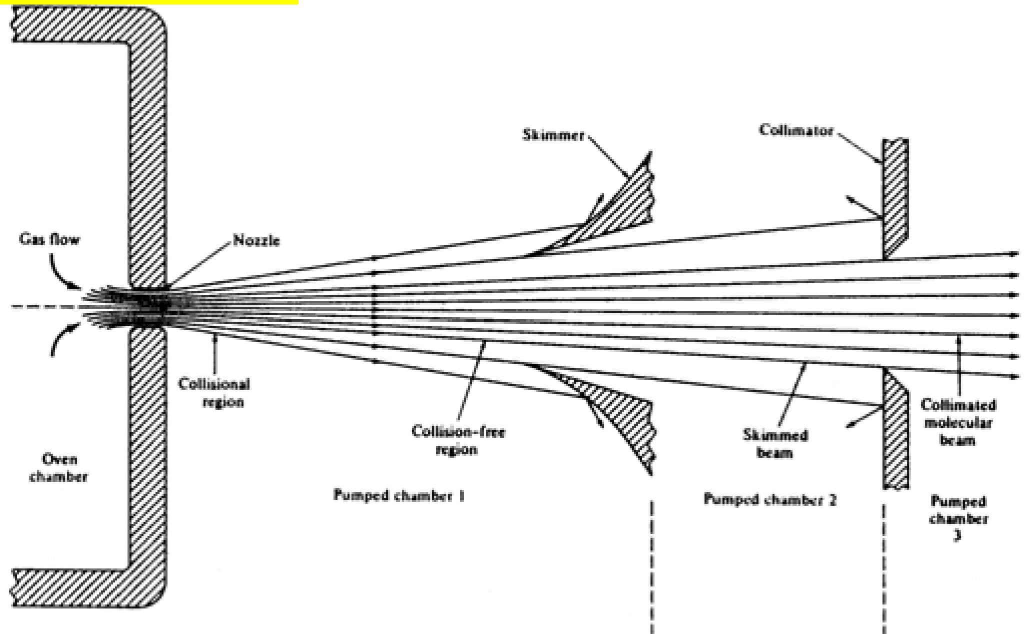



**Fig. 8:** Die mikroskopische Ursache für die Temperaturerniedrigung und Clusterbildung bei der adiabatischen Expansion [13]. Im Ausgangsbehälter herrscht vor der Expansion thermisches Gleichgewicht. Die ungerichtete Geschwindigkeitsverteilung der Teilchen ist durch die Maxwellverteilung bestimmt. Bei der Expansion des Gases durch eine Düse kommt es durch Stöße mit den anderen Gaspartikeln zur Abnahme der inneren Energie zu Gunsten der Expansionsgeschwindigkeit *u*. Die Relativgeschwindigkeit im kalten Molekularstrahl nimmt stark ab, wodurch die "kalten" Atome zu Clustern zusammenlagern.

## *General Features of a Molecular Beam*



## *General Features of a Molecular Beam*




backing pressure $P_0$:
0.1 ~ 100 atm

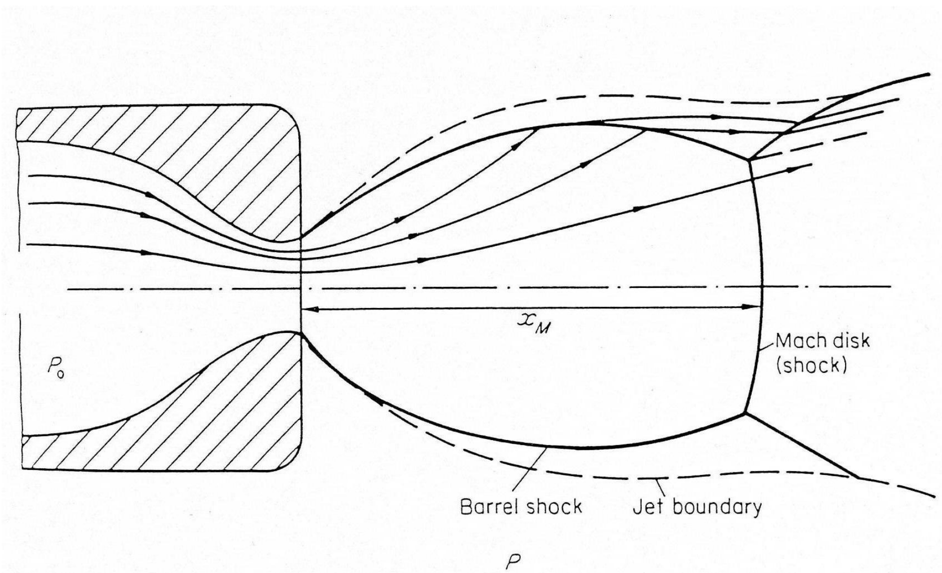
source chamber:
$10^{-6}$ ~ $10^{-2}$ torr (far away from nozzle)

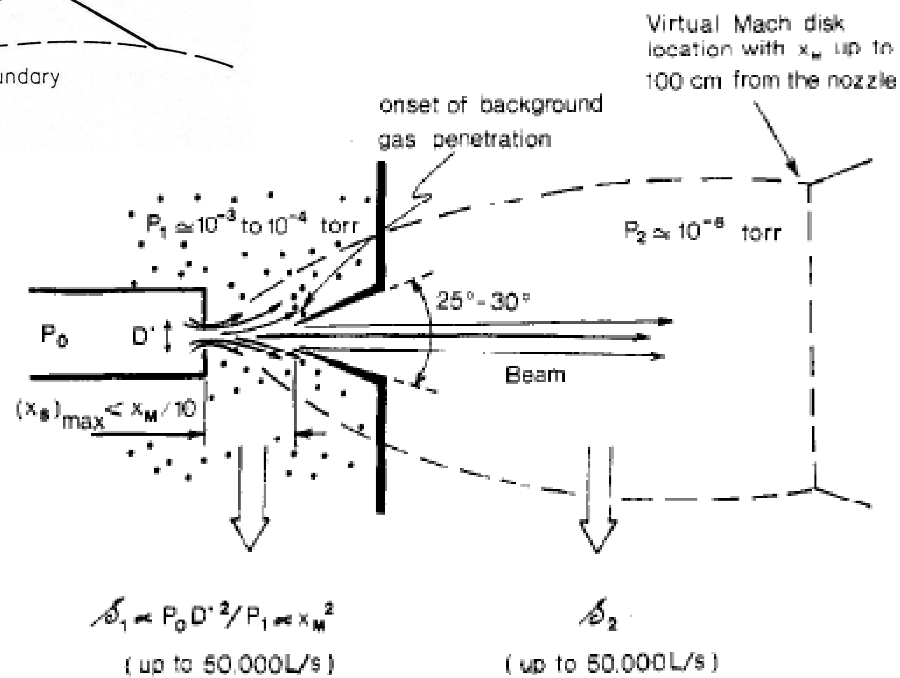
Expansion (Huge pressure drop >$10^3$)

⇨ Very Efficient Translational Cooling

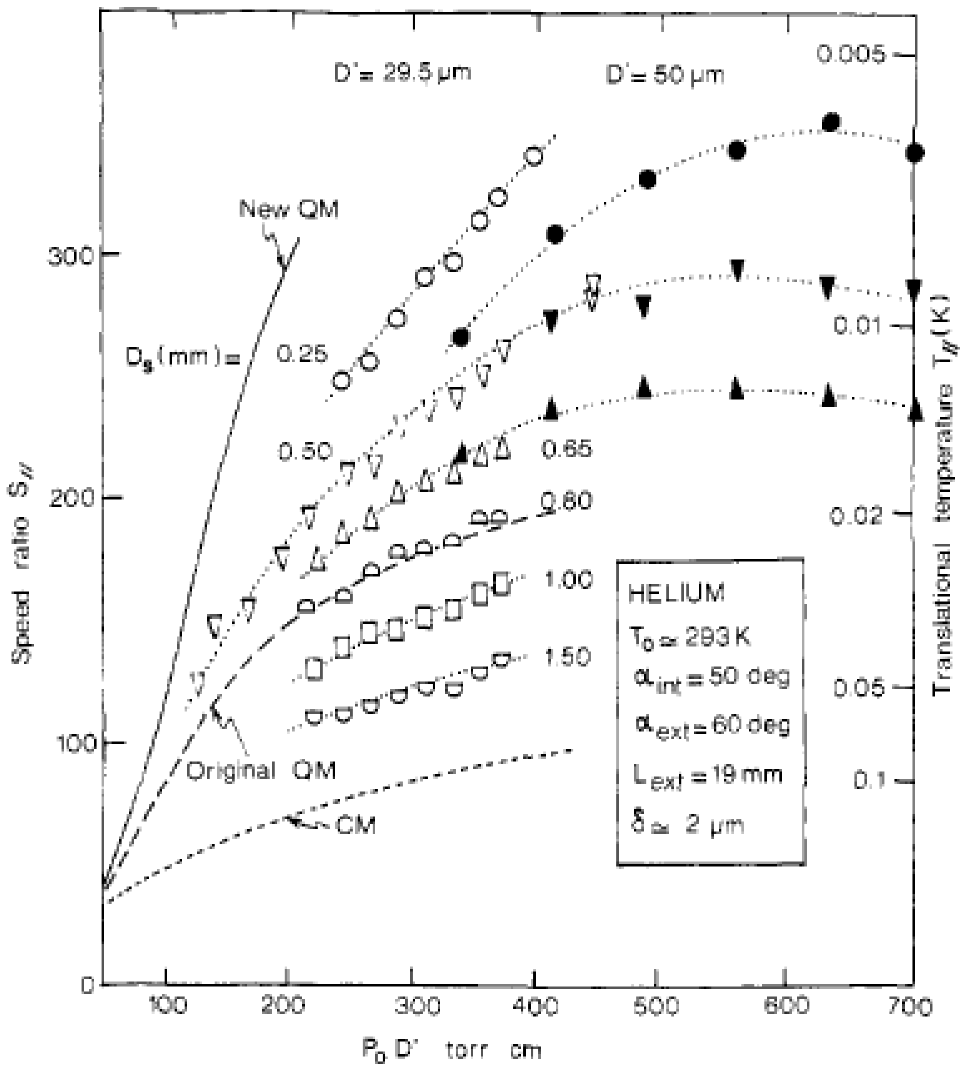
Translational Temperature ($T_{trans}$) can easily reach 1K~10K

# supersonic jet expansion



# cooling by supersonic expansion




effect of skimmer diameter D on the speed ratio S

Campargue J. Phys. Chem. 1984, 88, 4466

## *General Features of a Molecular Beam*

Very Efficient Translational–Rotational Energy Transfer

⇨ Very Efficient Rotational Cooling

Rotational Temperature ($T_{ROT}$) can easily reach 1K~10K

Poor Translational–Vibrational Energy Transfer

⇨ Inefficient Vibrational Cooling

Vibrational Temperature ($T_{vib}$) can keep the nozzle temperature or only slightly lower (e.g., cooled to 200K from 300K)

## *General Features of a Molecular Beam*

| Type of processes | # of collisions |
|---|---|
| velocity deflection | 1 |
| translational relaxation | 10 |
| rotational relaxation | $10^2$ |
| vibrational relaxation | $10^6$ |
| nozzle expansion | $10^3$ |

Relaxation rates depend on the gas, T, etc

# of collisions during expansion is scaled to $P_0 d$