UHV and Below
Routine or Challenge?

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Pressure Regimes

Rough Vacuum	Atmos – 10^{-3} mbar
Medium Vacuum	10^{-3} – 10^{-6} mbar
High Vacuum (HV)	10^{-6} – 10^{-9} mbar
Ultra High Vacuum (UHV)	10^{-9} – 10^{-11} mbar
Extreme High Vacuum (XHV)	< 10^{-11} mbar

Vacuum Equation

$$P = \frac{Q}{S}$$

Where P is the base pressure in the system

Q is the gas load in the system

S is the pumping speed available in the system

Gas load includes

$$Q = \cancel{Q_{inj}} + Q_{outgas} + Q_{leak}$$

Minimise

Includes Backstreaming

Challenges?

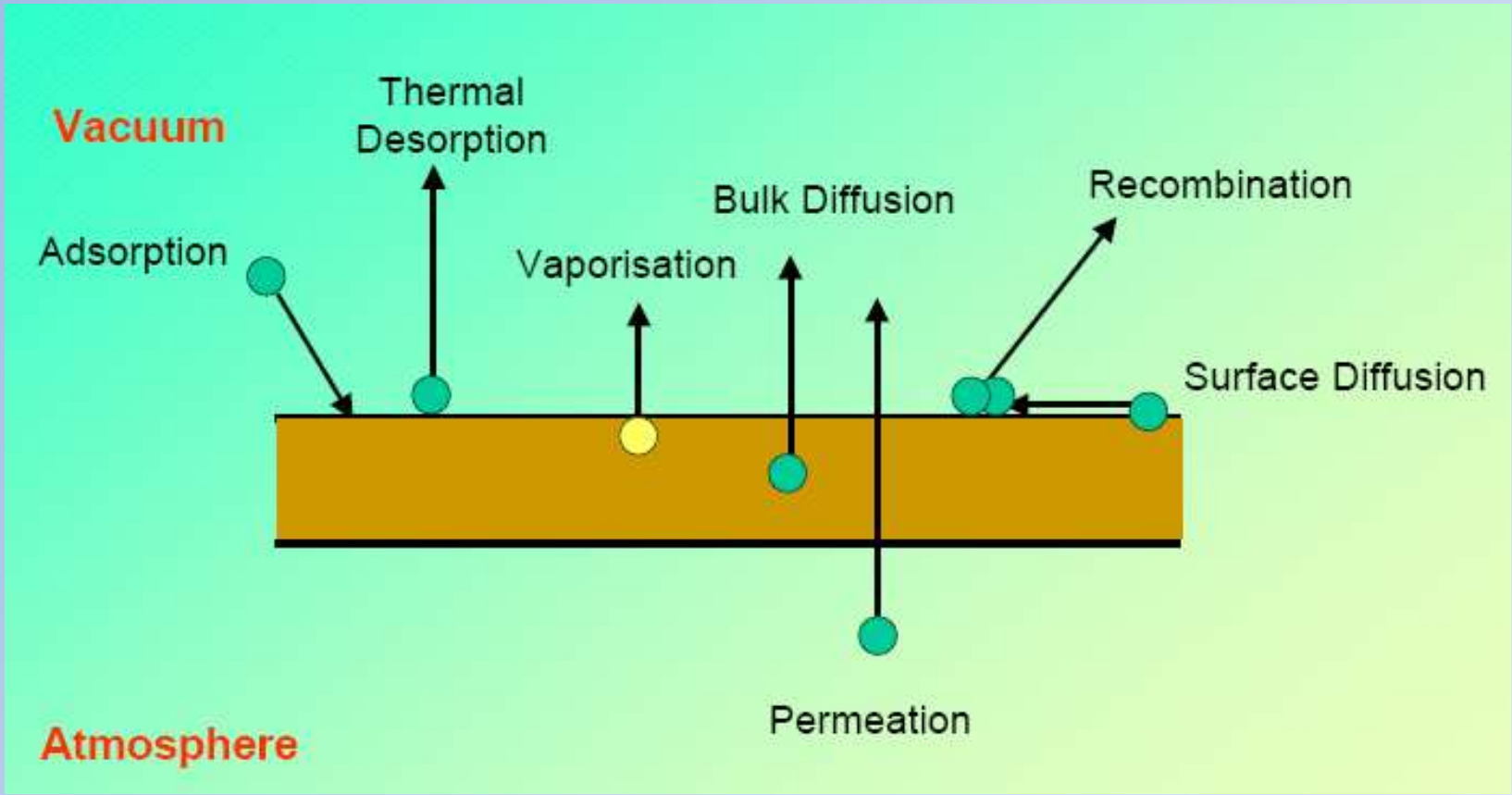
In general, for UHV outgassing rates can be reduced sufficiently and sufficient pumping speed can be applied.

So UHV is routinely achievable.

However, for XHV, the following challenges remain

- Increasing pumping speed by orders of magnitude
- Reducing gas sources by orders of magnitude

Outgassing


Vacuum
Thermal Desorption
Adsorption
Vaporisation
Bulk Diffusion
Recombination
Surface Diffusion
Permeation
Atmosphere

Pumping

At pressures in which we are interested, gas flow is molecular, therefore there is no “pumping”.

Gas finds its way to a place where it is removed from the system or trapped.

Lumped pumping

- Maximum pumping speed is the conductance of the entrance aperture

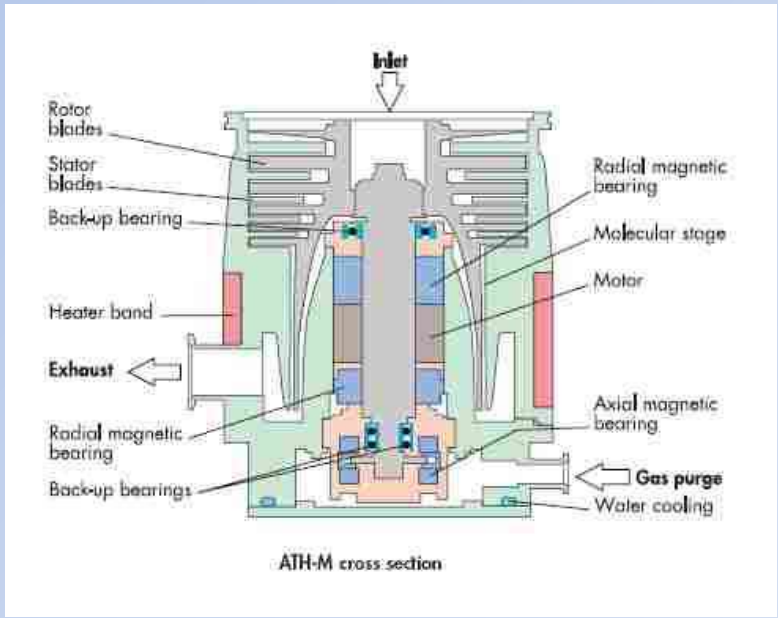
Distributed pumping

- Maximum pumping speed is determined by the area of the pumping surface

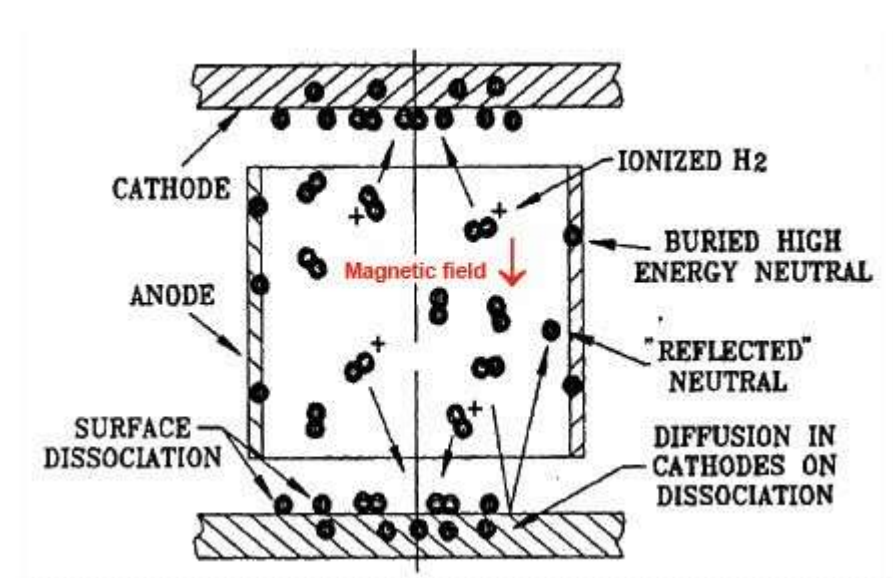
Lumped pumps

Turbomolecular pumps

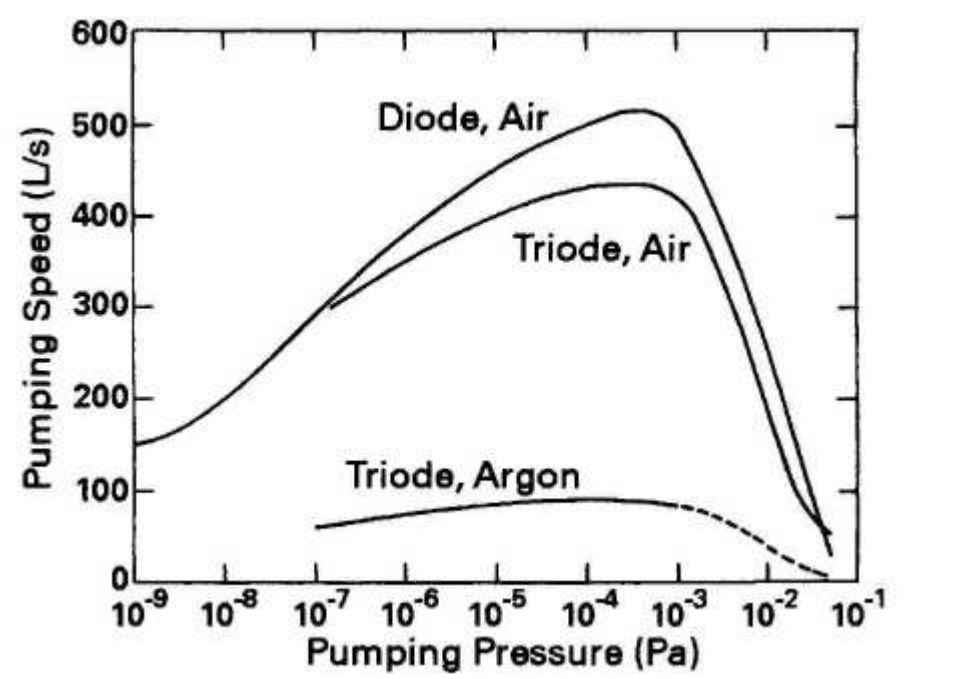
- Good pumping speed
- Compression ratio lower for light gases



Sputter Ion Pumps



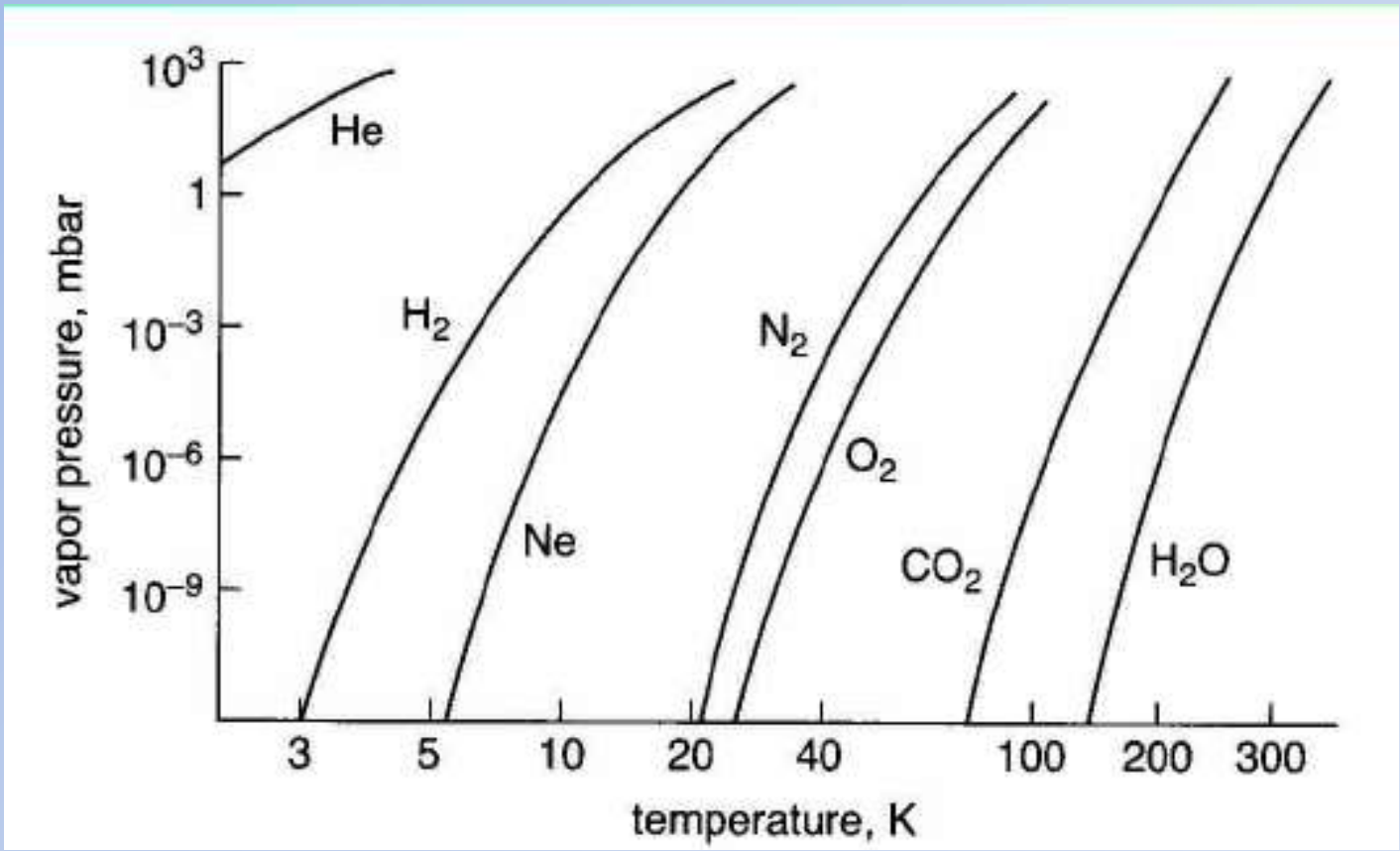
Sputter Ion pumps

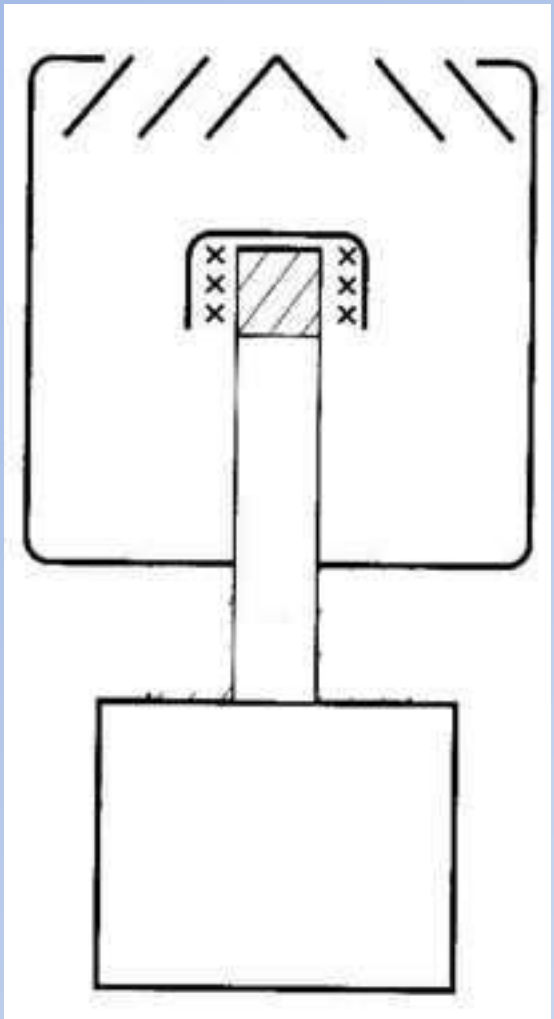


Moderate pumping speed

Low for noble gases

Cryogenic Pumps





- Very high pumping speed
- Sorbent required for Hydrogen, helium
- Regeneration required

Getter Pumps

Evaporated metal films

- Barium
- Titanium
- Good pumping speed
- Active gases only

Non evaporable films (NEG)

- Alloys (Ti – V – Zr)
- Good pumping speed
- Active gases only
- Very low outgassing

XHV

XHV is not routine, but is not an impossible challenge provided

- Outgassing is minimised by
  - Cleaning
  - Degassing materials
- Pumping is provided
  - Lumped for noble gases
    - Reduce outgassing/backstreaming by use of NEG coating
  - Distributed pumping by getters for active gases

Thank you for your attention