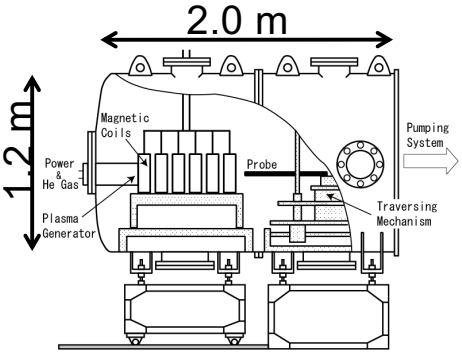
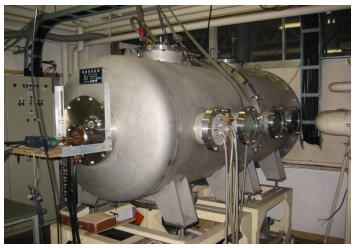
Plasma Physics — Characteristic measurement and numerical modeling of supersonic dilute plasma

Supersonic arc jet

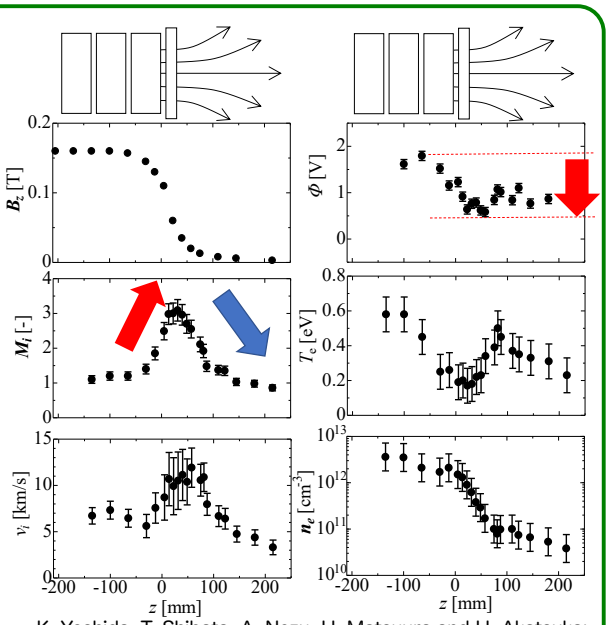
•Fundamental experiments for understanding the acceleration mechanism of supersonic plasmas



Rarefied gas wind tunnel



Supersonic plasma jet ejected from a magnet nozzle

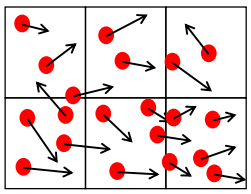


K. Yoshida, T. Shibata, A. Nezu, H. Matsuura and H. Akatsuka; *IEEE Trans. Plasma Sci.*, **37**, [8], 1414-1418 (2009).

- Plasma advances along magnetic lines of force
- When the sonic flow spreads, **supersonic** !
  - Magnetic lines work as a nozzle.

- Maximum Mach number Ma = 3
- Without magnets, Ma = 1
  - Lighter electrons try to move forward, but cannot do so leaving positive ions behind.
  - Positive ions are also electrostatically accelerated

Numerical modeling

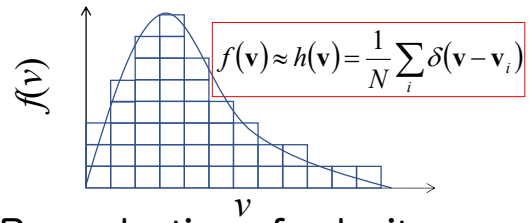


Rarefied gas

Kn > 0.1

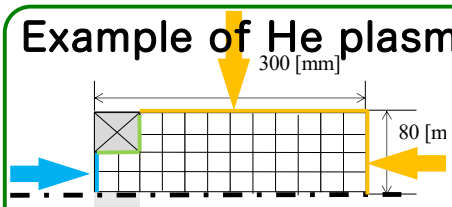
Particle method ~~Fluid method~~

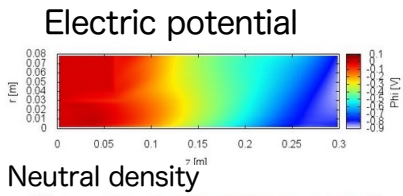
Movement and collision of sample particles



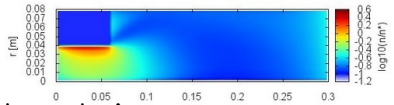
Reproduction of velocity distribution by statistics

Example of He plasma jet calculation

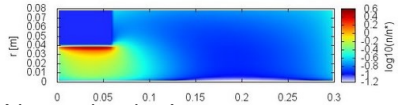




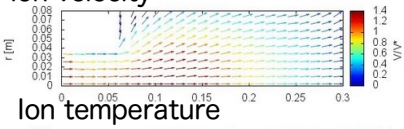
Density of He^+ Ion



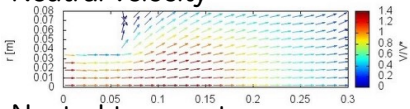
Neutral density



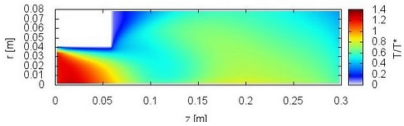
Ion velocity



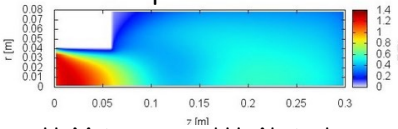
Neutral velocity



Ion temperature



Neutral temperature



S. Tsuno, T. Nakahagi, R. Yamashiro, A. Nezu, H. Matsuura, and H. Akatsuka, IEEE Trans. Plasma Sci, **42**, 3732 (2014).

Differences in temporal and spatial scales of movement

Ions and neutrals — Particle model

Electrons — Fluid model

Hybrid model

Specific applications

- Astronautic Engineering
  - Satellite Electric Propulsion
- Space/Geophysics
  - Astrophysical Plasma Flow Analysis