Supersonic gas injector for improved fueling and plasma diagnostic

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Motivation

Fueling methods of NSTX

- Gas puff (present)
- Neutral beam injection (present)
- Pellet injection (future)
  - Edge (near future)
  - Core (future?)
- Compact toroid injection (future)

Assessment of NSTX fueling

- Gas puff fueling efficiency $\eta < 10$ %
- NBI fueling efficiency $\eta < 60$ %
- Gas puff neutrals dominate other boundary sources during gas puff
- Recycling frequently dominates
- HHFW antenna frequently causes neutral influx from center stack
- Impurity fueling efficiency is small

- Density control (profile, peakedness, central value) and pressure profile control (for HHFW and H-mode target, for MHD mode and transport control), automated feedback
- NSTX long pulse fueling methods
- Requirements to fueling method: high fueling efficiency, minimal contact of neutrals with PFC's, ionization source inside LCFS

Physics of fueling

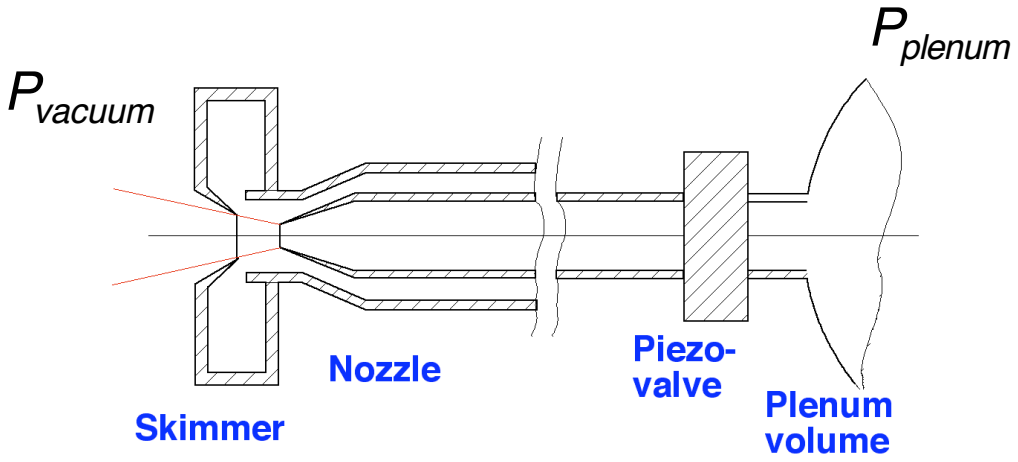
- Gas puff and recycling fueling: ionization source outside or at LCFS. Involves neutrals transport and ion transport through SOL and edge
- NBI, pellet injection fueling: ionization source well inside LCFS

- If ionization source is put inside LCFS: high efficiency, neutral transport less important

- Neutrals ionization mean free path for NSTX:

$$\lambda_i = \frac{v_t}{n_e < \sigma v >} \approx 2 - 4 \quad cm$$

Injector design and parameters



- Supersonic gas puff through shaped nozzle: compressible flow of gas at high Mach number - high density low divergence gas jet.
- Estimated parameters: fueling rate < 100 Torr l / s through sub-mm nozzle (for pressure in plenum 2000 Torr) - Optimizations possible
- Similar designs have been used on TJ-1U torsatron (Madrid, Spain), HT-7, HL-1M tokamaks (China)

Applications

- Fueling and density control

  Main ionization source inside LCFS, collimated particle beam

- Particle transport studies

  - Impurity transport (inexpensive and simple alternative to laser blow-off system)
  - Cold pulse propagation experiments

  Delta function -like spatial and temporal deposition profile

- SOL diagnostics: helium line intensity ratios for measuring electron temperature and density in the SOL (will work well with existing spectroscopy)