Formation of cluster jet with various gasses and its application to fusion plasma experiments

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Formation of the cluster jet using a Laval nozzle of 0.3 mm throat diameter has been examined in the temperature range from 293 K to 110 K. Conditions for cluster formation on various gasses of hydrogen, helium, methane, nitrogen, neon, and argon have been investigated. A phase transition from cluster to liquid state has been observed for methane, nitrogen, and argon, at a temperature range of 120 K ~ 170 K. This suggests a possibility of an intermediate massive particle supply method between gas-fueling and ice-pellet fueling.

In the experiment, time-resolved 2-D images of Rayleigh scattering of the laser light perpendicularly intersecting the gas flow was measured by a fast CCD camera. The scattering signals from hydrogen and neon at ~120 K show approximately cubic dependence on the backing pressure (Fig. 1). These results are similar to the results in [1, 2]. In the case of nitrogen at ~115 K, rapid increase of the signal intensity was observed at > 4 MPa (Fig. 2). Similar phenomena have also been observed in the cases of methane and argon. This might presumably be due to the phase transition to the liquid state. In this regime, the particle flow is visible by eye and it is possible to take the image of shadow graph by the fast CCD camera (Fig. 3).

Based on the knowledge obtained here, a new fueling method of supersonic cluster beam (SSCB) injection is being developed for LHD [2]. The phase transition enables SSCB to supply plasma a large number of particles within a short time, which might be beneficial for, for example, impurity transport experiments, rapid discharge termination, and disruption mitigation.

[1] R. A. Smith *et al.*, Rev. Sci. Instrum. **69,** (1998) 3798.
[2] A. Murakami *et al.*, to be published in Plasma Fusion Res.

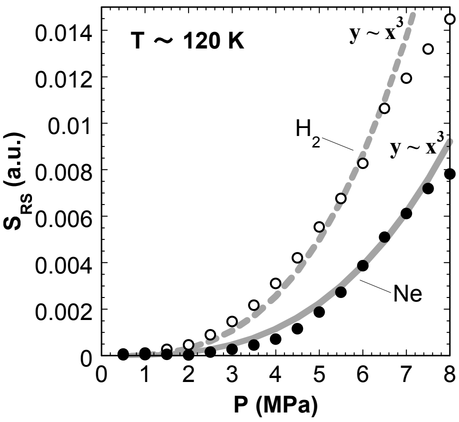

Fig. 1 Rayleigh scattering signals as a function of the backing pressure in the case of H_2 and Ne.

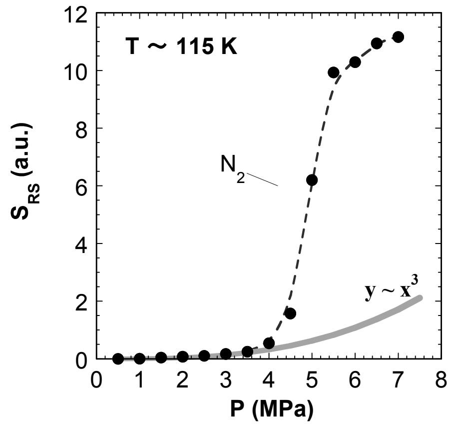

Fig. 2 Rayleigh scattering signal as a function of the backing pressure in the case of N_2.

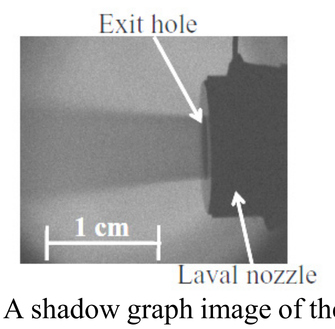

Fig. 3 A shadow graph image of the particle flow in the case of 7 MPa CH_4 at 180 K.