§28. Development of Cluster Beam for Fueling

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The original purpose of this project research is to develop a hydrogen cluster beam source for fueling. Major parameters of the proposed system are;

	LHD	Reactor
Fueling rate (Pa·m^3/s)	6	100
Mean cluster size (atoms/cluster)	1,000	10,000
Beam energy (MeV/cluster)	0.1	1
Number of nozzles	1	15

High energy cluster beam can be produced by a series of processing, namely, formation of cluster by adiabatic expansion of hydrogen gas, ionization of the cluster, and electrostatic acceleration of the cluster ions. Supersonic molecular beams are obtained in the first step of the processing and may be used directly for fueling. We consider such an application to LHD prior to the research on cluster beams.

When supersonic molecular beams are injected into low-pressure gas, shock front called Mach disc is formed in front of the beams. The length x_M from the nozzle to Mach disc is given by

$$x_M = 0.67d\sqrt{\frac{P_I}{P_O}},$$

where d denotes the throat diameter of the nozzle, P_I the inlet pressure, P_O the outlet pressure. The figure shows the dependence of the length x_M to the outlet pressure. The inlet pressure is assumed to be 2 atom, which is the pressure of the gas feeding system of LHD. The background pressure of LHD plasmas is known to be in the range 0.4 - 2.8 $\times$ 10^{-3} Pa. The length x_M is estimated to be longer than 1 m, if the outlet pressure corresponds to the background pressure of LHD plasmas and the throat diameter is chosen to be bigger than 0.2 mm. When a supersonic beam source is set apart from LHD plasmas via a port, a collimator and an auxiliary pumping system to limit the beam and to prevent the part of the beams of hitting the port wall. We can make the overall system very simple, if a supersonic beam source can be set just aside from LHD plasmas. To do so, a supersonic beam source which can be used under strong magnetic fields. We are now developing such a source on the basis of piezoelectric elements and are going to install it to LHD.