Compact toroid acceleration with a single-stage coaxial electrode and its application to fueling

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Compact toroid (CT) injection as an advanced fueling method has been studied so far. CT injection is expected to directly fuel a plasma core in a fusion reactor. We have developed the CT fueler of SPICA (SPheromak Injector using Conical Accelerator) for LHD at NIFS. Although the SPICA injector achieved CT parameters to penetrate into an LHD plasma at a magnetic field of B = 0.8 T, The performance needed to be enhanced much more than previously obtained for CT penetration into that at a higher B (~ 3 T). By optimization of the conical accelerator length, the performance of CT acceleration has been effectively improved, resulting in long CT transport through the 1.8 m drift tube with a density on the order of 10^{21} m^{-3} using the improved SPICA injector (M-type) [1]. However, for practical use of SPICA on LHD, the system should be simple and reliable for easy operation and maintenance. SPICA has two-stage coaxial electrodes for CT formation and acceleration. The power supplies are equipped with ignitron switches. The CT injection system is rather difficult to deal with. We have thus attempt single-stage operation of SPICA by connecting only the formation bank unit to both electrodes, and have investigated the acceleration performance. The formation bank unit will be replaced with the acceleration one to apply higher voltage in the next experiment.
We have also studied production of supersonic neutral gas jet by using the improved SPICA injector as a new application of CT injection technique. An accelerated CT plasmoid penetrating into a neutralizer cell, supersonic neutral gas jet is produced through charge-exchange reaction between CT plasma and neutral gas. The neutral gas jet may have a high speed of 300 km/s (equivalent to about 1 keV) and a high density of 10^{21} m^{-3}. Such a fueling method is expected to achieve deeper penetration of fuel particles and higher efficiency of fueling than the conventional fueling methods. Experiments on injection of supersonic neutral gas in several fusion devices show encouraging results. Recently, we have proposed a combined fueling system of CT and supersonic neutral gas injections. The choice of these injections is made in each shot. The system may allow us to make various plasma controls.

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