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OV/2-1: Extension of Operation Regimes and Investigation of Three-dimensional Current-less Plasmas in the Large Helical Device

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Progress in parameter improvement as well as physical understanding of three-dimensional net-current free plasmas in LHD is overviewed.
Efficient ion heating by the upgraded low energy NBI and improvement in ion transport have led to the central ion temperature of 7 keV at the density of 1.5x10^19 m^-3. The pre-wall conditioning by ICRF is effective to achieve high ion temperature. The volume averaged beta value has reached 5.1 % and the high beta state over 4.5% has been maintained for longer than 100 energy confinement times. A new dipole antenna has been installed for ICRF heating, which can control toroidal phasing and excite the fast wave with large wavenumbers. It shows better heating efficiency at higher density than the conventional monopole antenna as expected. Two of ten sections of inboard side helical divertor were modified to a baffled structure as a pilot, and neutral compression of more than 10 times was demonstrated, which agrees with the prediction of 3-D Monte Carlo simulation.
A resonant magnetic perturbation (RMP) with m/n = 1/1, which has resonance at the plasma periphery, has been applied to the experiments of divertor detachment, ELM mitigation and penetration of perturbed field. The RMP has a stabilizing effect on detached plasmas by changing the radiation pattern in the edge. A radiating plasma with reduced divertor heat load by a factor of 3-10 can be sustained stably. The RMP has reduced the ELM amplitude and increased the ELM frequency. It is noted that ELMs of LHD are thought to be induced by interchange modes destabilized at the edge while peeling ballooning modes cause ELMs in tokamaks. Two types of intrinsic toroidal rotation have been identified in LHD. One is intrinsic rotation in the counter direction driven by the positive radial electric field near the plasma periphery, and the other is that in the co-direction driven by the ion temperature gradient at half of the plasma minor radius. The existence of non-linearity in the latter rotation strongly suggests that the driving mechanism is Reynolds stress due to turbulence, not neoclassical viscosity. The dynamic response of micro-turbulence to ECH modulation has been studied in terms of the long distance radial correlation of turbulence, which is expected to be the most possible candidate for causing non-local transport.

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