3-2 Intrinsic Rotation Due to Plasma Pressure Discovered –Toward the Understanding of High Pressure / Highly Self-Regulating Plasma–

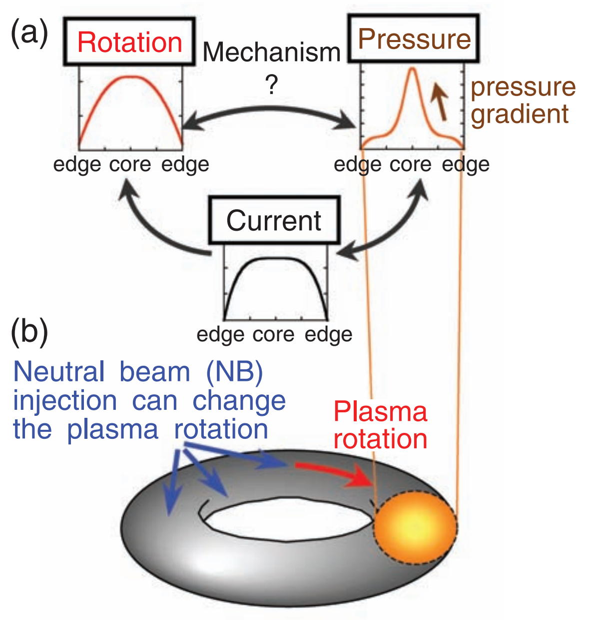

Fig.3-4
(a) Schematic view of self-regulating high pressure plasma
The plasma pressure, rotation, and electric current profiles are strongly linked to each other.
(b) Schematic drawing of JT-60 plasma
JT-60 has various neutral beams (NB) with different injection angles, which can change the direction of the plasma rotation and the rotation profile flexibly.

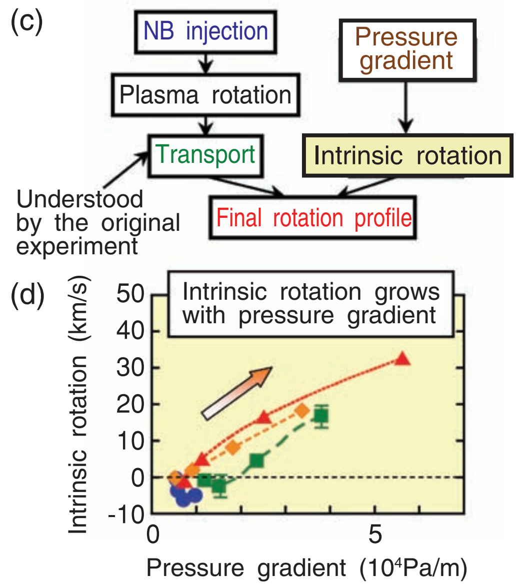

Fig.3-5
(c) Formation mechanism of the rotation profile
The rotation profile is determined by the external momentum input by NBs, momentum transport, and the intrinsic rotation caused by the plasma itself. Using an original experiment and analysis method, we have separately evaluated the externally induced rotation and the intrinsic rotation.
(d) Relation between the intrinsic rotation and the pressure gradient
The intrinsic rotation increases with increasing pressure gradient. The difference in color corresponds to the different NB power and torque.

Burning plasmas for nuclear fusion reactors are highly self-regulating, governed by strong linkage among plasma pressure, electric current, and rotation profiles as shown in Fig.3-4(a). To construct fusion reactors, it is essential to understand and control this self-regulating system. However, it has been an open critical issue for nuclear fusion research worldwide to understand the formation mechanism of the rotation profile and the relation between the rotation and pressure profiles. The rotation profiles are determined by various mechanisms: (1) the external torque input by neutral beams (NBs), (2) the momentum transport, and (3) the intrinsic rotation. However, these terms cannot be evaluated separately by the conventional steady-state-experiment and analysis.

In order to address this issue, we newly developed and applied an experimental method utilizing the modulation of a part of the NBs, and as a result we evaluated the momentum transport correctly. At low plasma pressure, it was found that the rotation profiles are determined by the external torque applied by the NBs and the momentum transport. At higher plasma pressures, the self-regulation appeared. In this case, we found that the measured rotation profiles cannot be explained merely by the momentum transport and the external momentum input from the NBs, and the intrinsic rotation becomes dominant. The relation found between the plasma pressure gradient and the intrinsic rotation in various confinement modes is shown in Fig.3-5(c). It was experimentally found for the first time that the intrinsic rotation grows with increase in the pressure gradient in all cases. This study enables us to understand the mechanism of the intrinsic rotation in high pressure and highly self-regulating plasmas, and gives important information about the prediction and operation of the self-regulation plasmas in ITER and other future fusion reactors.

Reference
Yoshida, M. et al., Role of Pressure Gradient on Intrinsic Toroidal Rotation in Tokamak Plasmas, Physical Review Letters, vol.100, 2008, p.105002-1-105002-4.