Experimental determination of an unknown torque density profile from temporal behavior of toroidal rotation velocity profile in a tokamak

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Toroidal plasma rotation has been recognized to play a key role in controlling the MHD instabilities as well as improving the plasma confinement. In the present-day tokamaks, neutral beam injection (NBI) has been dominantly applied to impart the toroidal momentum to the plasma. However, in the reactor-sized tokamaks such as ITER, NBI is not expected to rotate the plasma fast enough because of its large size and high density operation. After the observation of the spontaneous toroidal rotation without any external momentum input such as NBI, it has attracted many researchers to search for the physical mechanism which can explain the spontaneous rotation. On the one hand, it has been found that the toroidal plasma rotation can be strongly damped in the presence of the nonaxisymmetric magnetic fields. It has been expected that the magnetic field inhomogeneity in the toroidal direction enhances the neoclassical toroidal viscosity (NTV). Many theoretical models and numerical solutions have been proposed to explain the intrinsic rotation or neoclassical toroidal viscosity enhanced by nonaxisymmetric magnetic fields. Now, it is very important to accurately estimate the unknown momentum source (or sink) from the experimental data such as toroidal rotation profile in order to test and verify the proposed model. Any theoretical models or simulation results cannot be appropriately tested and verified without correct determination of the unknown momentum source (or sink). There are two commonly used methods to extract the unknown momentum source (or sink) from the temporal change of the toroidal rotation profile. One is simply assuming that the change rate of the toroidal rotation can represent the toroidal momentum source (or sink) well in the time range of few tens ms. The other [1] is utilizing a statistical analysis based on the momentum confinement time which is defined with the volume integrated angular momentum and torque density. But, the validities of these methods have not been checked in detailed. In this paper, we conclude that these methods are not practically valid. In addition, new alternative method is proposed and tested with the experiment of nonaxisymmetric magnetic braking in KSTAR.