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Measurements of the Deuterium Ion Toroidal Rotation in the DIII-D Tokamak and Comparison to Neoclassical Theory[1]

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Bulk ion toroidal rotation in tokamak plays a critical role in controlling microturbulence and MHD stability as well as yielding important insights into angular momentum transport and intrinsic rotation. So far, our understanding of the bulk plasma flow in hydrogenic plasmas has been inferred from impurity charge exchange measurements and neoclassical theoretical calculations. However, the validity of these inferences has not been tested rigorously through direct measurement, particularly in regions with steep pressure gradients where very large differences (up to 100 km/s) can be expected between bulk ion and impurity rotation. New advances in the analysis of wavelength-resolved D_α emission on the DIII-D tokamak have enabled accurate measurements of the main ion (deuteron) temperature and toroidal rotation. The D_α emission spectrum is accurately fit using a model that incorporates thermal deuterium charge exchange, beam emission and fast-ion emission (FIDA) spectra. Simultaneous spectral measurements of counter current injected and co current injected neutral beams enable a direct determination of the deuteron toroidal velocity, in quantitative agreement with time-dependent collisional-radiative modeling of photo-emission process in three-dimensional geometry. Discharges with low beam ion pressure and broad thermal pressure profiles exhibit deuteron temperature and toroidal velocities similar to carbon measurements. However, in conditions with internal transport barriers, large differences between the core deuteron and carbon rotation are observed which do not match the neoclassical predictions. First profile measurements of simultaneous carbon and deuterium rotation profiles will be presented, and the progress on edge pedestal measurements of bulk ion rotation will be discussed.

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