Toroidal Rotation and Core Ion Confinement with RF Heating in DIII–D*

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Stabilization of turbulent ion transport by sheared **E**×**B** flow has become a unifying theme in understanding transport barriers [1]. In DIII–D the core radial electric field is typically generated by the flow velocity resulting from neutral beam injection (NBI). In a variety of discharge conditions it is observed that electron heating reduces the toroidal rotation speed, U_ϕ, and core ion temperature, T_i. In DIII–D, electron heating is achieved with both electron cyclotron heating (ECH) and fast wave electron heating (FWEH). Both electron heating techniques have been observed to result in the reduction in U_ϕ and T_i [2,3]. To date, all target discharges have rotation first established with co-directed NBI. A key question is whether the U_ϕ and T_i reduction is due to electron heating per se, or some aspect of the physics of rf heating. The seemingly great difference in the ECH and FWEH heating mechanisms indicates the former. Also, the effect does not seem to depend upon the details of the launched toroidal wavenumber spectrum. However, in some instances of off axis ECH, where the increase in the electron temperature, T_e, is relatively small, the reduction effect is also observed.

There are different physics mechanisms which could be responsible for the observed reductions. One possible explanation is that the ion diffusivities for momentum and energy increase with T_e/T_i, in accord with models of turbulence growth rates. The electron heating in effect leads to an enhanced anomalous drag. Another is that the rf heating induces a radial current which creates a torque, reducing the bulk rotation in these discharges, and hence reducing the electric field, resulting in a loss of sheared **E**×**B** flow stabilization and thus enhanced net ion thermal diffusivity.

One specific mechanism may apply to some extent in the FWEH discharges. Recently, C.S. Chang and co-workers have discussed resonant ion radial transport for ion cyclotron resonance heating (ICRH) and shown how this affects toroidal rotation [4]. A definitive test of this model would be a case in which all of the resulting bulk toroidal torques from rf resonances with trapped and asymmetric passing ions are in the counter plasma current direction. Then fast wave heating of a counter rotating target discharge would result in increased counter rotation. Such an experiment is being carried out on DIII-D. Fast wave ray tracing with harmonic ion absorption will be used to analyze to what extent this mechanism is operative in the above described co-NBI experiments.

DIII–D data will be presented on the effects of rf heating on rotation and core ion thermal confinement. An evaluation will be made of the relative importance of torque due to resonant rf particle transport and of enhanced ion transport due to either increased turbulence growth rates or reduced shear in the electric field drift.

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[4] C.S. Chang, Physics of Plasmas, 40th meeting of the Division of Plasma Physics, APS, New Orleans (1998) to be published.

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