Confined Trapped-Alpha Behavior in TFTR Deuterium-Tritium Plasmas

S. S. Medley,[1] R. V. Budny,[1] H. H. Duong,[2] R. K. Fisher, M. P. Petrov,[3]
N. N. Gorelenkov,[4] M. H. Redi,[1] A. L. Roquemore,[1] and R. B. White[1]

General Atomics, P.O. Box 85608
San Diego, California 92186-9784, USA,

Abstract

Confined trapped-alpha energy and differential radial density distributions in TFTR D-T plasmas are obtained with the Pellet Charge-eXchange (PCX) diagnostic which measures high energy (Ea = 0.5 - 3.5 MeV), trapped alphas ($v_{||}/v = -0.048$) at a single time slice ($\Delta t \sim 1$ ms) with a spatial resolution of $\Delta r \sim 5$ cm. Other energetic ion species can be detected such as tritons produced in D-D plasmas and RF-driven energetic ion tails (e.g., H, 3He or T) and measurements of energetic tritium ion tails will be discussed.

PCX alpha and triton energy spectra extending up to their birth energies were measured in the core of MHD-quiescent discharges where the expected classical slowing down and pitch angle scattering effects are not complicated by stochastic ripple diffusion and sawtooth activity. Both the shape of the measured alpha and triton energy distributions and their density ratios are in good agreement with TRANSP predictions, indicating that the PCX measurements are consistent with classical thermalization of the fusion-generated alphas and tritons. In addition, these results set an upper limit on possible anomalous radial diffusion for trapped alphas of $D_\alpha \leq 0.01$ $m^2 s^{-1}$. Outside the core, the trapped alphas measured by the PCX are influenced by stochastic ripple diffusion effects. The PCX measurements are consistent with the functional dependence of the Goldston-White-Boozer stochastic ripple threshold on the alpha energy and the q-profile.

In the presence of strong sawtooth activity, the PCX diagnostic observes significant redistribution of the alpha density profile wherein alphas are depleted in the core and redistributed to well outside the q = 1 radius. This sawtooth redistribution data is not well described by modeling based on the magnetic reconnection formalism which is applicable to passing particles. However, good agreement is obtained with a model based on a perturbed helical electric field produced by the sawtooth crash. The PCX measurements also indicate that the radial extent of the sawtooth redistribution is delimited by the energy-dependent stochastic ripple loss boundary. In sawtooth-free discharge scenarios with reversed shear or with weak shear along with core localized TAE activity, the PCX diagnostic also observes alpha density profiles that are significantly broader than those for supershot plasmas.

---

[1]Princeton Plasma Physics Laboratory, P.O. Box 541, Princeton, New Jersey 08543, U.S.A.
[2]Oak Ridge Associated Universities Fellow. Present Address: University of Toronto, Toronto, Ontario, Canada.
[3]A. F. Ioffe Physical-Technical Institute, St. Petersburg, 194021 Russia.
[4]TRINITI, Troitsk 142092 Russia.