The Isotope Effect in GAM – Turbulence Interplay and Anomalous Transport in Tokamak

E.Z. Gusakov, A.D. Gurchenko, P. Niskala\*, A.B. Altukhov, L.A. Esipov, T. Kiviniemi\*, D.V. Kouprienko, M.Yu. Kantor, S.I. Lashkul, S. Leerink\*, A.A. Perevalov

Ioffe Institute, St. Petersburg, Russia,  
\*Aalto University, Espoo, Finland

The interaction between geodesic acoustic modes (GAMs), and drift-wave turbulence has been an important area of experimental and theoretical research for anomalous transport of energy and particles in toroidal plasmas during the last decade. GAMs, which are excited in plasma due to nonlinear three-wave interaction of drift waves, in their turn can influence the turbulent fluctuations and anomalous transport. Dependence of GAM excitation level and, more general, long-range correlations on ion mass could be responsible [1] for the isotope effect in tokamak anomalous transport [2] which is still unclear.

The talk presents results of comparative investigation of the anomalous transport phenomena in the hydrogen and deuterium discharges in the FT-2 tokamak using a set of highly localized microwave backscattering diagnostics and full-f global gyro-kinetic modeling by ELMFIRE code [3, 4]. It is demonstrated experimentally that the theoretically predicted possibility of GAM control of the turbulence associated with large inhomogeneity of poloidal rotation, accompanying GAMs possessing small radial wavelength and huge radial electric field, manifests itself in modulation of the turbulence level at the GAM frequency. This observation is supported by GK modeling demonstrating the modulation of density fluctuations as well as of the heat flux and diffusivity. A much larger level of the GAM amplitude is observed in deuterium discharge in comparison with hydrogen. The possible reason for this effect could be associated with the difference in ion collisionality in these discharges and steeper atom density profile in deuterium. The turbulence modulation enhancement in deuterium discharges accompanying the GAM amplitude growth is observed leading also to the stronger mean turbulence level suppression during the intermittent GAM bursts. The observed effect, as well as the growth of the drift-wave turbulence correlation length in deuterium, provides a possible mechanism for the isotope effect in tokamak plasma anomalous transport. It is able as well to explain the spatial and temporal anti-correlation of the GAM amplitude and the effective electron thermal diffusivity determined by the ASTRA code.

References

1. XU, Y., et al., Phys. Rev. Lett. 110 (2013) 265005.
2. STROTH, U., Plasma Phys. Control. Fusion 40 (1998) 9.
3. LEERINK, S., et al., Phys. Rev. Lett. 109 (2012) 165001.
4. GURCHENKO, A.D., et al., 25th IAEA Fusion Energy Conference (2014) IAEA-CN-221/EX/11-2Ra