Explore of magnetic topology by heat pulse propagation method

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Abstract

In the magnetized plasma, a heat pulse propagates both parallel and perpendicular magnetic field. The heat pulse propagates parallel to magnetic field in a time scale of thermal velocity of plasma, while it propagates perpendicular to magnetic field in the time scale of heat transport due to collisions and turbulences. Therefore the propagation speed parallel to magnetic field is much faster than that to perpendicular to magnetic field by more than one order of magnitude. By taking advantage of this characteristic, the magnetic topology can be explored by analyzing the propagation of heat pulse.

In laboratory plasmas, bifurcation physics of the magnetic topology has been investigated using the heat pulse propagation method produced by the modulation of electron cyclotron heating. There are two types of bifurcation phenomena observed in LHD and DIII-D. One is a bifurcation of the magnetic topology between nested and stochastic field[1, 2]. The nested state is characterized by the bi-directional (inward and outward) propagation of the heat pulse with slow propagation speed. The stochastic state is characterized by the fast propagation of the heat pulse with electron temperature flattening.

The other bifurcation is between magnetic island with larger thermal diffusivity and that with smaller thermal diffusivity[3]. The damping of toroidal flow is observed at the O-point of the magnetic island both in helical plasmas and in tokamak plasmas during a mode locking phase with strong flow shears at the boundary of the magnetic island[4]. Associated with the stochastization of the magnetic field, the abrupt damping of toroidal flow is observed in the large helical device [5]. The toroidal flow shear shows a linear decay, while the ion temperature gradient shows an exponential decay. This observation suggests that this flow damping is due to the change in the non-diffusive term of momentum transport.

In this method, a conditioning averaging technique is applied to improve a signal to noise ratio and the accuracy of the delay time measurements with small amplitude. The idea of heat pulse propagation method and the conditioning averaging technique could be applied to the research on magnetic field topology and to the visualization of the magnetic field in space and astrophysical plasmas. A feasibility of the application of this method to space and astrophysical plasmas will be discussed.

References

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