Contribution ID: **39** Type: **Oral**

Hybrid kinetic-MHD modelling of fast-ion flow induced by Alfvén instabilities measured by an imaging neutral particle analyzer

Tuesday, 7 December 2021 16:10 (30 minutes)

An imaging neutral particle analyzer (INPA) [1] provides energy and radially resolved measurements of the confined fast-ion (FI) population ranging from the high-field side to the edge on the midplane of the DIII-D tokamak. In recent experiments, a neutral beam modulation technique is employed to diagnose FI flow in the INPA-interrogated phase-space driven by multiple, marginally unstable Alfvén Eigenmodes (AEs). The INPA enables unprecedented phase-space resolution, required to identify the key features of this FI flow: (1) A phase-space 'hole'at the injected energy and q_{min}; (2) FI migration towards the plasma edge at lower energies; (3) The formation of a high-energy tail above beam injection energy in the plasma core, showing the first experiment evidence of inward FI transport induced by AEs, as seen in figure 1a.

The hybrid kinetic-MHD MEGA code [2] is used to reproduce the radial location and frequency of the modes observed in the experiment, as well as the associated FI transport. At the INPA-interrogated pitch angle, reversed shear Alfvén eigenmodes (RSAE) are found to create phase-space islands near the q_{min} location on the low-field side of the plasma. On the magnetic axis, these islands cover the topological boundary between passing and stagnation orbits. These islands induce flattening of the FI population along constant $E' = nE + P$, explaining the observed prompt FI pile-up in the plasma core at a few keV higher than the neutral beam injection energy.

To quantitatively reproduce the time-resolved phase space flow measured by the INPA, multi-phase simulations are performed including realistic neutral beam injection and collisions. These simulations combine sequential phases of purely kinetic with hybrid modelling, enabling simulation of the entire beam modulation period. During consecutive hybrid phases, an RSAE consistent with the experiment grows and saturates, redistributing the injected FI. Forward modelling of the instrument response [3] is applied to the simulated FI population. As seen in figure 1b, the synthetic INPA images are in good agreement with the measurement near the injection energy. The simulations track the FI redistribution at different pitch angles within the INPA range, confirming that the measured FI flow follows streamlines defined by the intersection of phase-space surfaces of constant magnetic moment μ and constant E'.

[1] X. Du et al., Nuclear Fusion 58, 082006 (2018)
[2] Y. Todo et al., Phys. Plasmas 5, 1321 (1998)
[3] X. Du et al., Nuclear Fusion 60, 112001 (2020)
*Supported by US DOE contracts DE-AC05-00OR22725, DE-AC02-09CH11466, DE-SC0018270, DE- SC0021201, and DE-FC02-04ER54698.

Indico rendering error

Could not include image: [403] Error fetching image

Speaker's Affiliation

University of California, Irvine

Member State or IGO

United States of America

Primary author: Dr GONZALEZ-MARTIN, Javier (University of California, Irvine)

Co-authors: DU, xiaodi (General Atomics); HEIDBRINK, William W. (University of California Irvine); VAN ZEELAND, Michael (General Atomics); WANG, Xin (Max Planck Institute for plasma physics); TODO, Yasushi (National Institute for Fusion Science)

Presenter: Dr GONZALEZ-MARTIN, Javier (University of California, Irvine)

Session Classification: Transport of Energetic Particles

Track Classification: Transport of Energetic Particles