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A multi-machine analysis of non-axisymmetric and rotating halo currents

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Halo currents are known to exhibit non-axisymmetric and rotating features in several devices including JET, Alcator C-Mod, DIII-D, ASDEX Upgrade, and NSTX. Such non-axisymmetries are of great interest to ITER because they can increase mechanical stresses during a disruption, especially if the rotation resonates with the natural frequencies of the vessel. This paper presents an ITPA-initiated multi-machine analysis of these phenomena. The ITPA non-axisymmetric halo current database presently includes data from C-Mod, DIII-D, AUG, and NSTX. Measurements from JET will be added as they become available. The various contributions to the database are processed within a common analytical framework to facilitate direct comparisons between devices. Each entry in the database contains halo current measurements from toroidally resolved arrays of either shunt tiles or segmented rogowski coils. Non-axisymmetry is quantified in terms of the toroidal peaking factor, TPF, and rotation is quantified by integrating the phase of an n=1 fit to the data. Significant non-axisymmetries and rotation are observed across devices, and the collective database covers a broader parameter range than is covered by any single device. With regard to rotation, similar rotation frequencies are observed when the timebase is normalized to the characteristic 'fast'quench timescale of each device. This indicates that the physics driving the rotation may be linked to the current quench. Additionally, the measured non-axisymmetry (TPF) is compared to the 'halo current magnitude.'Here, the halo current magnitude is defined as the peak measured halo current normalized to both the pre-disruption plasma current and the median halo current magnitude for a given device. With this normalization, the halo current magnitude and the toroidal peaking factor are found to be positively correlated. This runs counter to the published inverse correlation between the TPF and the 'halo current fraction,'which is instead defined as the total inferred halo current normalized to the pre-disruption plasma current. If it is in fact the case that larger halo currents produce larger non-axisymmetries, then it is even more imperative for the success of ITER to understand the physical processes that drive halo current non-axisymmetries and rotation. This work is supported by U.S. DOE Contract D-AC02-09CH11466.

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