Characterization of MHD Instabilities in TCABR Tokamak

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The experimental characterization and corresponding modeling of fusion plasmas instabilities are challenging due to the plasma high temperature and collective behavior, particularly in small machines with a limited number of diagnostics. Nevertheless, the quality of the plasma characterization can often be improved by properly combining relevant information from different diagnostics. This work reports on integrated studies of MHD instabilities, and associated particle transport, carried out in the Brazilian tokamak TCABR, a small circular cross section tokamak operating with Hydrogen plasmas.

Under several experimental conditions, the MHD activity in TCABR grows during the discharge up to a nonlinear saturated level in which large magnetic islands are present, during tens of milliseconds. These large islands substantially modify the confinement properties but do not produce disruptions and usually the plasma recovers its former behavior after the reduction of the island size. There are several ways to trigger this growth of the MHD activity, with the most reproducible ones being: (i) a slow ramp up of plasma current near integer values of edge safety factor; (ii) application of edge biasing with an electrode; or (iii) a slow increasing of gas injection. The mode decomposition of the Mirnov coil signals often shows the merging of two weak modes with different frequencies and poloidal structures into a strong mode, with lower frequency and broader poloidal structure, indicating the occurrence of nonlinear coupling. When the MHD activity grows the transport properties are strongly modified and large edge particle losses, synchronized with the MHD frequency, are observed with Langmuir probes. A similar synchronization is also observed in the high energy Bremsstrahlung emission from energetic runaway electrons detected by the hard X-ray diagnostic.

The position and extension of the MHD instabilities in TCABR are determined from line-integrated optical diagnostics (fast bolometry and soft X-ray). The spatial-spectral distributions of these signals are used to identify the MHD instability. The spatial properties of these instabilities and their evolutions are obtained by modeling the measured signals using synthetic diagnostics. In a similar way, the modifications of the equilibrium properties are studied, and a large inward impurity influx during the high MHD activity was identified. Furthermore, the interplay between impurity accumulation and MHD instabilities was also observed by the modification of the Global Alfvén Waves (GAW) resonant condition during sawteeth cycles.

Work supported by the Brazilian Agencies FAPESP (grant: 2011/50773-0) and CNPq.