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The Observation of Synchronous Oscillation prior to Disruption in the HL-2A Tokamak

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Recently, a class of distinctive MHD activities before the onset of disruption has been identified on HL-2A density limit and radiation induced disruptive discharges, where the higher radiation level is generally considered as the consequence of high electron density or excessive boundary fueling. This precursor mode is named here according to its phenomenological behavior as the Synchronous Oscillation prior to Disruption (SOD), which is characterized by the synchronous oscillations between electron cyclotron emission (ECE) signal, the core soft X-ray signal, Mirnov probe signal, and Ha line radiation signal in the divertor. Although the frequency of this behavior will decrease as the plasma evolves towards the onset of thermal quench, the oscillations will maintain in-phase throughout the process. It is also found that the frequency evolution of SOD has a strong correlation with the following thermal quench. This long time-scale behavior makes it suitable to be incorporated as a part of disruption prediction, avoidance and mitigation scheme. Furthermore, these characteristics of SOD also enable us to look deeper into the physics behind those phenomenological behaviors, thus provide us a clearer understanding about density limit and radiation induced disruptions.
It is found that a 2/1 mode and its higher order harmonics are dominant during the SOD activities. The frequency of this 2/1 mode would maintain above 2 kHz for several ten milliseconds or even longer before beginning to slow down. The ultimate mode locking will always trigger the onset of thermal quench. It should be noted that the frequency of this 2/1 mode corresponds to the toroidal rotation frequency at the plasma edge, suggesting that MHD modes locating at the plasma edge might be responsible for those activities. For most SOD discharges, it has been observed that most plasma current is contracted within the q=2 rational surface. The analysis of perturbation structure implies that resistive kink mode might be responsible for SOD. Further, it seems that the non-linear evolution of a resistive kink mode and its higher order harmonics, rather than the overlapping of a few major islands, triggered the disruption.

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