Characterization of the plasma current quench during disruptions in ADITYA Tokamak

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A major disruption event in a tokamak is generally observed to be a two-step process, in which a healthy tokamak plasma ceases abruptly by first losing its temperature, known as 'thermal quench' followed by the plasma current termination, known as 'current quench',(CQ) [1]. Both of these quenches have their impacts on the plasma-facing components in terms of damages they can cause to these vital elements of a tokamak. The thermal quench may results in the melting and vaporization of in-vessel components in reactor-grade tokamak plasma and the current quench can lead to large JxB forces on the vessel wall and other peripheral structures due to the induction of eddy currents. Furthermore, it has been theoretically predicted that the fraction of the plasma current converting into a runaway current depends on the rate of the current quench. The paper addresses the study of the current-quench phase via analyzing several disruptive discharges of ADITYA tokamak [2, 3]. Present understanding of plasma disruptions suggests that the current quench time is an important parameter to characterize the disruption. Although plasma disruption in tokamaks is often regarded as an entirely MHD phenomenon, the interaction between the plasma and the surrounding surfaces may also be influencing the CQ times in tokamak disruptions. As suggested by Ward and Wesson [4], the CQ time may be influenced by both stochaticisation of the magnetic field and the subsequent rapid influx of the impurity atoms during the two-stage disruption process.

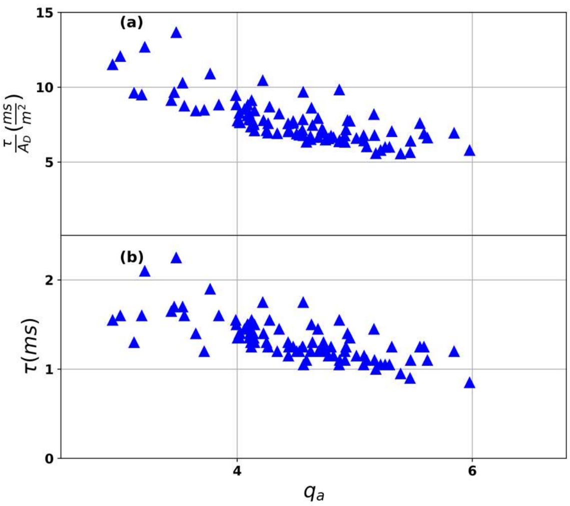

Figure 1: The area normalized average current quench time, (τ/A_D) (a) and average current quench time, (τ) (b) as a function of the edge safety factor, q_a

To address these issues, the characteristics of current quenches for a set of spontaneously disruptive discharges of ADITYA tokamak have been studied and key parameters like the area normalized current quench time, instantaneous current quench rates and, the pre-disruptive values of edge safety factor, q_a (the q_a value at the time of initiation of the CQ) are determined. The maximum instantaneous current quench rates are mostly found to be larger than the average quench rate in ADITYA tokamak. The area normalized current quench time, τ/A_D has been observed in the range of ~5–15 *ms* m^{-2}, similar to those observed in several other tokamaks. The post-disruption ADITYA plasmas, electron temperature of ~15–35 eV is observed and it increases with the area normalized current quench time. Interestingly, the τ/A_D for the disruptive discharges of ADITYA has been observed to be strongly dependent on the pre-disruptive values of the plasma edge safety factor, q_a, see figure 1. Further analysis of MHD activity prevailing at the time of initiation of the CQ reveals that the CQ time is strongly correlated with the MHD activity [5]. It has further been found out that the island widths of the $m = 2$ and $m = 3$ modes and the overlapping of these magnetic islands play a significant role in determining the CQ time in ADITYA tokamak, refer to figure 2.

References
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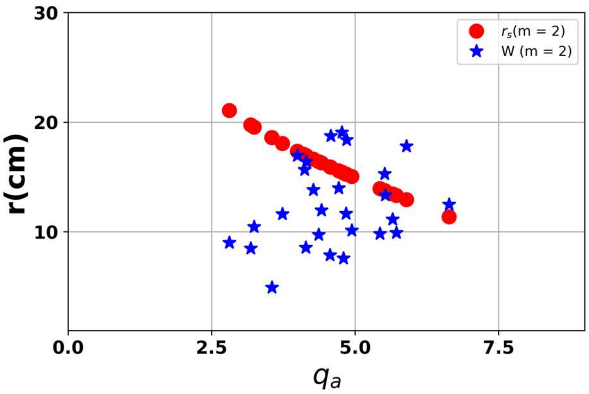

Figure 2: The $m = 2$ island width just before I_{PD} and the locations are shown as a function of edge safety factor, q_a.