Operation in low edge safety factor regime, passive disruption avoidance due to stellarator rotational transform in the Compact Toroidal Hybrid

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Low edge safety factor operation at a value less than two ($q(a) = 1/\iota_{tot}(a) < 2$) is routine on the Compact Toroidal Hybrid device with the addition of sufficient external rotational transform. Presently, the operational space of this current carrying stellarator extends down to $q(a) = 1.2$ without significant $n = 1$ kink mode activity after the initial plasma current rise of the discharge. The disruption dynamics of these low $q(a)$ plasmas depend upon the fraction of rotational transform produced by external stellarator coils to that generated by the plasma current. We observe that when about 10% of the total rotational transform is supplied by the stellarator coils, low $q(a)$ disruptions are passively suppressed and avoided even though $q(a) < 2$. When the plasma does disrupt, the instability precursors measured and implicated as the cause are internal tearing modes with poloidal, m, and toroidal, n, mode numbers of $m/n = 3/2$ and $4/3$ observed by external magnetic sensors, and $m/n = 1/1$ activity observed by core soft x-ray emissivity measurements. Even though $q(a)$ passes through and becomes much less than two, external $n = 1$ kink mode activity does not appear to play a significant role in the observed disruption phenomenology. Insight into the three dimensional structure of 3/2 MHD mode in CTH is obtained with a model of the mode as equilibrium magnetic field aligned perturbed current on the $q = 3/2$ rational surface of a CTH equilibrium. A distribution of the current on resonant surface is obtained by placing current filaments on the surface, the magnitude and phase of which are computed based on the measured fluctuations in poloidal field at the edge of the plasma. A good agreement between the model and the measured fluctuations has been observed.

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