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Understanding disruptions in tokamaks[1]

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Disruptions in tokamaks are known since 1963 but even now some aspects of them remain a mystery. This talk describes progress made recently in understanding disruptions. A major step forward occurred in 2007 when the importance of galvanic contact of the plasma with the wall in plasma dynamics was pointed out. The toroidal asymmetry of plasma current, observed in JET vertical disruptions, was explained by the theory of the wall touching kink mode [1]. The currents shared by the plasma with the wall and responsible for the asymmetry were identified as generated by the kink mode. Such currents are referred to as Hiro currents. They have shown exceptional consistency with the entire JET disruption data base (more than 5500 cases) and ruled out the long lasting interpretation based on "halo currents," which contradict experiments even in the sign of the measured asymmetry. Accordingly, the sideways forces are understood and their scaling from JET to ITER was justified. Hiro currents provide also a plausible explanation of the current spike at the beginning of the disruptions. The important role of the plasma edge and its interaction with the wall was revealed. Based on this new understanding of disruptions, dedicated experiments on the current spike (J-TEXT, Wuhan, China) and runaway prevention by the repetitive triggering of kink modes (T-10, AUG, Tore Supra) were motivated and are in progress. Accordingly, the need for new, adaptive grid approaches to numerical simulations of disruptions became evident. In addition to the core MHD, simulations of realistic wall geometry, disruption specific plasma edge physics, plasma-wall interaction, and energetic particles need be developed. The first results of simulations of the fast MHD regime, Hiro current generation, and slower plasma decay due to a wall touching kink mode made with the new DSC code are presented.

[1] L.E.Zakharov. Phys. Plasmas, 15, 062507 (2008)

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