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X-Divertors for Facilitating Detachment Without Degrading the DIII-D H-Mode

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Highly flared, highly flux-expanded X-Divertors (XDs) on DIII-D detached at a lower Greenwald fraction and higher pedestal pressure than standard divertors (SDs), strongly reducing problematic plasma exhaust at the target, allowing for improved control of the detachment front, and maintaining a higher-confinement H-mode necessary for a future fusion reactor. XDs exhibit lower parallel ion fluxes to the target than the SD, as evidenced by probe ion saturation currents. Because the fluxes calculated are field-parallel fluxes, their reduction in the XD cannot be explained by projection due to flux expansion alone. C-III emission images illustrate the differences in detachment evolution between XDs and SDs, where the XD temperature front is seen moving away from the target for lower pedestal densities and higher pedestal pressures. SOLPS models support the notion of an XD-stabilized detachment front. Poloidal profiles of model electron temperatures show that XDs achieve very low temperatures at the target, while still maintaining high temperatures near the x-point, "insulating" the core from the target. This temperature gradient indicates resistance to upstream migration of the detachment front, preventing core confinement loss and x-point MARFEs. Achieving stable detachment for less gas puffing, lower Greenwald fraction, and higher H-mode pedestal pressure will be critical to satisfy simultaneously the needs for good core performance and effective divertor heat load mitigation, in ITER and a future reactor. X-Divertors lower the puffing threshold for stable detachment magnetically, by increasing the electron/ion path length through the neutral-dense region at the target, and increasing plasma-neutral dissipative reaction rates. In this way, X-Divertors may offer a simple, magnetic solution to the problem of robust, detached divertor operation.

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Primary author: Dr COVELE, Brent (General Atomics)

Co-authors: Dr MCLEAN, Adam (Lawrence Livermore National Laboratory); Dr LEONARD, Anthony W. (USA); Dr HILL, David (Lawrence Livermore National Laboratory); Dr GUO, Houyang (General Atomics); Dr WATKINS, J. (Sandia National Laboratories); Dr FENSTERMACHER, M.E. (Lawrence Livermore National Laboratory); Dr KOTSCHENREUTHER, Mike (Institute for Fusion Studies); Dr VALANJU, Prashant (University of Texas); Dr MAHAJAN, S.M. (University of Texas at Austin)

Presenter: Dr COVELE, Brent (General Atomics)

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