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X-Divertors in ITER - Without any Hardware Changes or Additions - and in Current Machines, and DEMO Reactors

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We show that X-Divertors (XD), that mainly expand magnetic flux near the SOL peak heat flux strike point on the divertor plates, can be created for ITER, many existing tokamaks (e.g., SST-1, EAST, AUG, ⋯), and future Reactors (KDEMO, ARIES) without modifying their Poloidal Field (PF) coil sets (or adding internal coils). For ITER, KDEMO, SST-1, and EAST, we will present sequences of XDs, starting from their SDs, in which the flux expansions on the divertor plates increases smoothly. All these XDs (including ITER) can be made without adding any internal PF coils, with all currents in existing PF coils under their maximum limits, have nearly the same strike points as the SD cases so no modifications of their divertors or pumping will be needed, and have core plasma shapes that maintain the specified conformity with their given first walls. Further, because XDs preferentially expand flux near the SOL strike point, they are expected to increase stability of detached plasmas, thus allowing a possible way to overcome "shadowing"issues arising from lower angles of field line incidence. Note that the incidence angle at higher flux expansions at SOL strike points can only be reduced by increased major radius of the Super X-Divertor (SXD). The demonstration of these XDs opens the possibility that they could be tested and, then, used to assist in high-power operation on ITER. Some further issues need examination, e.g., full time-dependent plasma startup and operation scenarios, vertical stability, etc. The SOLPS code will be used to gauge the effects of XDs on SOL, and possibly plasma detachment.

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