Plasma convection near the magnetic null of a snowflake divertor

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A snowflake magnetic configuration is created when poloidal magnetic field and its first spatial derivatives become zero at a certain point. The separatrix then acquires a characteristic hexagonal shape reminiscent of a snowflake [1, 2]. The number of strike points increase from two to four. The robustness of this configuration and its favorable effect on the plasma performance has been demonstrated experimentally (e.g. [3, 4]). We study new features of the plasma macroscopic equilibrium and stability in the vicinity of the snowflake null. We note that, compared to the standard X-point divertor, the zone of weak poloidal magnetic field is much larger. It is found that this circumstance leads to development of intense plasma convection near the null-point. In a properly designed divertor, this convection may lead to a roughly equal splitting of the heat flux between the 4 snowflake strike points and to a broadening of the plasma wetted area. We focus on a low-beta plasma typical for the divertor region but assess also effects of a finite plasma pressure. The significance of our results is discussed for several existing tokamaks and for ITER-scale future tokamaks. Work performed for U.S. DoE by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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