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P4.170 Numerical simulations of 3D magnetohydrodynamic flows for dual-coolant lead lithium blankets

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In liquid metal blanket concepts for nuclear fusion reactors which are currently under development, the liquid metal PbLi serves as neutron multiplier, breeder material and shield against high neutron radiation. In helium-cooled or water-cooled blanket designs, the liquid metal may flow only at very small velocity since the entire heat released in the liquid metal is removed by water or helium. In the dual-coolant lead lithium (DCLL) blanket higher liquid metal flow rates are foreseen to remove the heat that is volumetrically released in the breeder, i.e. the liquid metal serves in addition as a coolant. The movement of the electrically conducting fluid in the strong magnetic field confining the fusion plasma leads to strong Lorentz forces, high pressure drop, and substantial modifications of velocity profiles compared with hydrodynamic flows.

In a first series of simulations, pressure-driven forced flow has been considered. Since for general applications the magnetic field is not always perpendicular or parallel to the duct walls, the validation of the used numerical code has been extended to such cases by comparison of data with exact analytical or asymptotic results for applications where the magnetic field may have arbitrary orientation with respect to the duct walls. A 3D numerical model has been derived from the most recent design of the European DCLL concept for a DEMO reactor. The model meshes the entire liquid metal domain formed by radial and poloidal rectangular channels, bends and U-turns, but also the conducting sheets of flow channel inserts used for electrically decoupling the fluid flow from the highly conducting duct walls for the purpose of pressure drop reduction. First results for pressure drop and flow distribution of 3D MHD flows in DCLL blankets are presented.

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