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SOL/Divertor Plasma Simulation of Diverging Magnetic Field Configurations for Advanced Divertors

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Handling heat loads onto divertor plates is one of the crucial issues. Advanced divertors expand the flux tube of a divertor plasma and reduce the heat load onto the divertor plate. A Super-X divertor (SXD) sets the outer target plate at a further position in major radius than an ordinary divertor (OD) leading to a largely diverging magnetic field (DMF). In order to simulate supersonic plasma flows caused by DMFs without giving any boundary conditions at the target plate, we have developed a plasma fluid model incorporating the anisotropic ion pressure (AIP). The parallel-momentum equation becomes hyperbolic with the AIP. Thus, the plasma flow velocity is calculated from the upstream side without using the downstream boundary condition and supersonic plasma flows in DMFs are consistently simulated with the AIP model even if the actual effect of AIP is small due to high collisionality. By a direct comparison between a conventional fluid model and the AIP model in a DMF configuration with no radial transport, it is demonstrated that a quite smooth and natural profile of supersonic flow velocity which is also observed in the magnetic-nozzle experiment is reproduced with the AIP model while an unphysical profile of plasma flow velocity is obtained with the conventional fluid model. An SXD is also simulated with the AIP model by adding another DMF region to an OD. The plasma flow velocity is increasing in the additional DMF region which might be an advantage for the retention of impurities in the divertor region by the friction force while the plasma density becomes lower which might be a disadvantage for the formation of detached plasmas. The AIP model, therefore, is beneficial to analyze the performance of advanced divertors such as an SXD from the viewpoint of impurity retentions and detached-plasma formations.

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