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A New Understanding of the Bootstrap Current in Steep Edge Pedestal and its Effect on the Pedestal Stability

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Based on the kinetic simulations with the new gyrokinetic neoclassical code XGCa in realistic magnetic separatrix geometry, we developed an improved bootstrap current formula [R. Hager, C.S. Chang, submitted to Phys. Plasmas (2015)] that is much more accurate in steep edge pedestal plasma than the widely used formula by Sauter et al. [O. Sauter et al., Phys. Plasmas 6, 2834 (1999)] while being equally easy to use.
The standard deviation of the Sauter formula from the XGCa result is about 24.8% while that from the new formula is only 5.4%.
The XGCa-based bootstrap current formula is then applied to the electromagnetic stability analyses in the hybrid gyrokinetic XGC1 code, which uses gyrokinetic ions and fluid electrons [S. Ku et al., Phys. Plasmas 16, 056108 (2009)], together with a magnetic equilibrium code that takes the bootstrap current into account.
The improved formula is suitable for applications that require fast and accurate calculation of the bootstrap current, and it incorporates finite orbit-width effects and other non-local physics that are introduced by a magnetic separatrix and strong ExB shearing rate.
The new formula was necessary because existing studies of the bootstrap current are often based on assumptions that are valid in the core plasma but easily violated in the plasma edge, and the accuracy of these conventional predictions become questionable.
Two significant findings from this XGCa study of the bootstrap current are the significant contribution of trapped electrons to the total current and the finite orbit-width effects that generally decrease the bootstrap current compared to the prediction from the conventional neoclassical theories and simulations.

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