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Towards oscillation-free implementation of the immersed boundary method with spectral-like methods for direct and lardy-eddy simulation

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Combined immersed-boundary/spectral method is widely used for direct and large-eddy simulation of flow around solid bodies. However, when the immersed boundary method (IBM) is implemented within spectral-like methods, the Gibbs oscillation seriously deteriorates the calculation of derivatives near the body surface. In this paper, a radial basis function based smoothing technique is proposed with the intention of eliminating or efficiently reducing the Gibbs oscillation without affecting the flow field outside the body. Based on this technique, a combined IBM/spectral scheme is developed to solve the incompressible Navier-Stokes equations. Numerical simulations of flow through a periodic lattice of cylinders of various cross sections are performed. The results demonstrate that the proposed methodology is able to give accurate and nearly oscillation-free numerical solutions of incompressible viscous flows. The method is extended to large-eddy simulation of atmospheric flow over complex terrain and can yield more reliable numerical results for studying turbulence at micro/meso scales.