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Numerical techniques for high-resolution MHD simulations

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Petascale computing is expected to be going to innovate numerical simulation studies. In plasma simulations, multiscale and multiphysics methods, in which multiple scale systems are numerically coupled, are actively examined. Basic studies of first principle calculations of plasmas are also steadily progressed. On the other hand, in next-generation simulation studies, will MHD simulations be finished as the role of fundamental studies? The answer is "NO". With the advent of petascale computers, "realistic" high-resolution MHD simulations will gradually be realized, and therefore, we must reach a deeper understanding of MHD phenomena in nature. Actually, quite recent MHD simulations for magnetic reconnection indicate intermittent and explosive energy release even in a uniform resistivity model [1,2], whose results seems to be qualitatively different from those obtained by past theoretical and simulation studies. However, in order to realize a higher resolution in petascale era, new numerical techniques for MHD will be required. Therefore, in this paper, future prospects of MHD researches opened by high-resolution MHD simulations are shown, and moreover, problems and prospects of numerical techniques for high-resolution MHD simulations are discussed. Concentrating in particular on numerical methods for compressible MHD with high-speed flows [3], we investigate elemental techniques inevitable for next-generation MHD simulations such as numerical stabilization, higher order method, magnetic divergence control.

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