§49. Development of AMR Three-dimensional MHD Simulation Code: Magnetized Shear Flow Simulation

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We are developing three-dimensional (3D) magneto-hydrodynamical (MHD) - Adapted Mesh Refinement (AMR) simulation code. The AMR technique adapts dynamically the grids to suit the physical conditions and can monitor running structures by fine grids, so this is appropriate for simulating dynamical motion of localized structure in evolved global structure. We adopted Roe method, one of TVD methods, for a flux part in order to capture discontinuities without artificial numerical viscosity in hydrodynamical (HD) simulation code and checked that code by reproducing a one-dimensional (1D) shock tube problem and a 3D Sedov solution. In order to extent our code to MHD and to make it suitable for an extension, we made the code of the flux part for three different methods, Lax, Roe and Roe-MUSCL ones so that those can be available by switching corresponding files in our code.

However we have still problem: noises in one component of magnetic field occur and increase after elapsing for many time steps in a shock tube test, and we improved the method of calculation of flux part at the boundary between the different size cells to solve this problem. We calculated the flux directly between the different size cells as so far. It was found that some artificial numerical noises could occur on the boundary of the different levels as described above. We set an overlap width between the different levels and tested this method by simulating magnetized shear flow. The grid consists of three levels and the cell size ranges from 0.039 to 0.156, corresponding to 1/1024 – 1/256 of the horizontal size of the simulation box. The initial conditions are that a density and a pressure are uniform and both are equal to 1. As for a velocity, x component is equal to + Cs for y > 5 and to – Cs for y < 5 where Cs is the sound speed, and y component is given randomly with the amplitude smaller than 0.01. Magnetic field is uniform in the x direction. It is noted that this simulation is performed in 3D, while this test problem is 2D.

Figures 1 and 2 show gray contour maps of the density and the x component of the velocity respectively. Upper panel is simulation result using the previous method and lower panel is the one using an overlap width method in both figures. The amplitude and wave length scale nearly coincide in results obtained using both methods. It can be seen that fine grids are set in the region of large gradient of the density and the velocity, which indicates that adaptive mesh refinement works well.

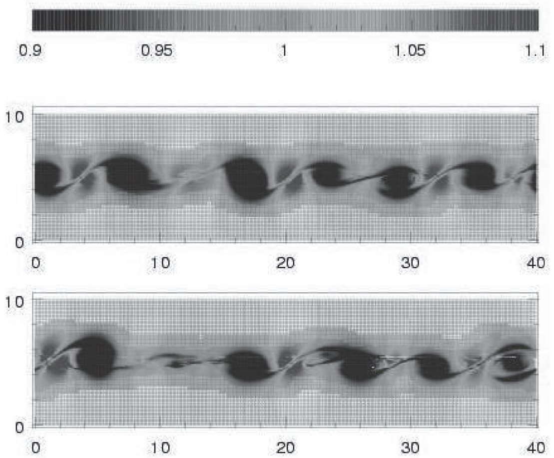

Fig.1 Gray contour map of the density.

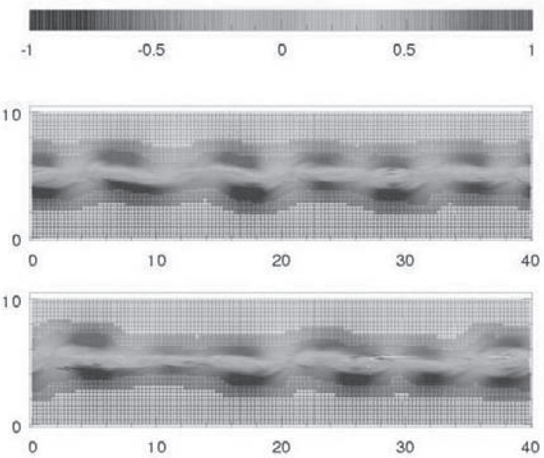

Fig.2 Gray contour map of the velocity.

We showed that our adaptive mesh refinement MHD code with an overlap width method is applicable for magnetic shear flow which is a typical problem of formation of complicated structure. We will perform 3D test problem as a next step and will apply our code to MHD phenomena.