An investigation of numerical techniques in an MHD relaxation method for NLFFF extrapolation

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Prediction of explosive phenomena in the solar corona such as solar flares and coronal mass ejections (CMEs) is one of the most important components for space weather forecast. These phenomena are considered to be processes that abruptly liberate the magnetic energy stored in the solar corona due to photospheric motions. In order to clarify these processes, three-dimensional information of the magnetic field in the solar corona is needed. The data, however, cannot be directly obtained in the solar corona though that on the photosphere can be observed. Therefore, various reconstruction methods from the vector magnetic field on the photosphere to a three-dimensional magnetic field have been proposed so far [1]. Particularly, a nonlinear force-free field (NLFFF) is often suited to model low beta coronal plasmas and seems to reconstruct the solar coronal magnetic field.

A magnetohydrodynamic (MHD) relaxation method is one of the promising methods for the NLFFF extrapolation [1]. The NLFFF obtained by the MHD relaxation method is directly usable as an initial condition of nonlinear MHD simulations because available discretization methods of the governing equations, MHD relaxation equations, are similar to the MHD simulations. However, modern numerical techniques for MHD such as upwind-type [2] and higher-order schemes [3] have not been investigated well in the MHD relaxation method. Therefore, in this paper, we study the numerical techniques for the MHD relaxation equations. We will also discuss an application to an extended MHD relaxation method for a non-force-free field (NFFF).

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Keywords: Solar corona, NLFFF, MHD relaxation method

