July 6, 2016

# First steps toward a three-dimensional MHD equilibrium code based on metriplectic dynamics

C. Bressan[1,2], M. Kraus[1,2], O. Maj[1], P. J. Morrison[1,3] and E. Sonnendrücker[1,2]

*1. Max Planck Institute for Plasma Physics, Garching.*
*2. Technische Universität München, Zentrum Mathematik.*
*3. Institute for Fusion Studies, The University of Texas at Austin.*

The construction of magnetohydrodynamics (MHD) equilibria in a fully three-dimensional geometry is a notoriously difficult problem. For instance, state-of-the-art codes for stellarator equilibria are limited by either the assumption of closed flux surfaces or the long computing time.

Metriplectic dynamics, i.e., a combination of symplectic and dissipative flows, as introduced by Morrison in [Morrison, Physica 18D (1986) 410-419] and then extended and used for numerics [Flier and Morrison, Physica D 240 (2011), 212–232; Chikasue and Furukawa, Physics of Plasmas 22 (2015), 022511 and Journal of Fluid Mechanics 774 (2015), 443–459] might offer an efficient solution to this long-standing problem: The state variable of the MHD fluid can be evolved according to a dissipative dynamics which is constructed on the basis of the Hamiltonian structure of ideal MHD equations. Such a dynamics dissipates selected functionals and relaxes the state of the plasma to an ideal MHD equilibrium. This method does not require any *a priori* assumption, such as the existence and the topology of flux surfaces, while the computing time is limited only by the stiffness of the (nonlinear) relaxation process.

In this talk, the basic principles of this method are illustrated together with an analysis of its application to realistic plasma equilibria.