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Kinetic Approach to microscopic-macroscopic coupling in fusion plasmas

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The need to handle the coupling between microscopic and macroscopic processes is an outstanding problem in plasma physics. The wide difference in mass between electrons and ions and the great change in time and space scales between large scale magnetohydrodynamic processes and small scale kinetic effects pose a great challenge to the simulation of plasma physics problems. The traditional approach has been to try to derive reduced models of the full first principles physics model, considering only the scales of interest. The approach decouples small scales and large scales and uses different methods for each. The classic example is anomalous resistivity that is used as a tool to summarize in resistive MHD models the presence of kinetic microinstabilities. We discuss an alternative approach [1], the use of the implicit kinetic PIC model to resolve all scales at the kinetic level. The approach relies on numerical methods that can effectively average the smallest scales within a correct kinetic treatment while focusing on large-scale structures. It is worth remarking that the approach is different from the gyrokinetic approach that relies on a mathematical formulation of the equations that eliminates the smallest scales. Our approach, instead, is valid on all limits and does not eliminate the contribution of any scale. We describe the new approach, its recent successful application to the study of reconnection [2] and its potential application to thermonuclear burning plasmas.

1. G. Lapenta, J.U. Brackbill, W.S. Daughton, Phys. Plasmas, 10, 1577, 2003; W. Daughton, G. Lapenta, P. Ricci, Phys. Rev. Lett., 93, 105004, 2004.

2. G. Lapenta, Space Sci. Rev., 107, 167, 2003.