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Effective Field Theories Motivated by Applications in Low-Temperature Plasmas

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Effective field theories are systematic derivations of a description of matter from first principles based upon an expansion parameter and a renormalization strategy. In principle, they allow quantification of error associated with successive orders of approximation. Lennard-Balescu theory is a common example in plasma physics, where the expansion parameter is associated with the strength of interactions and the renormalization is associated with the dynamics of binary collisions. This talk will overview three recent examples of effective field theories in plasmas along with the applications that motivated them. The first is a quasilinear extension of Lenard-Balescu theory that treats convectively unstable plasmas. This instability-enhanced kinetic theory has found application in understanding ion flow near sheaths, and in explaining anomalous electron transport in ExB discharges. The second is an extension of linear response kinetic theory to treat strongly magnetized plasmas in which the gyrofrequency exceeds the plasma frequency. This strongly magnetized kinetic theory led to the prediction of a novel friction force and associated transport relevant to non-neutral plasmas and ultracold neutral plasmas. The third example is a kinetic theory for strongly coupled plasmas based on an expansion in terms of the deviation of correlations from their equilibrium values, rather than the strength of correlations. This mean force kinetic theory has found application in the description of transport properties of high energy density plasmas and ultracold plasmas. This work was supported by the U.S. Department of Energy, Office of Fusion Energy Sciences under Award Number DE-SC0016159, by the National Science Foundation under Award No. PHY-1453736, and by the Air Force Office of Scientific Research under Award No. FA9550-16-1-0221.