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How electron collisions shape an ultracold plasma

EDWARD GRANT, University of British Columbia

Excitation of diatomic nitric oxide in a supersonic molecular beam forms a Rydberg gas with a temperature less than 1 K in the moving frame. This system relaxes to a molecular ultracold plasma with properties very comparable to plasmas formed by Rydberg excitation or threshold photoionization of atoms in a MOT. While, both MOT and molecular beam plasmas expand on a microsecond timescale with velocities determined by the electron temperature and the mass of the positive ions, molecular beam plasmas appear to expand slower than MOT plasmas suggesting a state of strong coupling. This observation challenges the conventional understanding of these systems. The nitric oxide plasma differs from MOT plasmas in one very important fundamental respect. Molecular cations carry the positive charge, and when a diatomic NO^+ ion recombines with an electron, it can dissociate to neutral atoms. The spatial distribution of ions and electrons in a quasi-neutral plasma determines the driving force for expansion. Dissociative recombination occurs fastest in the core of the plasma. This loss channel flattens the charged-particle density distribution in the centre. Model calculations show that this suppresses the expansion of the core, channeling the thermal energy of the electrons to flow instead to the hydrodynamic motion of the peripheral ions.