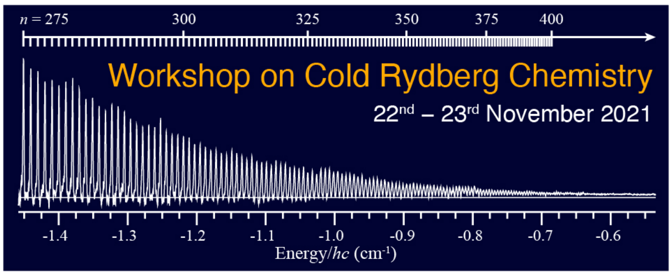


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# Dissipative dynamics of a molecular Rydberg gas: Avalanche to an ultracold plasma state of strong coupling

*Tuesday 23 November 2021 17:30 (45 minutes)*

Spontaneous avalanche to plasma splits the core of an ellipsoidal Rydberg gas of nitric oxide. Ambipolar expansion first quenches the electron temperature of this core plasma. Then, long-range, resonant charge transfer from ballistic ions to frozen Rydberg molecules in the wings of the ellipsoid quenches the centre-of-mass ion/Rydberg molecule velocity distribution. This sequence of steps gives rise to a remarkable mechanics of self-assembly, in which the kinetic energy of initially formed hot electrons and ions drives an observed separation of plasma volumes. These dynamics adiabatically sequester energy in a reservoir of mass transport, starting a process that anneals separating volumes to form an apparent glass of strongly coupled ions and electrons. Short-time electron spectroscopy provides experimental evidence for complete ionization. The long lifetime of this system, particularly its stability with respect to recombination and neutral dissociation, suggests that this transformation affords a robust state of arrested relaxation, far from thermal equilibrium. We see this most directly in the absorption spectrum of transitions to states in the initially selected Rydberg series, detected as the long-lived signal that survives a flight time of 400 µs to reach an imaging detector. The initial density of electrons produced by prompt Penning ionization, which varies with the selected initial principal quantum number and density of the Rydberg gas, determines a balance between the rising density of ions and the falling density of Rydberg molecules. This Penning-regulated ion - Rydberg molecule balance appears necessary as a critical factor in achieving the long ultracold plasma lifetime to produce spectral features detected after very long delays.

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