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What is the temperature of an ultra-cold Rydberg plasma?[1] DUNCAN TATE, GABRIEL FOREST, YIN LI, EDWIN WARD, Colby College, ANNE GOODSELL, Middlebury College — We have measured the asymptotic expansion velocities and effective plasma electron temperatures of ultra-cold plasmas (UNPs) which evolve from cold, dense, samples of Rydberg rubidium atoms using ion time-of-flight spectroscopy. A plasma forms when ionization caused by thermal radiation, cold dipole collisions, or hot-cold Rydberg collisions results in a high enough ion density to trap electrons. Thereafter, during the avalanche regime, electron-Rydberg collisions ionize as much as 75% of the atoms, and the remaining neutral atoms are down-scattered into states of higher binding energy. We find that the amount of energy transferred to the UNP from the Rydberg atoms during the avalanche increases with the initial Rydberg atom binding energy and density. The effective electron temperature is determined when the avalanche ends, i.e., when the adiabatically cooled electrons can no longer ionize the remaining down-scattered Rydberg population. We also find that the dependence of the electron temperature on Rydberg atom density and binding energy gives strong indirect evidence for the existence of a bottleneck in the spectrum of Rydberg states in coexistence with a cold plasma.

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