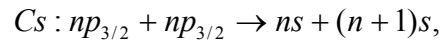


**HIGH RESOLUTION SPECTROSCOPY OF COLD RYDBERG GASES:
FROZEN RYDBERG GAS VERSUS DIPOLE GAS, IONIZATION PROCESSES,
DIPOLE BLOCKADE**

Pierre Pillet

Laboratoire Aimé Cotton, CNRS, Campus d'Orsay, Orsay cedex, France

An assembly of cold Rydberg atoms nl can be obtained by laser excitation of a cold atomic sample. The physics of cold Rydberg atoms is quite interesting and exciting because at the intersection of atomic physics, molecular physics, plasma physics and solid state physics. Because Rydberg atoms can interact at very large distances, a dilute cold Rydberg gas can be considered as a frozen Rydberg gas: dipole-dipole energy transfer experiments are so quite analogous to migration of an exciton in an anamorphous solid. For denser samples, the motion of the Rydberg atoms cannot be ignored, and the role of the dipole-dipole forces exerted between atoms has to be considered leading to l - or n -mixing or to ionization. The complex dynamics of the cold Rydberg atoms draws the frontier between frozen Rydberg gas and dipole gas. A depumping high resolution spectroscopy of a Rydberg sample of cesium atoms in the resonant configuration



where the p state is by Stark shift located in energy between the two s neighbour states, shows different behaviours by considering attractive or repulsive dipole-dipole forces between the atoms.

For still denser cold Rydberg samples or higher n , the spontaneous evolution of a cold Rydberg sample towards an ultracold plasma can be observed. The ignition of the processes of the evolution can be cold Rydberg atom – hot Rydberg atom collisions, blackbody radiation, cold Rydberg atom collisions. During this first phase of the evolution ($\sim 1-2 \mu s$), ionization leads to the formation of an ionic space charge, while the electrons go away. When the space charge is enough to trap the electrons, fast avalanche ionization occurs leading to the formation of an ultracold plasma. This extreme behaviour shows the importance of ions and ionization processes in cold Rydberg samples. A few

examples will be discussed as adding a Rydberg atoms in a plasma or as the role of a few number of ions for high resolution spectroscopy of cold Rydberg atoms.

Cold Rydberg atoms are quite promising candidate systems for fast quantum information scheme. Rydberg-Rydberg interactions may so be exploited to induce a phase in a conditional phase-gate operation and to inhibit excitation of pairs of Rydberg atoms within mesoscopic volume. We will present recent experiments to control the dipole blockade of the Rydberg excitation through Stark effect. The presence of ions and the role of ionization processes will be also considered in this case.