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**QUANTUM PHASES AND NONEQUILIBRIUM DYNAMICS WITH RYDBERG GASES**

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Abstract:

Motivated by recent experimental efforts to realize exotic phases and study non trivial quantum dynamics with ultracold atomic Rydberg gases, I will discuss two examples from our recent work in the field.

In the first part I will focus on the engineering of soft-core interactions that give rise to supersolid phases for physical parameter ranges. I will discuss the crossover between the so called density wave supersolid and the defect-induced mechanism introduced by Andreev-Lifschitz and Chester by a complete analysis of the phase diagram at low densities.

In the second part I will discuss the preparation of strongly correlated phases in a laser excited two-dimensional atomic Mott insulator, whose effective dynamics can be mapped to a long range Ising model with transverse and longitudinal fields. In particular I will show the emergence of mesoscopic crystalline structures with a well-defined number of excitations via adiabatic sweeps of the laser parameters in finite two dimensional optical lattices.