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Long-range interactions and many-body effects in a cold Rydberg gas[1] JOVICA STANOJEVIC, ROBIN CÔTÉ, University of Connecticut, Department of Physics (Storrs, CT) — In recent years, the unique combination of properties of ultracold Rydberg atoms, such as long radiative lifetimes or strong long-range interactions, has led to proposals for using them to implement fast quantum gates. Here, we explore the behavior of macroscopic atomic samples where laser excitation of ultracold atoms to high-lying Rydberg states is locally blockaded due to the strong van der Waals interactions between Rydberg atoms. We discuss a mean-field model that defines local blockade domains and agrees well with experimental observations. In a N-atom mesoscopic sample under perfect blockade condition, the single excitation is described by a many-body Rabi frequency, *i.e.* $\sin^2(\sqrt{N}\Omega\tau)$. Here, we generalize the result to a macroscopic sample with several "domains" containing effectively $N_{\rm eff}$ atoms; the number of excited atoms is then $N_{\rm exc} \sim \sum_{\rm domain} \sin^2\left(\sqrt{N_{\rm eff}}\Omega\tau\right)$.

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