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Many-body physics of optically excited, frozen Rydberg gases[1]
DOMINIK MUTH, ACHIM LAUER, Fachbereich Physik und Forschungszentrum OPTIMAS, TU Kaiserslautern, Germany, JOHANNES OTTERBACH, Department of Physics, Harvard University, Cambridge, MA, USA, MICHAEL FLEISCHHAUER, Fachbereich Physik und Forschungszentrum OPTIMAS, TU Kaiserslautern, Germany — We discuss the many-body physics of an ensemble of optically excited Rydberg atoms with van der Waals dipole-dipole interactions [1]. Starting from a fully quantized model of the optical excitation we show that Rydberg excitations always possess a finite kinetic energy mediated by photon exchange even if the motion of the atoms can be disregarded. The kinetic energy competes with the repulsive vdW interactions. Using discretization and DMRG, we calculate the many-body ground state in the one-dimensional case. It is correlated much more strongly than possible for any local interaction, i.e., with a Luttinger parameter $K \ll 1$. In the presence of an additional lattice, a fractal phase diagram [2] emerges with Mott-insulating phases at any rational filling fraction. [1] see e.g. H. Weimer, R. Löw, T. Pfau, and H. P. Büchler; Phys. Rev. Lett. 101, 250601 (2008) [2] F. J. Burnell, M. M. Parish, N. R. Cooper, and S. L. Sondhi; Phys. Rev. B 80, 174519 (2009)

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