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Exploring Quantum Matter with Ultracold Atoms in Optical Lattices

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Publisher Summary

This chapter explores quantum matter with ultracold atoms in optical lattices. The chapter focuses on bosonic atoms in optical lattices and on the regime where strong correlations between the atoms become important. In the interaction of atoms with coherent light fields, two fundamental forces arise. The Doppler force is dissipative in nature and can be used to efficiently laser cool a gas of atoms and relies on the radiation pressure together with spontaneous emission. The dipole force creates a purely conservative potential in which the atoms can move. No cooling can be realized with this dipole force, however if the atoms are cold enough initially, they may be trapped in such a purely optical potential. The chapter also presents a classical model for dipole force, in which it highlights the electron as harmonically bound to the nucleus with oscillation frequency. An external oscillating electric field of a laser with frequency can induce an oscillation of the electron resulting in an oscillating dipole moment of the atom. Such an

oscillating dipole moment will be in phase with the driving oscillating electric field, for frequencies much lower than an atomic resonance frequency and 180Â° out of phase, for frequencies much larger than the atomic resonance frequency. The induced dipole moment interacts with the external oscillating electric field, resulting in a dipole potential experienced by the atom.

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