Topological properties of a dense atomic lattice gas

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We investigate the existence of topological phases in a dense two-dimensional atomic lattice gas. The coupling of the atoms to the radiation field gives rise to dissipation and a non-trivial coherent long-range exchange interaction whose form goes beyond a simple power-law. The far-field terms of the potential – which are particularly relevant for atomic separations comparable to the atomic transition wavelength – can give rise to energy spectra with one-sided divergences in the Brillouin zone. The long-ranged character of the interactions has another important consequence: it can break the standard bulk-boundary relation in topological insulators. We show that topological properties such as the transport of an excitation along the edge of the lattice are robust with respect to the presence of lattice defects and dissipation. The latter is of particular relevance as dissipation and coherent interactions are inevitably connected in our setting.