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Dynamical crystallisation of a low-dimensional Rydberg gas

PETER SCHAUSS, JOHANNES ZEIHER, SEBASTIAN HILD, TAKESHI FUKUHARA, Max-Planck-Institut für Quantenoptik (MPQ), 85748 Garching, Germany, MARC CHENEAU, Laboratoire Charles Fabry - Institut d'Optique, Palaiseau, France, MANUEL ENDRES, FRAUKE SEEßELBERG, MPQ, TOMMASO MACRI, THOMAS POHL, Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany, CHRISTIAN GROSS, MPQ, IMMANUEL BLOCH, MPQ & LMU München, 80799 München, Germany — Rydberg atoms provide a way to investigate long-range interacting many-body systems in a very controlled way. In our setup we implemented an optical detection technique for Rydberg atoms with sub-micron resolution, which allows for the measurement spatial correlations in strongly interacting collective states of Rydberg atoms. We prepare a well-defined configuration of ground state atoms in an optical lattice and laser couple them to a Rydberg state. The Rydberg atoms interact via the van der Waals force, which extends over approximately half the system size, thereby leading to strong correlations. Using numerically optimized pulse shapes for coupling strength and detuning, we deterministically prepare the crystalline state in this long-range interacting many-body system. Control of the spatial configuration of the initial state is of great importance for the investigation of the phase diagram. To achieve this, we developed an experimental scheme based on single site addressing which allows for the preparation of initial states with sub-Poisson number fluctuations. The developed techniques might allow for the detailed characterisation of the phases in Rydberg gases and their coherence properties.

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