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Quantum Transport of Rydberg Excitation with Synthetic Spin-Exchange Interactions FAN YANG, SHUO YANG, LI YOU, State Key Laboratory of Low Dimensional Quantum Physics, Department of Physics, Tsinghua University, Beijing 100084, China, DEPARTMENT OF PHYSICS, TSINGHUA UNIVERSITY TEAM — Coherent transfer of quantum state in a many-body system is indispensable for quantum information processing. In this work, a simple scheme is proposed for engineering quantum transport dynamics of spin excitations in a chain of laser-dressed Rydberg atoms. The transport occurs due to a synthetic spin exchange arising from diagonal van der Waals interaction. For a single Rydberg exciton, we show that deterministic entanglement between distant atoms can be established by tuning local dressing parameters. Furthermore, the topological exciton pumping can be realized by dynamically modulating dressing fields, which facilitates quantized entanglement transfer. For multi-excitons, we show that long-range exciton-exciton interaction permits the formation of high-order magnon bound state, which exhibits nonlocal correlated transport even when dephasing dominates over its center of mass motion. Different from previous schemes discussed, our proposal requires neither resonant dipole-dipole interaction nor off-diagonal van der Waals interaction, and thus avoids the complicated excitation schemes encountered in multi-Rydberg-level systems.

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