JOURNAL CLUB: Observation of string breaking on a (2 + 1)D Rydberg quantum simulator

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Seminar Room

Lattice gauge theories (LGTs) describe a broad range of phenomena in condensed matter and particle physics. A prominent example is confinement, responsible for bounding quarks inside hadrons such as protons or neutrons. When quark-antiquark pairs are separated, the energy stored in the string of gluon fields connecting them grows linearly with their distance, until there is enough energy to create new pairs from the vacuum and break the string. While such phenomena are ubiquitous in LGTs, simulating the resulting dynamics is a challenging task. Here, we report the observation of string breaking in synthetic quantum matter using a programmable quantum simulator based on neutral atom arrays. We show that a (2+1)D LGT with dynamical matter can be efficiently implemented when the atoms are placed on a Kagome geometry, with a local U(1) symmetry emerging from the Rydberg blockade, while long-range Rydberg interactions naturally give rise to a linear confining potential for a pair of charges, allowing us to tune both their masses as well as the string tension. We experimentally map out the corresponding phase diagram by adiabatically preparing the ground state of the atom array in the presence of defects, and observe substructure of the confined phase, distinguishing regions dominated by fluctuating strings or by broken string configurations. Finally, by harnessing local control over the atomic detuning, we quench string states and observe string breaking dynamics exhibiting a many-body resonance phenomenon. Our work paves a way to explore phenomena in high-energy physics using programmable quantum simulators.

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