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High-energy physics at ultracold temperatures – quantum simulation of lattice gauge theories with cold atoms

Tuesday 13 July 2021 16:30 (1 hour)

Despite the importance of gauge theories for modern physics, solving their out-of-equilibrium dynamics on classical computers is extremely challenging. This difficulty is currently stimulating a worldwide effort to implement them in dedicated quantum simulators.

In this talk, I will discuss recent progress towards quantum simulation of gauge theories using ultracold atoms. I will show recent breakthroughs to overcome the main challenge, the realization of a dynamics that respects gauge symmetry. In particular, I will present a recent experiment based on engineering of suitable energy penalties in an optical lattice, which has realized a many-body gauge theory in a 71-site Hubbard model and has certified the fulfilment of Gauss's law for the first time. Further, I will discuss recent progress in understanding gauge breaking errors in this and related models as well as possibilities to mitigate them.

I will also illustrate some of the fascinating physics attainable in quantum simulators of gauge theories even for simple target models and with realistic resources, such as dynamical topological quantum phase transitions. Finally, I will discuss the state of art and common issues of gauge quantum simulation, and thus aim at outlining a roadmap towards mature and practically relevant quantum simulation of gauge theories.

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