

New avenues for quantum simulation with atoms, molecules and photons

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40 years ago, Richard Feynman outlined his vision of a quantum computer for quantum simulations of complex calculations of physical problems. Today, his dream of analog and digital quantum simulations has become a reality and a highly active field of research across different platforms ranging from ultracold atoms and ions, to superconducting qubits and photons. In my talk, I will outline how ultracold atoms in optical lattices started this vibrant and interdisciplinary research field 20 years ago and now allow probing quantum phases in- and out-of-equilibrium with fundamentally new tools and single particle resolution and control. Novel (hidden) order parameters, entanglement properties, full counting statistics or topological features can now be measured routinely and provide deep new insight into the world of correlated quantum matter. I will introduce the measurement and control techniques in these systems and delineate recent applications regarding quantum simulations of strongly correlated electronic systems.