

**Quantum simulations with strongly interacting photons:
Simulating exotic phases of matter and applications in quantum technology**

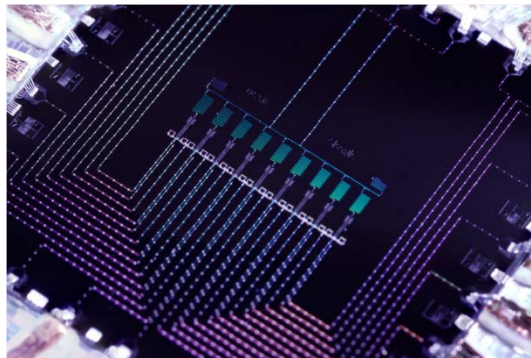
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Classical computers require enormous computing power and memory to simulate even the most modest quantum systems. That makes it difficult to model, for example, why certain materials are insulators and others are conductors or even superconductors. R. Feynman had grasped this since the 1980s and suggested to use instead another more controllable and perhaps artificial quantum system as a "quantum computer" or specifically in this case a "quantum simulator".

I will briefly review in non-specialist terms the main results in this area including our early ideas on realizing Mott insulators, Fractional Hall states and Luttinger liquids with interacting photons [1,2]. After that I will present in more detail a recent experiment realizing the Hoeffstadter butterfly and the many-body localization (MBL) transition using interacting photons in the latest superconducting quantum chip of Google [3]. A simple method to study the energy-levels-and their statistics - of many-body quantum systems as they undergo the ergodic to the MBL transition, was proposed and implemented. The formation of a mobility edge of an energy band was observed and its shrinkage with disorder toward the center of the bands was measured. Beyond the applications in understanding fundamental physics, the potential impact of quantum simulators in different areas of quantum and nano technology, material science as well as machine learning and big data processing will be touched upon.



The 9 qubit quantum chip used for the quantum simulation experiment in the recent collaboration with the Google quantum hardware group

References

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