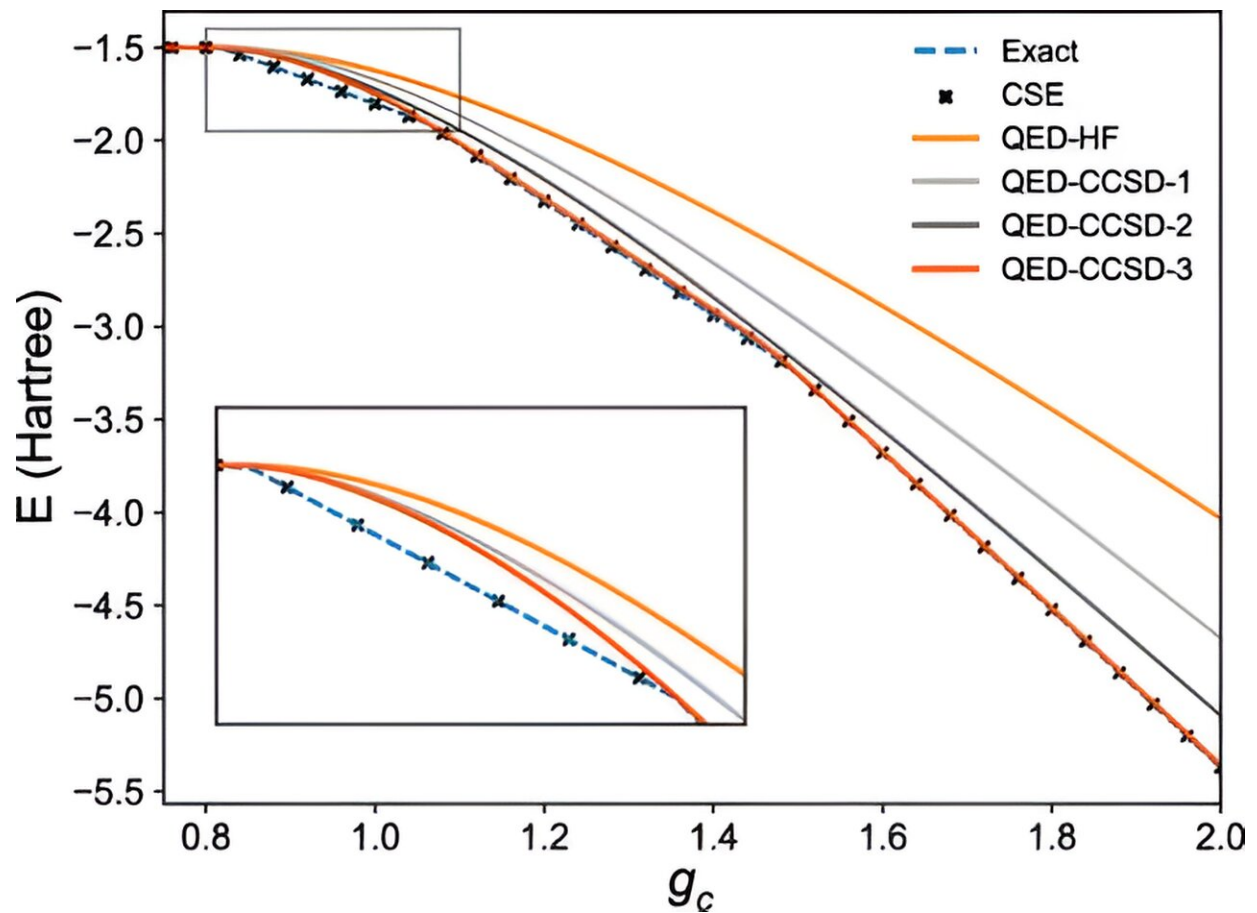


# Study proposes generalized approach to light-matter interactions

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CSE and QED-CCSD energies for the three fermion Tavis-Cummings model with increasing coupling. The Hamiltonian parameters from Eq. (14) were fixed as  $(\mu, \nu) = (2, 0.5)$ , while  $\lambda$  is varied as shown along the  $g_c$  axis. The QED-CCSD- $n$  methods are named according to the convention used in Ref. [41].

Credit: *Physical Review Letters* (2024). DOI: 10.1103/PhysRevLett.133.080202

A study coordinated by the University of Trento with the University of Chicago proposes a generalized approach to the interactions between electrons and light. In the future, it may contribute to the development of quantum technologies as well as to the discovery of new states of matter. The study is [published](#) in *Physical Review Letters*

Understanding the interaction between [quantum particles](#) is crucial in the discovery of new molecules or materials that can be used for novel technological or medical applications. For instance, when molecules or [chemical compounds](#) interact with light, their physical properties can change substantially.

Bearing this in mind, the new field of polaritonic chemistry aims to trigger new chemical reactions using light as a catalyst. More generally, controlling [light-matter interactions](#) provides a way to manipulate and synthesize new quantum matter.

The research work, as always, progresses by making hypotheses that must be verified. But when the object of study is a quantum system involving a multitude of different elements, i.e. electrons, photons, phonons, the situation can be even more complicated. It is difficult to accurately calculate the wave function of such a system, that is, a function that contains the relevant physical information to make accurate predictions about the behavior of many quantum particles of more than one type.

A group of researchers from the University of Chicago, coordinated by Carlos Leonardo Benavides-Riveros, a research fellow at the Department of Physics of the University of Trento, and David A. Mazziotti from the University of Chicago, made a contribution to this topic.

They started with an "ansatz," a theoretical prescription, that can help them predict the interactions among the particles in a many-body quantum system on a quantum computer. Then they generalized this ansatz to treat systems that contain more than one type of quantum particle, e.g., systems that contain not only electrons but also photons and/or phonons.

To demonstrate, the researchers have simulated a universal quantum algorithm on an IBM quantum computer, with zero theoretical error.

And that is the novelty of this study: the researchers have developed a single approach that can be used to generate exponential prescriptions (ansatzes) for many-body quantum systems with more than one type of particle that, when implemented on quantum devices, produces exact wave functions.

According to physicists, this solution also opens up new perspectives in the study of the states of matter.

"Quantum systems as molecules or solids, as we find them in nature, never contain only electrons. Many fascinating properties can be created or suppressed when light interacts with them," explains Benavides-Riveros.

"What we did," he continues, "was to introduce other quantum particles beyond electrons such as particles of light, commonly known as photons. And by following our universal formulation of the problem we can understand the structure of its [wave function](#) and hence, its physical properties."

"Because the ansatz is particularly suitable for quantum computers, the advance opens new possibilities for using quantum computers to model important molecular problems in light-matter interaction, such as occur

in polaritonic chemistry," Mazziotti says.

**More information:** Samuel Warren et al, Exact Ansatz of Fermion-Boson Systems for a Quantum Device, *Physical Review Letters* (2024). DOI: [10.1103/PhysRevLett.133.080202](https://doi.org/10.1103/PhysRevLett.133.080202). On *arXiv*: DOI: [10.48550/arxiv.2402.12273](https://doi.org/10.48550/arxiv.2402.12273)

Provided by University of Trento

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