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Abstract for an Invited Paper  
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**A quantitative analysis of small atomic and molecular systems<sup>1</sup>**

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Ultracold atoms in an optical lattice provide a unique toolbox for emulating the prototypical models of condensed matter physics. Before the optical lattice system can be trusted as a quantum simulator however, it needs to be validated and benchmarked against known results, for which quantum Monte Carlo simulations are ideally suited. In the first part of this talk, an overview of recent numerical studies of ultracold bosonic and fermionic systems in an optical lattice will be given, starting with a full comparison based on experimental time-of-flight images of bosons in an optical lattice and ab-initio simulations. Next, the temperature and entropy in present experiments on fermions in an optical lattice will be estimated, and the full thermodynamics on approach to the Neel temperature will be presented. In the second part of the talk, a similar numerical analysis will be given for polar bosonic molecules. Special emphasis will be given on the feasibility of observing supersolid phases.

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