Impurities and Polarons in Bosonic gases — A platform towards a quantum simulator of quasiparticles.

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The study of impurities interacting with a bosonic field is one of the most paradigmatic problems in physics, ranging from high-energy to atomic physics. Polarons are quasiparticles formed when impurities atoms are dressed by the low-energy excitations of the host environment, such as electrons interacting with lattice vibrations. Understanding the motion of impurities in a polar crystal gives profound insight into how collective excitations propagate in a material. However, a complete microscopical description of this problem is not possible yet, since materials are usually imperfect and interactions are not easy to characterize **[1]**. The versatility and control of ultracold quantum gases opened up a plethora of theoretical predictions on polaronic physics using ultra-cold quantum gases, resulting in several experimental realizations **[2]**. Notwithstanding, the bosonic bath has a linear dispersion relation akin to a lattice in a polar crystal. The role of long-range interactions is still unknown and may provide one step closer to a more accurate simulator of the solid-state polaron. In this talk, we will discuss ionic polarons created as a result of charged particles interacting with a Bose Einstein condensate.

In this talk I provide a pedagogical overview on Bose polarons in quantum gases, liquids and solids with superfluid properties **[3 — 5]** (also known as supersolids). I will discuss the state-of-the art of Bose polaron subjected to long-rage interactions **[6,7]** that are suitable candidates for technologically robust quantum devices. Possible research directions of interest for the National Quantum Science and Technology Institute (NQSTI) will be discussed.

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