

# Dilute impurities in a Bose-Einstein condensate: Orthogonality catastrophe and perturbative solution at unitarity

**Pietro Massignan**

N.-E. Guenther, N. Yegovtsev, R. Schmidt, G. M. Bruun, V. Gurarie  
*Universitat Politècnica de Catalunya, 08034 Barcelona, Spain*  
[pietro.massignan@upc.edu](mailto:pietro.massignan@upc.edu)

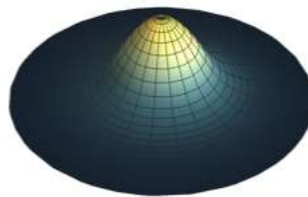
Abstract

We study the properties of dilute impurities immersed in a weakly interacting Bose gas, i.e., of Bose polarons. We first show that immersing a very heavy impurity in an ideal BEC generates a massive perturbation of the bath, i.e., a bosonic analogue of Anderson's orthogonality catastrophe (OC) [1]. Then we introduce a simple and accurate coherent Ansatz, and show that a bosonic OC happens also for mobile impurities in the limit of a dilute BEC [2]. Finally, we demonstrate that the case of unitary interactions between a heavy impurity and the bath bosons admits a rigorous perturbative solution [3]. In this way, we show that all quasiparticle properties of the unitary Bose polaron depend on the impurity-boson potential via a single parameter characterizing its range.

## REFERENCES

- [1] P. Massignan, C. J. Pethick, and H. Smith, *Phys. Rev. A*, **71** (2005) 023606.
- [2] N.-E. Guenther, R. Schmidt, G. M. Bruun, V. Gurarie, and P. Massignan, *Phys. Rev. A*, **103** (2021) 013317.
- [3] P. Massignan, N. Yegovtsev, and V. Gurarie, *Phys. Rev. Lett.*, in print (2021).

## FIGURE



**Figure 1:** A single impurity can alter dramatically the density of a large Bose-Einstein condensate, thereby creating the bosonic analog of the Anderson orthogonality catastrophe.