



Temperature precision measurements in Bose Einstein Condensates

An ICFO-Nottingham collaboration, published in *Physics Review Letters* and highlighted as an Editor's suggestion, reports on a novel model to determine the temperature of BECs without destroying the sample.

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Bose Einstein Condensates (BECs)---a state of matter made of ultra-cold bosonic gases cooled down to almost absolute zero---have shown to be extremely useful for precision measurement applications, or quantum information processing. In addition, simulations of strongly correlated systems can be carried out with BECs loaded in optical lattices---correlated magnetic quantum phases can be simulated below critical temperatures of order $\sim 0.2nK$.

Quantum thermometry seeks to determine the fundamental limits on how precise temperatures close to absolute zero can be measured. Current experiments have been able to achieve high precision thermometry at very low temperatures. However, the mechanism and the attainable accuracy varies quite considerably depending on the specific experimental platform. Even more, in the case of cold atomic gases, most of the current techniques employed to measure temperature in the sub-nanoKelvin domain end up destroying the BEC after the measurement.

In a recent study published in *Physics Review Letters* and highlighted as an Editor's suggestion, ICFO researchers Mohammad Mehboudi, Aniello Lampo, Christos Charalambous, Miguel Angel Garcia March, and ICREA Prof. Maciej Lewenstein, in collaboration with Luis A. Correa, from the University of Nottingham, introduce a novel minimally-disturbing method for measuring temperature of BECs in the sub-nanoKelvin regime. In their theoretical approach, the team of researchers took an abstract standpoint and, by means of meticulous theoretical modelling and adopting experimentally relevant parameters, found that current precision standards in these systems can be improved. In particular, they demonstrated the possibility of measuring temperatures below 1nK with large accuracy without destroying the BEC gas.

Their theoretical approach was based on the Bose-Polaron model, in which they took an atomic impurity and embedded it into the cloud of BEC atoms. They then allowed both components of the system to interact with one-another, in such a way that the impurity acquires information about the temperature of the BEC. They found that the position and the velocity of the impurity become critically dependent on the temperature of the BEC. Subsequently, by measuring these, one can reveal the temperature of the BEC, while hardly perturbing the BEC itself.

The results obtained in this study open a new pathway for obtaining accurate low-temperature measurements in ultra-cold systems, broadening the range of applications that can benefit from this discovery, in particular for emerging quantum technologies.

