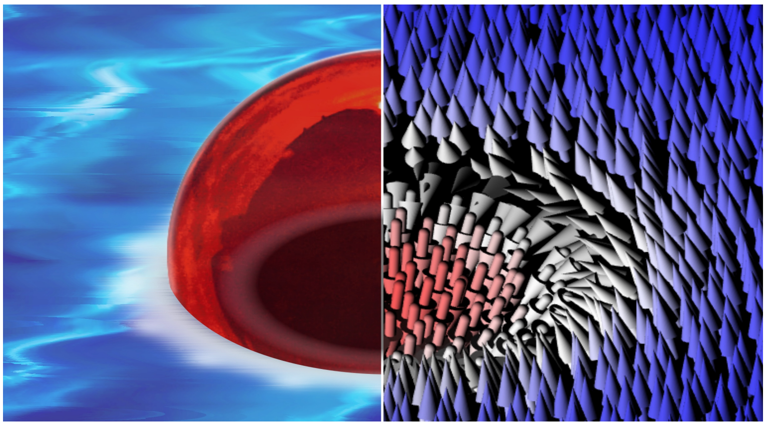
Press Releases

BUBBLES OF ULTRACOLD ATOMS TO UNDERSTAND THE QUANTUM VACUUM AND THE UNIVERSE



The ultracold atoms lab of the Pitaevskii Center for Bose-Einstein Condensation in Trento reports for the first time the observation of phenomena related to the stability of our universe. The results arise from the collaboration among the National Institute of Optics of Cnr, the Physics Department of the University of Trento, Tifpa-Infn and the University of Newcastle and it has been published in Nature Physics.

In which kind of vacuum is our universe? Modern physics describes our universe as an intricate outcome of the interactions between particles and fields (the electromagnetic one, for example). From a general point of view, our universe could be in a not so stable configuration, known as *false vacuum*, which has an energy higher than the absolute minimum. So, in principle it could decay to the lowest energy state, the *true vacuum*, triggered by quantum or thermal fluctuations.

False vacuum decay could take place on very different time scales, depending on the system parameters and it manifests with the appearance of bubbles of *true vacuum*, similarly to the formation of liquid drops in a gas cooled below the condensation point. This process is strongly related to cosmological phenomena and the research community has dedicated great effort to understand in which kind of vacuum our universe is. Several research groups have developed sophisticated theories to describe this process, and, in the absence of a direct access to the conditions of the Big Bang, table top experimental platforms for testing and simulating these models have been devised.

Today the first observation of this decay is reported in a study published on Nature Physics and with Alessandro Zenesini (Pitaevskii BEC Center, Istituto nazionale di ottica del Consiglio nazionale delle ricerche e Dipartimento di Fisica dell'Università di Trento, Tifpa Trento Institute for Fundamental Physics and Applications, INFN as first author. Researchers prepared a cloud of sodium atoms in an initial state which looks like a *false vacuum*. They then measured the time it takes to the system to decay to the real vacuum, under different experimental conditions. After a first comparison with numerical simulations of the system, the authors joined the theory group of Ian Moss, well known cosmologist which has also collaborated with Stephen Hawking, to verify that the most reliable theory of false vacuum decay is compatible with the observations.

Once again, ultracold atoms prove to be an ideal platform for quantum simulation both of the extremely small and the extremely large. "We used the magnetic properties of atoms to create artificial *false* and *true vacuum* in an ultra-stable and controllable environment. This exquisite control of the degenerate atomic cloud allows us to study false vacuum decay in different experimental conditions and to compare our results with theoretical predictions." reports Alessandro Zenesini, Cnr-Ino researcher who collaborated for this research with Giacomo Lamporesi and Alessio Recati from the same institute.

"False vacuum decay theories were developed more than fifty years ago having in mind processes typical of high-energy and subnuclear physics and cosmology." says Gabriele Ferrari (UniTrento). "The results are a first step toward the validation of theories which were only on paper, and pave the road to new lines of experimental research on the different aspects of the birth and dynamics of the *true vacuum* bubble, with also effects on biochemistry and quantum computation."

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