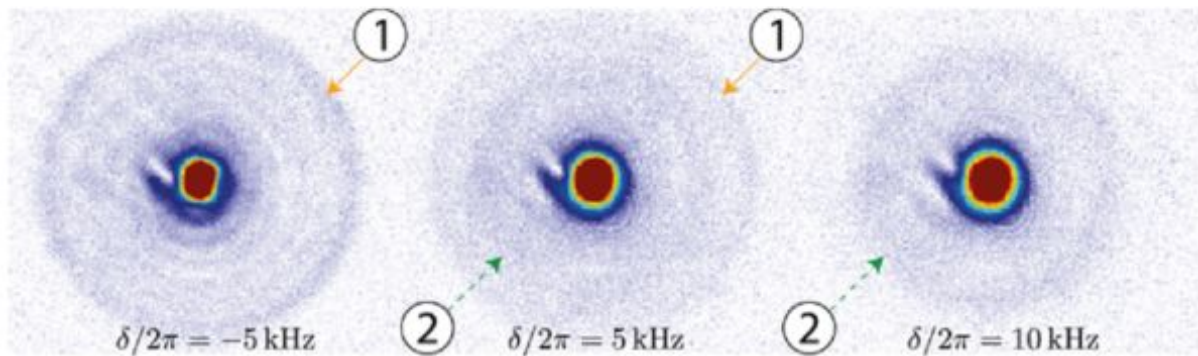




Using radio waves to control interactions in Bose-Einstein condensates

Dressing the atoms with radio-frequency fields allows to tune the strength and sign of their interactions, and to create correlated atom pairs

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Bose-Einstein condensates are one of the most versatile forms of quantum matter available in Nature. They can be used to engineer synthetic quantum systems composed by many interacting quantum particles, whose properties can be adjusted at will. Thanks to this, researchers often use them as quantum simulators - special-purpose quantum computers- to investigate open questions spanning many fields of science, from condensed-matter to high-energy physics. Key to most quantum simulation protocols is the ability to control interactions between the atoms of the condensate in a fast and flexible manner. Thus, developing new tools for interaction control in Bose-Einstein condensates is crucial for the development of the field.

In a recent study published in **Physical Review Letters**, ICFO researchers Dr Julio Sanz, Anika Frolan, Craig S. Chisholm and Dr Cesar R. Cabrera, led by ICREA Prof. at ICFO Dr Leticia Tarruell, have demonstrated a new method to control the interaction properties of Bose-Einstein condensates using a radio-frequency field. To this end, they create synthetic atomic states which combine a radio-frequency photon and two internal states of an atom, forming a coherent superposition. When the original atomic states have different interactions, the new states dressed by the radio-frequency field acquire new collisional properties, which can be flexibly adjusted by controlling the field's frequency and intensity. For instance, the researchers show how to completely cancel the interactions of the condensate, to rapidly switch their sign from repulsive to attractive values, or to trigger an inelastic collision process in a controlled manner. This allows them to form new types of solitons, to investigate the formation of soliton trains, and to form correlated pairs of atoms with adjustable properties.

The demonstration of this new interaction control method sets the ground for the engineering of more complex interactions in Bose-Einstein condensates using optical fields, enlarging the toolbox of quantum simulators, and provides a new source of correlated atom pairs for quantum atom optics experiments.