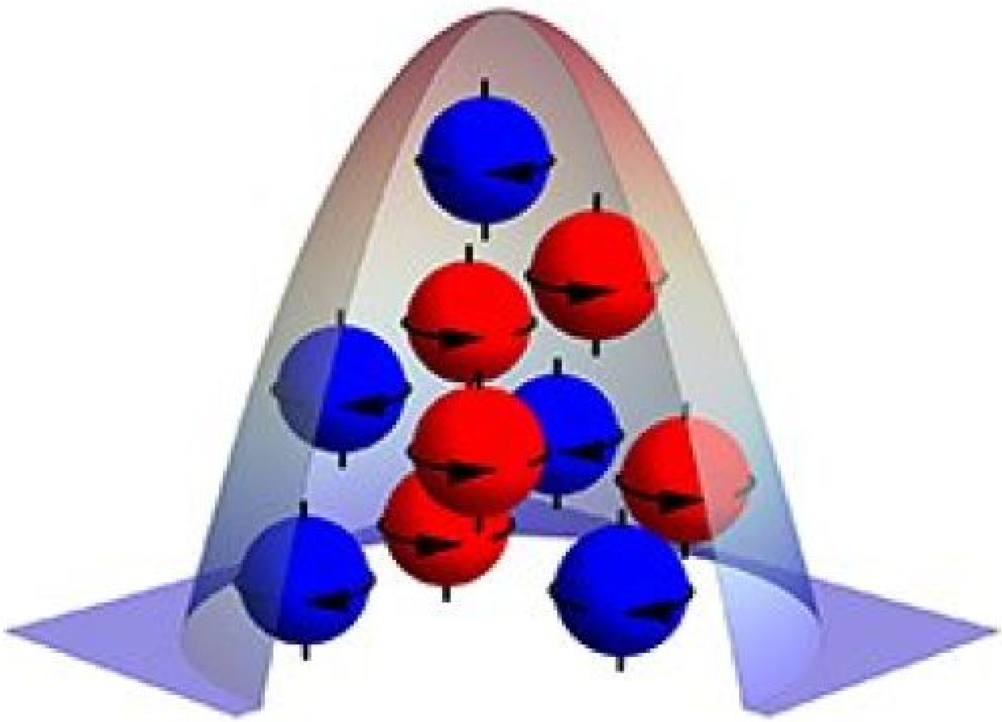

PhD Thesis Defense PAU GOMEZ KABELKA 'Spinor Bose-Einstein Comagnetometer and Interhyperfine Interactions in Rb87'

PAU GOMEZ KABELKA

September 28, 2021

10:00

ICFO Auditorium and Online (Teams)

Tuesday, September 28, 2021, 10:00. ICFO Auditorium and Online (Teams)

PAU GOMEZ KABELKA

Atomic Quantum Optics

ICFO-The Institute of Photonic Sciences

In this work we demonstrate the first realization of a comagnetormeter in the ultracold regime. In comparison to regular magnetometers, which are designed to maximize their magnetic field sensitivity, a comagnetometer uses paired magnetometers in a differential configuration to cancel the effects of the magnetic field and resolve weak dynamics that differently affect its constituents. Here, we implement a comagnetometer within the f =1 and f = 2 ground state hyperfine manifolds of a 87Rb spinor Bose-Einstein condensate (SBEC). The hyperfine manifolds feature nearly opposite gyromagnetic ratios and thus the sum of their precession angles is only weakly coupled to external magnetic fields, while being highly sensitive to any effect that rotates both manifolds in the same way.

A fundamental limitation of the comagnetometer is f = 2 ? f = 1 hyperfine relaxing collisions, where the liberated kinetic energy expels colliding atoms from the optical trap. These collisions are state-dependent and can be avoided by preservin the f = 2 spin state in a stretched configuration. We show how this can be achieved at low magnetic fields, where the spin-dependent contact interaction is the dominant energy contribution and stabilizes the spin orientation of the SBEC. Under these conditions, the comagnetometer coherence time can be extended to ~1 s and the observed common magnetic field suppression is 44.0p8q dB. The technique is applied to precision measurement of the interhyperfine interaction in 87Rb. The uncertainty in the obtained interhyperfine scattering lengths is reduced by more than a factor three with respect to previously reported values. We also present preliminary studies on phase-resolved parametric amplification within a SBEC comagnetometer. In this case, the f = 2 manifold undergoes parametric amplification, while the f = 1 manifold keeps track of the rotating reference frame induced by the applied external magnetic field. We describe technical improvements to the experimental system in two areas: magnetic control and manipulation, and optical trapping and probing. The first group of improvements includes the implementation of radiofrequency (rf) and microwave (mw) driving and the development of a real-time rf source. The second group of improvements includes a pulsed optical trapping technique, a digital implementation of the laser locking scheme, and a hyperfine-selective Faraday probing method.

Tuesday, September 28, 2021, 10:00. ICFO Auditorium and Online (Teams)

Thesis Director: Prof Dr. Morgan W. Mitchell

Pau Gomez Kabelka's Thesi Cover