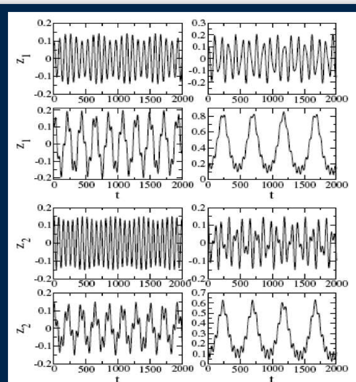
Josephson junction with 2 bosonic species

Atomic Josephson junctions (AJJs) keep in touch ultracold atoms and superconductivity. Josephson predicted the macroscopic quantum tunneling of Cooper pairs occurring in superconductor-oxide-superconductor junctions in 1962. This work is a contribution to the study of the atomic counterpart of the Josephson effect.

Here, the analysis of AJJs performed with a single Bose-Einstein condensate (BEC) is extended to the case of two species of Bose-Einstein condensed atoms. The two BECs are trapped by means of a one-dimensional double-well potential and are interacting with each other; their spatio-temporal evolution is controlled by two coupled Gross-Pitaevskii equations (GPEs). Performing the so-called two mode approximation, AJJs temporal evolution can be described by a system of four coupled ordinary differential equations (ODEs), whose mechanical analog are coupled pendula. By these ODEs the oscillations of the relative population of each species are determined.



► Relative populations z of the two bosonic species versus time (ODEs). For each z, the intra-species interaction is fixed, while - from left to right - the strength of the inter-species interaction is increased.

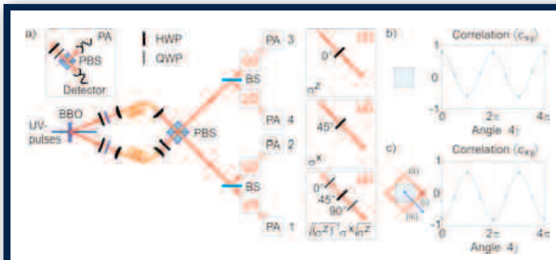
The main points of the paper are three:

1) The agreement between the oscillations predicted by the GPEs and by the ODEs.
2) By solving the ODEs, it is proved that even if the intra-species interaction is not strong enough to ensure the oscillations of the relative populations around a non-zero time averaged value, if the inter-species interaction is greater than a certain value, this phenomenon occurs.
3) The possibility to establish links with the current experiments on the ultracold atoms. In the paper, are derived analytical formulas for the frequencies of the relative populations oscillations around stable equilibrium points. Such formulas can be used to address measures of the inter-species inter-atomic scattering length. ■

G. Mazzarella, **M. Moratti**, **L. Salasnich**, **M. Salerno** and **F. Toigo**,
'Atomic Josephson junction with two bosonic species',
J. Phys. B: At. Mol. Opt. Phys. **42**, 125301 (2009).

Revealing **anyonic features**

In Nature particles appear in two distinct types according to their statistics: bosons and fermions. This is due to the fact that in three dimensions the observable particle statistics is limited to these two cases. In two-dimensional systems, the situation changes drastically: anyons can appear which exhibit fractional statistics ranging continuously from bosonic to fermionic.



▲ Echo spectroscopy Ramsey fringes as a function of the time separation between two light pulses around the echo pulse.

Amongst others, anyons can be realized as quasiparticles in highly entangled, two-dimensional many-body lattice systems. In our work, we encode the corresponding relevant many-body state of a simple anyonic model in the multi-partite state of polarization entangled photons. This physical realization, Fig. (a), allows the demonstration of anyonic statistics in the minimal instance of a square plaquette of the lattice, Fig.(b). There, an anyon and the path of a second anyon circulating it, can be encoded, Fig.(c). As the circulation of one particle around another is equivalent to two successive exchanges of these particles it is possible to probe the exotic statistical behaviour of these anyons with our experimental implementation.

Our experiment demonstrates the presence of fractional statistics by the manipulation of entangled quantum states. For future applications one would like to employ anyons to perform error-free quantum computation by exploiting their topological properties. This is the first in-principle demonstration for the implementation of such anyonic quantum processing. ■

J. K. Pachos, **W. Wieczorek**, **C. Schmid**, **N. Kiesel**, **R. Pohlner** and **H. Weinfurter**,
'Revealing anyonic features in a toric code quantum simulation', *New Journal of Physics* **11**, 083010 (2009)

Erratum

In the Highlight EPN 40/4, p.11, right, the title should be 'Field-free molecular alignment probed by FLASH' and the reference at the bottom should be: M.J.J. Vrakking, 'Field-free molecular alignment probed by the free electron laser in Hamburg (FLASH)', *J. Phys. B: At. Mol. Opt. Phys* **42**, 134017 (2009)".