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Negative-mass effects in atomic and polariton superfluids

DAVID COLAS

The University of Queensland

Abstract: When we think of mass, we usually consider the inertial mass – the resistance of a body to acceleration due to an applied force. According to Einstein's equivalence principle, this mass is identical to the gravitational mass. However, by modifying the dispersion relation of quasiparticles it is possible to tune their effective mass. Indeed, even negative effective masses for wave packets can be achieved by engineering the dispersion relation in a range of quantum systems. Examples include holes within semiconductors, exciton-polaritons in 2D microcavities, or atomic spin-orbit coupled Bose-Einstein condensates (SOCBEC).

Recent experiments on these different platforms have shown how qualitatively new forms of wave packet dynamics can arise in the region of negative effective mass. Features like shock waves, soliton train, self-trapping [1] and the formation of non-spreading X-waves [2] from the free expansion of Bose-Einstein condensate have been reported. In this seminar I will explain how the formation of these peculiar wave structures occurs due to a complex balance between the self-interference of the wave function and non-linear interactions [3,4]. I will make use of the wavelet transform, a powerful spectral representation that brings unique insights into these complex wave packet dynamics.

References:

[1] M. A. Khamehchi et al., Physical Review Letters, 118, 155301 (2017).

[2] L. Dominici et al., Light: Science and Applications, 7, 17119 (2018).

[3] D. Colas and F. P. Laussy, Physical Review Letters, 116, 026401 (2016).

[4] D. Colas, F. P. Laussy and M. J. Davis, Physical Review Letters, 121, 055302 (2018).

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