Non-linear mode excitations in two coupled superfluids

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In 1941, Landau gave an explanation why a superfluid could flow without friction [1]. He showed that a massive point-like impurity moving in a superfluid would only be able to excite it above a critical velocity whose expression is related to the dispersion relation of elementary excitations. For a weakly-interacting Bose-Einstein condensate, the critical velocity is just its sound velocity. In our cold atom experiment consisting of trapping and cooling ^{6}Li and ^{7}Li atoms we were able to study a mixture of Bose and Fermi superfluids [2]. By performing a counterflow experiment, we measured the critical velocity of the dual superfluid system as a function of fermion-fermion interactions [3]. The experiment raised questions on the expected value of the critical velocity for such system and of possible explanations to the existence of a clear threshold for dissipation. Indeed, a priori, our experiment is far from the ideal setup of Landau's thought experiment. To have more insight about what are the mechanisms of dissipation in a dual superfluid system, we studied numerically and theoretically the dynamics of two Bose-Einstein condensates oscillating in each other. We use coupled Gross-Pitaevskii equations to describe the system. We uncover a non-linear mechanism analog to a parametric instability that can resonantly enhance the creation of modes in both superfluids and lead to dissipation in a similar fashion as for the homogeneous case.

Références

1. J. Phys. USSR 5 :70 (1941)
2. Science 345, 1035 (2014)
3. Phys. Rev. Lett. 115, 165203 (2015)