Topological superfluids in a Fermi-Bose mixture with a high critical temperature

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We show that a two-dimensional (2D) spin-polarised Fermi gas immersed in a 3D Bose-Einstein condensate (BEC) constitutes a very promising system to realise a topological superfluid. The fermions attract each other via an induced interaction mediated by the bosons, and the resulting pairing is analysed with retardation effects fully taken into account. This is further combined with Berezinskii-Kosterlitz-Thouless (BKT) theory to obtain reliable results for the superfluid critical temperature. We show that both the strength and the range of the induced interaction can be tuned experimentally, which can be used to make the critical temperature approach the maximum value allowed by general BKT theory. Moreover, this is achieved while keeping the Fermi-Bose interaction weak so that three-body losses are small [1].

We furthermore show that if the fermions are confined in two layers, they can realise a so-called $\mathbb{Z}_2$ topological superfluid with time-reversal symmetry and chiral edge states in analogy with the quantum spin Hall state [2]. Finally, we discuss how the induced interaction mediated by the BEC can be detected unambiguously and probed systematically using the bi-layer system [3].

[1] Z. Wu and G. M. Bruun, Phys. Rev. Lett. **117**, 245302 (2016).
[2] J. M. Midtgaard, Z. Wu, G. M. Bruun, arXiv:1705.10169.
[3] D. Suchet, Z. Wu, F. Chevy, and G. M. Bruun, Phys. Rev. A **95**, 043643 (2017).