Composite-boson signature of atomic dimers in the interference pattern of colliding condensates

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All particles consisting of an even number of fermions are boson-like, which bears a strong consequence: they must undergo Bose-Einstein condensation.

We predict that, compared to elementary bosons, the interference pattern of two colliding BEC made of fermionic-atom dimers must have additional high frequency modes. As these new modes are many-body in essence, previous experiments performed with two rather dilute condensates have only seen interferences ruled by the condensates' momentum difference, a result obtained by taking atoms as elementary bosons. The higher frequency modes we predict result from fermion exchanges between condensates, and thus constitute a striking signature of the dimer composite nature. We analytically derive the 2-coboson spatial correlation functions and use Shiva diagrams, specific to coboson many-body effects, to identify the physical origin of these high-frequency modes and determine the conditions to see them experimentally, using optical lattices. A dimer granularity appears because Pauli blocking prevents two dimers to occupy the same site.

In the same way as the composite nature of semiconductor excitons has already revealed a breadth of remarkable effects, we anticipate cold-atom systems to provide a novel, fully controllable playground to investigate further in depth the very unique many-body effects that result from dimensionless fermion exchanges, i.e., exchange in the absence of fermion-fermion interaction. Recent optical lattices already reach densities high enough for these new many-body effects to be observable, including the signature predicted here.

References

[1] SY Siau, A. Chenu, M. Combescot, New J. Phys. 21 (2019) 043041Reference 2