

Is the superfluidity of a Bose gas related to the spontaneous breaking of $U(1)$ symmetry?

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It is widely accepted that phonons in a superfluid Bose gas are Goldstone bosons, and that the spontaneous breaking of $U(1)$ symmetry is the primary cause of superfluidity. The first statement is justified by spontaneous symmetry breaking (SSB), which is usually defined as follows: the Hamiltonian of the system is invariant under the $U(1)$ transformation $\hat{\Psi}(\mathbf{r}, t) \rightarrow e^{i\alpha}$

[1] M. Tomchenko, Is a phonon excitation of a superfluid Bose gas a Goldstone boson? J. Phys. A: Math. Theor. 59, 305202 (2026). <https://doi.org/10.1088/1751-8121/ae8c94>

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