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Complex-valued problem on FRG analysis of relativistic BEC

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Although the relativistic Bose-Einstein condensates (BEC) of pion and kaon may emerge and impact the equation of state, the behavior of mesons in neutron stars is not well understood. The functional renormalization group (FRG) seems a promising tool to study the BEC formed through a second-order phase transition, where quantum fluctuations should be taken into account. Even in the local potential approximation, however, the flow equation becomes complex-valued, leading to complex thermodynamic quantities, while preceding works usually ignore their imaginary parts or keep the flow equation real-valued by restricting values of parameters.

We clarify the physics underlying in this complex-valued problem, and solve it by imposing a physically plausible condition for the effective potential and chemical potential. Applying the condition to the FRG of the complex scalar theory, we successfully extract the real-valued BEC from the complex flow equation and obtain phase diagrams on the temperature-chemical potential plane [1]. In order to observe the effect of quantum fluctuations, we also make a comparison with the phase diagrams in the mean-field approximation (MFA) [2]. The FRG phase transition line becomes closer to that of the MFA for weak interaction while it is more deviated for strong interaction. Our finding shows that quantum fluctuations become crucial for strong coupling, revealing the application range of the MFA. This work would lead to more accurate analyses of the pion-BEC in the core of neutron stars than the MFA and one-loop approaches [3].

[1] F. Terazaki, K. Mameda, and K. Suzuki, Relativistic BEC extracted from a complex FRG flow equation, (2024), arXiv:2409.04361 [hep-ph].
[2] J. I. Kapusta, Bose-Einstein Condensation, Spontaneous Symmetry Breaking, and Gauge Theories, Phys. Rev. D 24, 426 (1981).
[3] J. Bernstein and S. Dodelson, Relativistic Bose gas, Phys. Rev. Lett. 66, 683 (1991); K. M. Benson, J. Bernstein, and S. Dodelson, Phase structure and the effective potential at fixed charge, Phys. Rev. D 44, 2480 (1991).

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