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Self-Pinned State of Impurities in a Bose-Einstein Condensates

Sunday, 10 September 2023 22:00 (20 minutes)

We show that a Tonks-Girardeau gas that is immersed in a Bose-Einstein condensate can undergo a transition to a crystal-like Mott state with regular spacing between the atoms without any externally imposed lattice potential. We characterise this phase transition as a function of the interspecies interaction and temperature of the Tonks gas, and show how it can be measured via accessible observables in cold atom experiments. We also develop an effective model that accurately describes the system in the pinned insulator state and which allows us to derive the critical temperature of the transition.

We will also show how extending the above idea to multicomponent Tonks -Girardeau gases can lead to the spontaneous emergence of more complex crystal structures with antiferromagnetic order, and how finite interactions in the immersed component lead to additional superfluid phases. Furthermore, the dynamics of the immersed component can be mapped on solitonic models with quantum statistics inherited from the ones of the impurities.

[1] T. Keller, T. Fogarty, Th. Busch, Phys. Rev. Lett. 128, 053401 (2022)
[2] T. Keller, T. Fogarty, Th. Busch, arXiv:2302.01743 (2023)

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