From Quantum Fluids to Emergent Gravity: Quantum potential induced non-local BEC and Analogue Hawking radiation

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Addition of a minimal correction term to the local Gross-Pitaevskii equation represents non-locality in the interactions. The effective minimal non-locality can make the healing length (ξ) decrease more rapidly with the increase of s-wave scattering length (a). Implication in the context of condensed matter physics - the size of a quantized vortex can considerably be changed at finite a by tuning ξ. From analogue gravity perspectives, this shrinking of ξ via tuning a, in principle, does make the high momentum regime more accessible by keeping the dispersion relation restricted up to linear fluctuations [1]. The presence of the Lorentz-breaking quantum potential term in the non-local Bose-Einstein Condensates (BEC) model apparently gives rise to the massive scalar excitations for large wavelength phonon modes (of $\mathcal{O}(1/\xi)$) characterized by a 'massive' minimally coupled free Klein-Gordon equation in the context of experimental observations of analogue Hawking radiation where at least one spatial dimension is kept free to allow for the source/sink of the background fluid flow [2]. Thus arising out of a non-relativistic non-local BEC, an Analogue gravity model is formulated up to $\mathcal{O}(\xi^2)$ accuracy in the presence of the quantum potential term for a canonical acoustic black hole in $(3+1)$-d spacetime. A UV-IR coupling between short wavelength 'primary' modes (which are supposedly Hawking radiated through the sonic event horizon) and the large wavelength 'secondary' modes is the striking upshot which is inevitable in the quantum gravity experiments of analogue Hawking radiation in the laboratory. These 'secondary' modes would grow over space by gaining energy from the Hawking radiated quanta ('primary' modes) that are distinguished by their characteristic features of the respective growth rates [3]

[1] Supratik Sarkar and A. Bhattacharyay, Journal of Physics A: Mathematical and Theoretical **47**, 092002 (2014)

[2] Supratik Sarkar and A. Bhattacharyay, Phys. Rev. D **93**, 024050 (2016).

[3] Supratik Sarkar and A. Bhattacharyay, arXiv **1703.08027** [gr-qc] (2017).