Testing BEC Dark Matter with Gravitational Waves

An abstract prepared for the 22nd International Conference on General Relativity and Gravitation, 7-12 July 2019, Valencia

Dimitar Ivanov,[1,2], Takeshi Kobayashi,[3], and
and Stefano Liberati [1,2]

[1]SISSA - International School for Advanced Studies, via Bonomea 265, 34136 Trieste, Italy.
[2]INFN, sezione di Trieste, via Valerio 2, Trieste, Italy.
[3]The Abdus Salam International Centre for Theoretical Physics (ICTP) Strada Costiera, 11 - I-34151 Trieste, Italy

March 9, 2019

This talk is based on theoretical work [1] in which we analyse a model of non-minimally coupled Dark Matter (DM) in light of recent Gravitational Wave (GW) - Gamma Ray Burst (GRB) observations [2]. The model of a relativistic non-minimally coupled Bose-Einstein Condensate (BEC) as a DM candidate has been proposed in [3] as a way to improve some of the small-scale problems of Cold Dark Matter such as the Core-Cusp problem. The basic idea is that a healing length of the same order as the length scale of the curvature would allow the condensate to couple directly to second derivates of the metric (a non-minimal coupling) which would modify the small scale behaviour of DM thus making it more consistent with observations. On the other hand, the recent simultaneous detection of the GW and GRB events GW170817 and GRB170817A has allowed to put sharp constraints on various models of Dark Energy which include similar non-minimal coupling terms [4, 5, 6]. However, the implications of these observations for models of DM have rarely been considered. In this talk I am going to discuss whether the BEC model for DM is consistent with these observations. I am going to focus on two possible cases - first when the condensations occurs within galaxies, and second when the condensation occurs within clusters of galaxies. Finally, I will talk about the implications of these events for non-minimally coupled DM in general.

References

[1] D. Ivanov, T. Kobayashi, S. Liberati, "Testing BEC dark matter with gravitational waves", in preparation

[2] LIGO Scientific Collaboration and Virgo Collaboration, Fermi Gamma-ray Burst Monitor, and INTEGRAL, "Gravitational Waves and Gamma-Rays from a Binary Neutron Star Merger: GW170817 and GRB 170817A", The Astrophysical Journal Letters, 848:L13 (27pp), 2017 October 20, https://doi.org/10.3847/2041-8213/aa920c

[3] D. Bettoni, M. Colombo, S. Liberati, "Dark matter as a Bose-Einstein Condensate: the relativistic non-minimally coupled case", JCAP 1402 (2014) 004, DOI: 10.1088/1475-7516/2014/02/004, arXiv:1310.3753 [astro-ph.CO]

[4] T. Baker, E. Bellini, P.G. Ferreira, M. Lagos, J. Noller, I. Sawicki, "Strong constraints on cosmological gravity from GW170817 and GRB 170817A", Phys.Rev.Lett. 119 (2017) no.25, 251301, DOI: 10.1103/PhysRevLett.119.251301, arXiv:1710.06394 [astro-ph.CO]

[5] Paolo Creminelli, Filippo Vernizzi, "Dark Energy after GW170817 and GRB170817A", Phys.Rev.Lett. 119 (2017) no.25, 251302, DOI: 10.1103/PhysRevLett.119.251302, arXiv:1710.05877 [astro-ph.CO]

[6] Jose Maria Ezquiaga, Miguel Zumalacarregui, "Dark Energy After GW170817: Dead Ends and the Road Ahead", Phys.Rev.Lett. 119 (2017) no.25, 251304, DOI: 10.1103/PhysRevLett.119.251304, arXiv:1710.05901