Contribution ID: **7** Type: **not specified**

Causality, Superfluid Dark Matter, and Modified Gravity

Tuesday 14 March 2023 14:00 (40 minutes)

Superfluid dark matter is a novel way of reconciling the apparent discrepancy between galactic phenomenology and {\Lambda}CDM. The success of these models is that on cosmological scales they can play the role of CDM, while on galactic scales there is a phase transition to a superfluid, and the nontrivial dynamics in this regime can reproduce the observed Tulley-Fisher relation. However, in general, these models exhibit a breakdown of causality, which indicates they would resist having any UV completion in the usual sense of Wilsonian field theory. Constructing a class of theories of this form that are explicitly causal, instead of dark matter we can consider these as scalar modifications of gravity, which in very dense environments can become stronger than ordinary gravity. We find various observational constraints in this class of modified gravity theories, where the strongest constraint comes from the stability of neutron stars.

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