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Searching for Dark Photon Dark Matter with Laser Interferometers and Quantum Sensors

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Traditionally, Dark Matter (DM) searches are dominantly focused on GeV –TeV mass window. However, though these experiments have reached unprecedented detection sensitivities, the successes only resulted in a push for stronger limits on parameters. This forces people to keep their minds open to other DM candidates, especially in the different mass regimes. If a DM particle is an ultralight gauge boson, i.e., dark photon, DM should be considered as a background field. With certain assumptions on its coupling to Standard Model particles, this DM background field could either exert forces on test masses in gravitational wave detectors, resulting in displacements with a characteristic frequency set by the gauge boson mass, or source electromagnetic fields within a metal shield which can be probed by state-of-the-art quantum sensors, such as SERF. In this talk, I will discuss a novel strategy to hunt for such DM. I will also give more details about DM background simulation, the properties of the DPDM signal, and the cross-correlation analysis method using LIGO data. The analysis method can be migrated to the one using SERF magnetometer arrays.

We performed the first proof-of-concept U(1)*B or U(1)*(B-L) DPDM search using LIGO O1 data and improved the constraint using the latest LIGO O3 data. Also, we performed the robust kinetically mixed DPDM lab search at a low-frequency regime using data taken from SERF magnetometer arrays. Large unexplored parameter space can be probed based on this method.

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