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Detecting Gauged $L_\mu - L_\tau$ using Neutron Star Binaries

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We show that gravitational wave emission from neutron star binaries can be used to discover ultra-light $\mathrm{U}(1)_{L_\mu - L_\tau}$ vectors by making use of the large inevitable abundance of muons inside neutron stars. In pulsar binaries the $\mathrm{U}(1)_{L_\mu - L_\tau}$ vectors induce an anomalously fast decay of the orbital period through the emission of dipole radiation. We study a range of different pulsar binaries, finding the most powerful constraints for vector masses below $\mathcal{O}(10^{-18}\,\mathrm{eV})$. For merging binaries the presence of muons in neutron stars can result in dipole radiation as well as a modification of the chirp mass during the inspiral phase. We make projections for a prospective search using the GW170817 event and find that current data can discover light vectors with masses below $\mathcal{O}(10^{-18}\,\mathrm{eV})$. In both cases, the limits attainable with neutron stars reach gauge coupling $g' <\sim 10^{-20}$, which are many orders of magnitude stronger than previous constraints. We also show projections for next generation experiments, such as Einstein Telescope.

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