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CEνNS-based Supernova Neutrino Detection with LZ

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The LUX-ZEPLIN (LZ) experiment is a low-threshold low-background dark matter detector sensitive to CEνNS interactions from astrophysical neutrinos. LZ is deployed 4850 feet underground at the Sanford Underground Research Facility in Lead, South Dakota. LZ's central volume is a time projection chamber (TPC) containing 7 tonnes of liquid xenon (LXe) in the active volume. CEνNS interactions in the LXe deposit $\mathcal{O}(1)$ keV, an energy regime to which LZ is sensitive. LZ will detect CEνNS interactions with neutrinos emitted from the next galactic core-collapse supernova (CCSN), providing complimentary information to observations by scintillator and water-based detectors.

To model LZ's response to the neutrino signal from a CCSN, we have developed νESPER: the Neutrino Engine Simulating the Process of Energetic Recoils. We present the architecture of νESPER and discuss the CCSN progenitor models available for simulation. We explore the rate of CEνNS interactions from a 27^{-}M$_{\odot}$ CCSN progenitor, and make comparisons to the rate of non-CEνNS neutrino interactions from this progenitor in LZ's TPC and veto systems.

We study LZ's CEνNS detection efficiency using νESPER and the Noble Element Simulation Technique (NEST), a fast simulation tool which models the TPC response. We examine the response for a variety of CCSN progenitors. Finally, we discuss LZ's participation in the Supernova Neutrino Early Warning System 2.0 (SNEWS2.0) network, and the role of CEνNS-sensitive liquid noble element detectors in multi-messenger astrophysics.

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