Investigation of Neutrino Properties with Global Analysis of CEνNS Data
Snowmass 2021 Letter of Interest

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Overview: The observation of coherent elastic neutrino-nucleus scattering (CEνNS) [1–3] is one of the major achievements in neutrino physics of the last years, which was performed for the first time in 2017 by the COHERENT Collaboration using a cesium-iodide (CsI) detector [4], and repeated in 2020 by the same Collaboration using a liquid-argon (LAr) detector [5]. Several other experiments are under way or planned for the future (CONUS [6], CONNIE [7], MINER [8], ν-cleus [9], and others [10]).

Already before the COHERENT observations it was expected that CEνNS measurements could have probed neutrino properties, electroweak interactions and the structure of nuclei [11–14]. This expectation has been confirmed by the impressive number of studies that have been done using the data of the COHERENT experiment (see the review in Ref. [15] and the recent Refs. [16–21]).

Global Analysis: The information that can be extracted from CEνNS data is enhanced by comparing and combining the results of different experiments that use diverse nuclear targets and neutrino sources. So far, we have only the COHERENT observation of CEνNS on CsI [4] and Ar [5] using the electron and muon neutrino fluxes produced by pion and muon decays at rest in the Spallation Neutron Source at Oak Ridge National Laboratory. The CONNIE experiment established only an upper limit to CEνNS interactions of reactor electron neutrinos [22]. However, results of other experiments are expected in the next years and we believe that global analysis of CEνNS data will play an important role for extracting the maximum amount of information.

The existing COHERENT observation of CEνNS on CsI [4] and Ar [5] already confirmed the expected approximate dependence of CEνNS cross section on N^2, where N is the nuclear neutron number. Moreover, the combined analysis of the COHERENT CsI and Ar data led to improvements on the constraints on neutrino properties and electroweak interactions [17, 18, 20].

Physics Goals: We plan to continue and improve the global analysis of CEνNS data by including the future new experimental results, that will allow us to better probe the following Standard Model (SM) and Beyond the Standard Model (BSM) neutrino properties:

- The value of the weak mixing angle, that determines the SM neutrino CEνNS cross section [17, 18, 23–28].
- The SM neutrino charge radii [17, 18, 26–29].
- BSM neutrino electromagnetic interactions generated by neutrino magnetic moments, neutrino millicharges, and BSM contributions to the neutrino charge radii [17, 18, 23, 26–31].

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- BSM neutrino Non-Standard Interactions (NSI) generated by light and heavy mediators [16, 17, 20, 21, 23, 26, 27, 30, 32–41].
- Active neutrino disappearance due to BSM active-sterile neutrino mixing [23].

We will also obtain interesting information on the structure of the target nuclei [17–19, 25–28, 42–44].

Analysis Details: An important aspect of the analysis of CEνNS data is the possibility to use all the available experimental information, taking into account the proper systematic uncertainties. This has been allowed by the COHERENT collaboration through the publication of appropriate data releases for the CsI [45] and LAr [46] measurements. We strongly encourage all experimental collaborations to do the same for a proper use of their experimental data by the community.

In particular, the correlated arrival time and recoil energy of the COHERENT data available through the data releases gives a better handle for the study of the electron and muon neutrino properties [16, 28, 29, 37, 39].

Summary: Coherent elastic neutrino-nucleus scattering is a growing field of experimental, phenomenological and theoretical research that received an exciting boost from the first measurement of CEνNS in the COHERENT experiment [4]. The global analysis of CEνNS data will play an important role in the investigation of neutrino properties in the next decade covered by Snowmass 2021.

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