Neutrino interactions with nucleons and nuclei: nuclear reactions and effects of interest for neutrino oscillation experiments

Research Project / Research Group Description:
Recent years have witnessed an intense experimental and theoretical activity aimed at a better understanding of neutrino interactions with nucleons and nuclei. Although this activity has been stimulated mostly by the needs of neutrino oscillation experiments in their quest for a precise determination of neutrino properties, the relevance of neutrino interactions with matter extends over a large variety of topics, including hadronic and nuclear physics. Indeed, neutrino cross section measurements allow to investigate the axial structure of the nucleon and baryon resonances, enlarging our views of hadron structure beyond what is presently known from experiments with hadronic and electromagnetic probes, not forgetting about lattice QCD. Besides, modern neutrino experiments are performed with nuclear targets. For nuclear physics this represents a challenge and an opportunity. A challenge because the precise knowledge of neutrino and baryon properties can only be achieved if nuclear effects are under control. An opportunity because neutrino cross sections incorporate richer information than electron-scattering ones, providing an excellent testing ground for nuclear structure, many-body mechanisms and reaction models.

To achieve the precision goals in the current neutrino oscillation measurements, and to reliably extract information about the axial properties of the nucleon and baryon resonances, it is crucial to develop robust theoretical nuclear models for the experimental data analysis. Among many processes we will emphasize the relevance of multinucleon mechanisms for the reconstruction of the neutrino energy and the correct interpretation of the quasielastic scattering data. Another active topic of research will be weak strangeness production. We have already studied the weak excitation of Λ (1405), which leads to the first prediction for the production of $\Sigma\,\pi$ pairs with antineutrinos. We plan to extend this study to other resonances, involving also charm quarks.

Job position description:
To carry out the research project outlined above, we seek for a candidate with a strong interdisciplinary background on nuclear and particle physics and with robust computational skills. On the other hand, in the medium and long terms, we aim also at having our models incorporated in the neutrino event generators. This will certainly increase the impact of our research in the field. That would require a combined effort from both the developers of the event generators and from our side, and in this context the help of a young fellow would be also highly valuable.

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"la Caixa" Foundation
IFIC INSTITUT DE FÍSICA CORPUSCULAR
EXCELENCIA SEVERO OCHOA
This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 713673.