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Study of the full electric dipole strength of the double halo nucleus 11Li using proton inelastic scattering

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Over the years there have been many efforts put in trying to understand the electric dipole (E1) strength of atomic nuclei. It is known that the nuclear E1 response is mostly dominated by the IsoVector electric Giant Dipole Resonance (IVGDR), which can be understood as a collective harmonic motion of protons against neutrons. In neutron-rich nuclei, part of the E1 strength is redistributed around the neutron separation energy, producing a concentration of low-energy dipole excitations known as a Pygmy Dipole Resonance (PDR), which instead consists in an oscillation of a neutron skin against an isospin-symmetric core. The closer we are to the neutron drip-line, the more complex the PDR becomes, heavily affecting its properties. This study focuses on the double neutron halo nucleus 11Li. The PDR in 11Li is significantly different from a regular PDR due to the very low neutron separation energy of 11Li, which produces a large imbalance of neutrons in the neutron skin with pairing energy playing an important role in it. Although the PDR for 11Li was initially observed, this observation only accounts for a small part of the total E1 response in 11Li. Recent theoretical studies have predicted the presence of an IVGDR in 11Li that was not observed before, which accounts for most of its E1 strength. In order to experimentally study the complete E1 strength of 11Li, an inelastic scattering experiment in inverse kinematics was performed at the Facility for Rare Isotope Beams (FRIB) in July 2024. A 53.4 MeV/u 11Li beam was sent into the Active Target Time Projection Chamber (AT-TPC), which acted as the proton active target as well as the tracking detector for the scattered protons from the reaction. Additionally, the S800 spectrometer was used at the end of the beam line in order to study the decay products of the excited 11Li. Although the PDR in 11Li was already observed previously, the results from this experiment provide a preliminary measurement of an IVGDR in 11Li, which to our knowledge is a first for double halo nuclei. These results are of importance to fully understand the E1 response of 11Li and may provide useful insight into the E1 properties of halo nuclei in general.

Author: LÓPEZ GONZÁLEZ, Jose Manuel (IGFAE)

Co-authors: Dr MITCHELL, AJ (Australian National University); BARIONI, Adriana (Federal University of São Paulo); VOTAW, Ben (Davidson College); WAGNER, Ben (Davidson College); KAY, Benjamin (Argonne National Laboratory); OLAIZOLA, Bruno (Institute for the Structure of Matter CSIC); BENETTI, Caleb (Facility for Rare Isotope Beams); MAHER, Cavan (Facility for Rare Isotope Beams); ARDELEAN, Claire (Michigan State University); CABO, Cristina (IGFAE - USC (Spain)); BAZIN, Daniel (Facility for Rare Isotope Beams - Michigan State University); RAMIREZ, Daniela (Facility for Rare Isotope Beams); SHARP, David (The University of Manchester); VIGEZZI, Enrico (National Institute for Nuclear Physics); BARRANCO, Francisco (University of Seville); MCCANN, Gordon (Facility for Rare Isotope Beams); POTEL AGUILAR, Gregory (Universidad de Sevilla); CHEN, Jie (Southern University of Science and Technology (Shenzhen, China)); PEREIRA, Jorge (Facility for Rare Isotope Beams); Dr LAY VALERA, José Antonio (Dpto. de Física Atómica, Molecular y Nuclear, Universidad de Sevilla); ZAMORA, Juan Carlos (Facility for Rare Isotope Beams); KUICH, Magdalena (Facility for Rare Isotope Beams); Prof. GAI, Moshe (University of Connecticut (US)); HARAKEH, Muhsin N. (University of Groningen); D. PATHIRANA, Neshad (Facility for Rare Isotope Beams); ZEGERS, Remco (Facility for Rare Isotope Beams); BECEIRO NOVO, Saúl (Universidade da Coruña); PAINTER, Shane (Michigan State University); NOJI, Shumpei (Facility for Rare Isotope Beams); GIRAUD, Simon (French Alternative Energies and Atomic Energy Commission); ALI, Sk Mustak (Facility for Rare Isotope Beams); GARG, Umesh (University of Notre Dame); GUIMARÃES, Valdir (University of São Paulo); DOMINIK, Wojtek (University of Warsaw); MITTIG, Wolfgang (Facility for Rare Isotope Beams); AYYAD, Yassid (IGFAE - USC (Spain)); SERIKOW, Zach (Facility for Rare Isotope Beams); RAHMAN, Zarif (Facility for Rare Isotope Beams)

Presenter: LÓPEZ GONZÁLEZ, Jose Manuel (IGFAE)

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