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Transfer Reactions with 16C as a Probe of Neutron-Rich Carbon Structure

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Carbon isotopes provide a rich testing ground for the evolution of shell structure and halo phenomena in light neutron-rich nuclei. In particular, $^{15}\mathrm{C}$ [1] is a well-known one-neutron halo candidate, with the valence neutron weakly bound ($S_n \approx 1.2$ MeV) in a $2s_{1/2}$ orbital.

Its first excited state at 0.74 MeV has a dominant single-particle configuration with a neutron in the $1d_{5/2}$ orbital and a lifetime of 2.61 ns [2]. The transition between these states is expected to involve weak core polarization due to the inert $^{14}\mathrm{C}$ core, which may be further reduced by the spatial decoupling of the halo neutron. Understanding how the halo in $^{15}\mathrm{C}$ impacts core polarization is directly relevant for constraining the quadrupole moments of $^{16}\mathrm{C}$ [3].

To address these questions, we studied the one-neutron transfer $^{16}\mathrm{C}(p,d)^{15}\mathrm{C}$, the two-neutron transfer $^{16}\mathrm{C}(p,t)^{14}\mathrm{C}$, and the deuteron-induced transfer $^{16}\mathrm{C}(d,t)^{15}\mathrm{C}$. These complementary reactions provide sensitivity to single-particle and pairing correlations in neutron-rich carbon isotopes and serve as benchmarks for theoretical models of transfer reactions with exotic beams.

The experiment was performed in 2023 at the Argonne Tandem Linac Accelerator System [4] (ATLAS) using the Active Target Time Projection Chamber (AT-TPC) [5] and HELIOS solenoidal spectrometer [6,7]. A primary $^{18}\mathrm{O}$ beam with an energy of 222.72 ± 0.43 MeV was degraded to produce a $^{16}\mathrm{C}$ secondary beam, which was subsequently used to study these transfer channels.

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Abstract

Primary author(s) : Sra. XIFRA GOYA, Georgina (USC (Universidade de Santiago de Compostela)); Sr. MA, Jun Rui (Southern University of Science and Technology (SUSTech)); Dr. AYYAD LIMONGE, Francesc Yassid (USC)

Co-author(s) : Dr. CHEN, J. (Southern University of Science and Technology (SUSTech)); Dr. BAZIN, D. (Facility for Rare Isotope Beams (FRIB)); Prof. MITTIG, W. (FRIB/MSU); Sr. LÓPEZ-GONZÁLEZ, J.M. (USC); Sr. SUÁREZ-BUSTAMANTE, D.P. (IGFAE (USC)); Dr. CABO LANDEIRA, C. (UIniversidade de Santiago de Compostela); SERIKOW, Z. (FRIB - Michigan State University); KUMI, H. (Universidade da Coruña); Dr. KAY, B. P. (Argonne National Laboratory (ANL)); Dr. JAYATISSA, H. (Los Alamos National Laboratory (LANL)); Dr. TANG, T. (FRIB/MSU); Dr. ANTHONY, A. (High Point University); Sr. TURI, N. (FRIB/MSU); Dr. ZAMORA, J. (FRIB); Dr. HUNT, C. (FRIB); Dr. TOLSTUKHIN, I. (Argonne National Laboratory (ANL)); Dr. BHATT, K. (Argonne National Laboratory (ANL)); BECEIRO-NOVO, S. (Universidade Da Coruña); Dr. HALL-SMITH, A. (ANL/UoY); Dr. WATWOOD, N. (ANL); Dr. AVILA, M. (ANL)

Presenter(s) : Sra. XIFRA GOYA, Georgina (USC (Universidade de Santiago de Compostela))

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