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Spectroscopy of the T=$\frac{3}{2}$, $A = 47$ and $A = 45$ Mirror Nuclei via One- and Two- Nucleon Knockout Reactions

S. Uthayakumaar[1], M. A. Bentley[1], E. C. Simpson[2], T. Haylett[1], R. Yajzey[1,3], S. M. Lenzi[4], W. Satula[5], D. Bazin[6,7], J. A. Belarge[6], P. C. Bender[6], P. J. Davies, B. A. Elman[6,7], A. Gade[6,7], H. Iwasaki[6,7], D. Kahl[8,9], N. Kobayashi[6], B. R. Longfellow[6,7], S. J. Lonsdale[8], E. M. Lunderberg[6,7], L. Morris[1], D. R. Napoli[10], T. G. Parry[11], X. Pereira-Lopez[1,12], F. Recchia[4,6], J. A. Tostevin[11], R. Wadsworth[1] and D. Weisshaar[6]

[1]Department of Physics, University of York, Heslington, York, YO10 5DD, United Kingdom, [2]Research School of Physics, The Australian National University, Canberra ACT 2600, Australia, [3]Department of Physics, Faculty of Science, Jazan University, Jazan 45142, Saudi Arabia, [4]Dipartimento di Fisica e Astronomia dell'Università and INFN, Sezione di Padova, I-35131 Padova, Italy, [5]Institute of Theoretical Physics, Faculty of Physics, University of Warsaw, ul. Pasteura 5, PL-02-093, Warsaw, Poland, [6]National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824, USA, [7]Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA, [8]School of Physics and Astronomy, University of Edinburgh, Edinburgh EH9 3FD, United Kingdom, [9]Extreme Light Infrastructure –Nuclear Physics, Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH), 077125 Bucharest-Măgurele, Romania, [10]INFN, Laboratori Nazionali di Legnaro, I-35020 Legnaro, Italy, [11]Department of Physics, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford, Surrey GU2 7XH, United Kingdom, [12]Center for Exotic Nuclear Studies, Institute for Basic Science (IBS), Daejeon 34126, Republic of Korea

The study of nuclei close to the N=Z line region on the nuclear chart provides a pathway to investigate proton-rich systems that are in proximity of the proton drip line. The phenomenon of isospin symmetry, which plays a key role when examining nuclei either side of the line of N=Z, occurs due to the exchange symmetry between protons and neutrons resulting from the near-identical nuclear force between the two types of nucleon. Isobaric analogue states can be compared to understand the various factors that could cause isospin symmetry to be violated [1]. To develop our understanding of isospin symmetry breaking effects, an in-beam gamma-ray spectroscopic study of the exotic proton-rich 47Mn and 45Cr systems was performed through one- and two-neutron knockout reactions from the radioactive 48Mn and 47Cr beams delivered by the NSCL facility, respectively. The analogue one- and two-proton knockout reactions from 48V to 47Ti (the mirror of 47Mn) and 47V to 45Sc (the mirror of 45Cr) were also performed.

This novel approach –i.e. 'mirrored'knockout reactions –allows for detailed comparison of both the analogue reaction processes (i.e. -1n, -2n and -1p, -2p from a pair of mirror nuclei, respectively) and of the subsequent level schemes of the resulting mirror pair products. Through comparison of the corresponding mirrored reactions, and by exploiting the direct nature of the process, a confident identification can be made of the states in the unknown proton-rich systems being studied –i.e. 47Mn and 45Cr in this case. This also allows the measurement of analogue spectroscopic cross sections, on a state-by-state basis, in these analogue knockout reactions. The measurement of such analogue reactions also has the capability to inform discussion about suppression of spectroscopic strength in knockout reactions –see ref [2].

The experiment was performed at the National Superconducting Cyclotron Facility (NSCL) with the radioactive beams selected by the A1900 fragment separator. The beams impinged onto a 9Be target to produce the pair of analogue nuclei, 47Mn/47Ti and 45Cr/45Sc. Prompt gamma-rays were detected by the state-of-the-art tracking array, GRETINA, with the resulting residues detected and identified using the S800 spectrometer.

The latest results from the analysis of 47Mn and 45Cr will be presented, including partial level schemes, a mirror-energy difference analysis and a comparison of the analogue reactions. The comparison of the results from shell-model calculations to a recently developed DFT approach [3] will also be presented.

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[2] J. A. Tostevin and A. Gade, Phys. Rev. C. 103, 054610(2021)
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Topic

Experiment

Author: UTHAYAKUMAAR, Sivahami (University of York)

Presenter: UTHAYAKUMAAR, Sivahami (University of York)

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