European Nuclear Physics Conference 2025

Report of Abstracts

https://indico.in2p3.fr/e/30430

Abstract ID : **232**

Study of ^{68}Ni by means of (d,p) and (p,d) transfer reactions

Content

The evolution of nuclear shell structure in exotic nuclei provides key insights into the fundamental nature of nuclear forces. In nuclei far from stability, conventional magic numbers can disappear, while new ones may emerge, a phenomenon known as shell evolution [1]. A well-known example is the evolution of the N=28 shell gap from ^{40}Ca to ^{48}Ca, which has been successfully explained by three-nucleon (3N) forces [2]. Similarly, the N=14 shell gap in oxygen isotopes shows a comparable trend [3]. These studies highlight the crucial role of many-body interactions in shaping shell structure. To extend our understanding to heavier nuclei, we investigate the evolution of the N=50 shell gap for which the isotopic chain of Ni would be the perfect candidate. An experiment was carried out at GANIL to study ^{68}Ni via (p,d) and (d,p) reactions, as this nucleus is the anchor point to determine the amplitude of the N=50 shell gap in ^{78}Ni, from relatively well known neutron-neutron effective interaction from experimental data. By performing neutron-adding and neutron-removing reactions in ^{68}Ni, we also get a unique access to the spectroscopic strengths and thus, the occupancy of the orbitals below and above N=40. This allows to characterize the magicity at N=40. Indeed, depending on whether a sharp occupancy drop is observed or not, the nucleus can be concluded to have either a magic or a superfluid nature [4]. Moreover, it is also planned to deduce the information on the $2p_{1/2}$ - $2p_{3/2}$, $1g_{7/2}$ - $1g_{9/2}$ and $1f_{5/2}$ - $1f_{7/2}$ spin-orbit splittings.

A primary beam of ^{70}Zn was bombarded on a thick Be target to produce a secondary beam of ^{68}Ni by fragmentation using the LISE spectrometer. With this secondary beam, ^{69}Ni and ^{67}Ni nuclei were populated in inverse kinematics using CD_2 and CH_2 as secondary targets in three separate channels: (1) ^{68}Ni (d,p) ^{69}Ni @ 18 MeV/u, (2) ^{68}Ni (d,t) ^{67}Ni @ 18 MeV/u and, (3) ^{68}Ni (p,d) ^{67}Ni @ 40 MeV/u. The detector setup consisted of two position sensitive gas detectors before target for beam tracking. The transfer-like products (^{67}Ni and ^{69}Ni) are tracked by means of Drift Chambers, and are identified using Ionization chambers and Plastic Scintillators which make the zero-degree detection (ZDD). The light particles produced in the forward direction transfer reactions {(p,d) or (d,t)} are detected by 4 highly segmented Si-CsI array MUST2 and in the backward direction {(d,p)} by another Si detector setup MUGAST to determine the energy loss and angles. A Ge-clover detector array EXOGAM2 is used to detect the in-flight and the isomeric-delayed gamma rays along with one detector at the end of the ZDD to detect the $9/2^+$ isomeric state populated from the ^{68}Ni (p,d) reaction.

Thanks to such a cover-it-all experimental setup and the selection of kinematics of the outgoing nuclei, the first analysis shows promising data and statistics. The triple coincidence gamma measurements obtained by gating at the light particles in MUST2/MUGAST, the transfer-like products in the ZDD, as well as the correlated gammas are allowing us very precise energy determinations. As is evident, this study addresses a variety of key features related to the understanding of nuclear forces. The analysis of (d,p) part is almost finished and that of (p,d) has been started in parallel. Both will be presented in this contribution.

References

[1] O. Sorlin and M.G. Porquet, Prog. Part. Nucl. Phys. 98, 602-673 (2008).

[2] J. D. Holt et al., J. Phys. G: Nucl. Part. Phys. 39, 085111 (2012).

[3] T. Otsuka et al., Phys. Rev. Lett. 105, 032501 (2010).

[4] O. Sorlin, S. Leenhardt, C. Donzaud, J. Duprat, F. Azaiez, et al., Phys. Rev. Lett. 88, 092501 (2002).

Author: Mr SHARMA, P. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France)

Co-authors: Dr AKTAS, Ö. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France); Dr KOYAMA, S. (RIKEN Nishina Center, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan); Dr SORLIN, O. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France); Dr BARRIÈRE, A. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France); Dr MATTA, A. (Laboratoire de Physique Corpusculaire de Caen, ENSICAEN CNRS/IN2P3, 14050 Caen, France); Dr REBEIRO, B. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France); Dr PAXMAN, C. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France); Dr BEAUMEL, D. (Institut de Physique Nucleaire Orsay, 15 Rue, Georges, Clemenceau 91400 Orsay, France); Dr CLÉMENT, E. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France); Dr DIDIERJEAN, F. (Institut Pluridisciplinaire Hubert Curien, CNRS/IN2P3 and Université de Strasbourg, Strasbourg, France); Dr GALTAROSSA, F. (INFN-LNS, Laboratori Nazionali del Sud, Catania, Italy); Dr ROTARU, F. ("Horia Hulubei"National Institute of Physics and Nuclear Engineering, RO-077125 Bucharest, Romania); Dr DE FRANCE, G. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France); Mr JACOB, H. (Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France); Dr THOMAS, J-C. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France); Ms DIENIS, L. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France); Dr ASSIÉ, M. (Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France); Dr MOUKADDAM, M. (IPHC, CNRS/IN2P3, Université de Strasbourg, 67037 Strasbourg, France); Dr STANOIU, M. (IFIN-HH, Post Office Box MG-6, Bucharest, Romania); Mr DÉLIGNAC, Q. (Laboratoire de Physique des 2 Infinis de Bordeaux, France); Dr BOTTONI, S. (INFN, Sezione di Milano, I-20133, Milano, Italy); Mr KUMAR, S. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France); Dr GIRARD-ALCINDOR, V. (Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France); Dr BLUMENFELD, Y. (Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France)

Presenter: Mr SHARMA, P. (Grand Accélérateur National d'Ions Lourds, CEA/DRF - CNRS/IN2P3, B. P. 55027, F-14076 Caen Cedex 5, France)

Track Classification: Nuclear Structure, Spectroscopy and Dynamics

Contribution Type: Oral Presentation

Submitted by **SHARMA, Prabhat** <prabhat.sharma@etu.unicaen.fr> on **Tuesday 1 April 2025**