AGATA Collaboration Meeting 2022

Friday, 10 June 2022 - Friday, 10 June 2022

Legnaro National Laboratory

Book of Abstracts

Contents

1

Report on the AGATA@GANIL experiment E793S

Authors: Charlie Paxman[1]; Adrien Matta[2]; Wilton Catford[1]

[1] *University of Surrey*

[2] *LPC Caen CNRS/IN2P3*

Corresponding Author: c.paxman@surrey.ac.uk

The region around the magic numbers $N = 28$ and $Z = 20$ is of great interest in nuclear structure physics. Moving away from the doubly-magic isotope ^{48}Ca, in the neutron-rich direction there is evidence of an emergent shell gap at $N = 34$ [1], and in the proton-deficient direction, the onset of shape deformation suggests a weakening of the $N = 28$ magic number [2]. The ^{47}K(d,p)^{48}K reaction is uniquely suited to investigating this region, as the ground state configuration of ^{47}K has an exotic proton structure, with an odd proton in the $\pi(1s_{1/2})$ orbital, below a fully occupied $\pi(0d_{3/2})$ orbital [3]. As such, the selective neutron transfer reaction (d,p) will preferentially populate states in ^{48}K arising from $\pi(1s_{1/2}) \otimes \nu(fp)$ cross-shell interactions. The implications of this extend both down the proton-deficient $N = 28$ isotonic chain, where these interactions are expected to dominate the structure of the exotic, short-lived ^{44}P nucleus [4], and across the neutron-rich region, where the relative energies of the $\nu(fp)$ orbitals is the driving force behind shell evolution.

The first experimental study of states arising from the interaction between $\pi(1s_{1/2})$ and the orbitals $\nu(1p_{3/2})$, $\nu(1p_{1/2})$ and $\nu(0f_{5/2})$ has been conducted, by way of the ^{47}K(d,p) reaction in inverse kinematics. A beam of radioactive ^{47}K ions was delivered by the GANIL-SPIRAL1+ facility, with a beam energy of 7.7 MeV/nucleon. This beam was estimated to be $> 99.99\%$ pure, with a typical intensity of 5×10^5 pps, and was impinged upon a 0.13 mg/cm^2 CD_2 target. The MUGAST+AGATA+VAMOS detection setup [5] allowed for triple coincidence gating, providing a great amount of selectivity. An analysis based both on excitation and gamma-ray energy measurements has revealed a number of previously unobserved states, and preliminary differential cross sections for the most strongly populated of these states will be presented.

[1] D. Steppenbeck *et al.*, Nature **502**, 207 (2013).
[2] O. Sorlin and M.-G. Porquet, Prog. Part. Nucl. Phys. **61**, 602 (2008).
[3] J. Papuga *et al.*, Phys. Rev. C, **90**, 034321 (2014).
[4] L. Gaudefroy, Phys. Rev. C **81**, 064329 (2010).
[5] M. Assié *et al.*, Nucl. Instrum. Methods A **1014**, 165743 (2021).

2

Report on AGATA@GANIL experiment E810_20 (ex-E766) ”Identification of exotic reaction channels in ^{238}U+^{238}U”

Authors: Dieter Ackermann[1]; for the E810_20 collaboration[None]

[1] *GANIL*

Corresponding Author: dieter.ackermann@ganil.fr

The aim of the experiment was to produce and identify neutron-rich nuclei in the uranium region by multi-Nucleon Transfer (MNT) aiming at a particle identification in atomic mass A by VAMOS and in atomic charge Z by x-ray detection (L and K radiation) in ID-fix, a set of three Low Energy Photon Spectrometers (LEPS), in the reaction ^{238}U+^{238}U at above-Coulomb barrier energies. The VAMOS setup was equipped with a new target chamber accommodating the three LEPS x-ray detectors and a second arm including the HARPEE particle detector. VAMOS was equipped with new MWPC detectors. AGATA was used to investigate the nuclear excitation structure of the detected nuclei as well as their K x-rays.

From May 20^{th} to 29^{th} 2021 a ^{238}U beam with 7.2 MeV/u and 6.765 MeV/u was used to irradiate a ^{238}U target. While the data taken at the higher energy is probably very limited and the probability to extract data for exotic reaction channels is low, the amount of data taken for the second energy should allow the investigation of isotopes with a production cross section down to ≈20 μbarn. The experiment suffered from various problems on the accelerator side which lead to a drastically reduced, accumulated beam dose, equivalent to ≈1.5 days at nominal beam intensity, as compared to the requested 7 days of beam on target.

Nevertheless, a proof-of-principle investigation should be possible and the presently ongoing data analysis will indicate possibilities for a continuation of the project either at VAMOS with an alternative γ-detection setup or possibly at LNL with the combination of AGATA+PRISMA.

The actual status of the data analysis will be presented.

3

Report on the AGATA experiment E806

Author: Yung Hee KIM[1]

Co-authors: Antoine Lemasson [2]; Alahari Navin [3]; Francois Didierjean [4]; Wolfram Korten [5]; ANDREY ANDREEV [6]; Dieter Ackermann [3]; Giacomo De Angelis [7]; Jérémie Dudouet [8]; Chloé Fougères [3]; Jeongsu Ha [7]; Rosa Maria Perez Vidal [7]; Diego Ramos [3]; Francesco Recchia [9]; Maurycy Rejmund [3]; Kseniia Rezynkina [7]; Gilles de FRANCE [3]; Yoshikazu Hirayama [10]; Sunchan Jeong [10]; Hiroari Miyatake [10]; Toshitaka Niwase [10]; Momo Mukai [10]; Marco Rosenbusch [11]; Peter Schury [11]; Seonho Choi [12]; Youngju Cho [13]; Yutaka Watanabe [10]; Sunghan Bae [14]; Kyungyuk Chae [15]; Kyung Mo Gu [15]; Chanhee Kim [15]; Minju Kim [15]; Joochun Park [14]; Sohyun Kim [15]; Yonghyun Son [12]; SARMISHTHA BHATTACHARYYA [16]; Gopal MUKHERJEE [16]; Ranbir Banik [16]; BHATTACHARYA Soumik [16]

[1] *Center for Exotic Nuclear Studies, Institute of Basic Science*

[2] *GANIL / CNRS*

[3] *GANIL*

[4] *IPHC - UNISTRA*

[5] *CEA-Saclay*

[6] *Univ. of York*

[7] *Istituto Nazionale di Fisica Nucleare*

[8] *IP2I*

[9] *University and INFN Padova*

[10] *KEK*

[11] *RIKEN*

[12] *Seoul National University*

[13] *Seounl National University*

[14] *IBS CENS*

[15] *Sungkyunkwan University*

[16] *VECC*

Corresponding Author: yunghee.kim@ibs.re.kr

The evolution of low-lying nuclear states of the neutron-rich nuclides near N=126 magicity in the south of 208Pb is important for studying the evolution of nuclear orbitals, interactions and understanding constraints to astrophysical r-process predictions. However, only limited knowledge of the excited states of these nuclei was available, owing to the difficulty in producing these nuclei using conventional methods. The recent multi-nucleon transfer reaction showed promising results with cross sections several orders of magnitude larger than those for fragmentation reactions.

The E806 experiment was carried out at GANIL to explore isotopes near N=126 shell closure using multi-nucleon transfer reactions. The beam of 136Xe (7MeV/u) and 198Pt target was used to populate nuclei of interest. VAMOS++ magnetic spectrometer and AGATA HPGe tracking array were used to measure projectile-like fragments and prompt gamma-rays from target-like fragments. Furthermore, several new experimental techniques were implemented in this experiment. First, a second arm, composed of a vacuum chamber and multi-wire proportional counter, was newly installed to measure the velocity vector of the target-like fragments. Second, four EXOGAM HPGe clover array was installed at the end of the second arm to measure the delayed gamma rays from the excited states of the produced nuclei. Finally, a new method to determine particle identification is under development using a machine learning algorithm. In this meeting, the preliminary result of the experiment, such as the proof of principle of the second arm and particle identification by machine learning, will be presented.

4

Title: Structure of 83As, 85As and 87As: from semi-magicity to gamma-softness

Authors: Kseniia Rezynkina[1]; Duc Dao[2]; Gilbert Duchêne[2]; Jérémie Dudouet[3]; Frédéric NOWACKI[4]; Emmanuel Clement[5]; Antoine Lemasson[6]

[1] *Istituto Nazionale di Fisica Nucleare*

[2] *IPHC-CNRS-UNISTRA*

[3] *IP2I*

[4] *IPHC Strasbourg*

[5] *GANIL*

[6] *GANIL / CNRS*

Corresponding Author: kseniia.rezynkina@pd.infn.it

The neutron-rich nuclei beyond Z=28 and N=50 shell closures present a rich variety of collective effects, such as shape coexistence found in 78Ni [1,2]. In germanium isotopes, an onset of triaxial deformation with filling of the s1/2 and d5/2 neutron orbitals has been reported [3-5]. One proton heavier, the arsenic (Z=33) nuclei are expected to manifest a similar structure, with the onset of collectivity beyond N=50. The quantification of deformation over the region of Ge, As and Se chains may be an important feature to connect with r-process nucleosynthesis scenarios, as these nuclei lie in the path of the r-process flow.

The exotic arsenic isotopes between 83As and 87As (N=50 to 54) were populated in the inverse-kinematic fusion-fission reaction 238U+9Be (6.2 MeV/u) in the experiment performed in GANIL. The AGATA array composed of 24 HPGe crystals was coupled to the VAMOS spectrometer placed at 28° to detect the most exotic light fragments, in order to study the isotopes beyond N=50 in the 78Ni region. The previously existing information about the level schemes of these exotic species is scares. In this talk the extended level schemes of 83As and 85As will be presented, along with the first suggested level scheme of 87As. The data are interpreted in terms of the state-of-the-art LSSM calculations, pseudo-SU3 symmetries and the beyond-mean-field calculations with the novel DNO-SM method. The comparison points to the prolate deformation of the 85As and 87As ground states and confirms the presence of triaxiality and gamma-softness in this region.

[1] R. Taniuchi et al., Nature 569, 53–58 (2019)
[2] F. Nowacki et al., Phys. Rev. Lett. 117, 272501 (2016)
[3] M. Lettmann et al., Phys. Rev. C 96, 011301 (R) (2017)
[4] M. Lebois et al., Phys. Rev. C 80, 044308 (2009)
[5] K. Sieja et al., Phys. Rev. C 88, 034327 (2013)

5

Report on the AGATA@GANIL experiment E664

Authors: Desislava Kalaydjieva[None]; Magda Zielinska[1]; Marco Siciliano[2]

Co-author: Jose' Javier Valiente Dobon [3]

[1] *CEA Saclay*

[2] *Argonne National Laboratory*

[3] *Istituto Nazionale di Fisica Nucleare*

Corresponding Author: desislava.kalaydjieva@cea.fr

The E664 experiment at GANIL aimed to investigate the nuclear structure in the Z~50 region through a measurement of lifetimes of excited states in ^{106,108}Sn using the Recoil Distance Doppler Shift (RDDS) method. The nuclei of interest were populated via multi-nucleon transfer reactions between a 770-MeV ^{106}Cd beam and a ^{92}Mo target. The emitted gamma rays were detected by the AGATA tracking array, while the complete identification of the reaction products was obtained with the VAMOS++ spectrometer. The main physics goals of this experiment were accomplished [1] while additionally a number of lifetimes in the $^{102-108}$Cd isotopes were measured using the same technique [2].

The excited states in ^{106}Cd were populated through inelastic scattering, and thanks to the position sensitivity of VAMOS++ the cross sections for this process could be analyzed as a function of the scattering angle. Since under the experimental conditions the Cline's safe distance criterion, which ensures a purely electromagnetic interaction between the collision partners, was not fulfilled, the nuclear interaction is expected to influence the cross-section distributions. This would *a priori* require a sophisticated analysis using a suitable model to include the nuclear interaction between the reaction partners. While certain global optical model potentials suitable for this beam-target combination exist, they would still require additional adjustments to elastic scattering data, which is not available for this particular case.

The possibility to circumvent such model-dependent analysis was explored by performing a Coulomb-excitation analysis, with the coupled-channel code GOSIA, of the data collected at the smallest scattering angles. The balance between Coulomb and nuclear interaction in the population of individual excited states was investigated by comparing the experimental -ray yields in the full scattering angle range with the predicted -ray yields, obtained with GOSIA.

This study demonstrates that such unsafe data, rarely analyzed, yet often collected as a by-product in various experiments that employ position-sensitive particle detectors, can be used to correctly evaluate the reduced transition probabilities between certain low-lying states. An evaluation of the effects of the nuclear interaction on the experimental data will be presented, including a comparison of the transitional E2 matrix elements obtained with two independent techniques, i.e. Coulomb excitation and the RDDS method.

[1] M. Siciliano et al, Phys. Lett. B 806 (2020) 135474
[2] M. Siciliano et al, Phys. Rev. C 104 (2021) 034320