Institut national de physique nucléaire et de physique des particules

COLLABORATION AGREEMENT

IN2P3 - COPIN

I. Identification of the laboratories	
Partner	COPIN
IN2P3 laboratories	**IJCLab**
Partner laboratories	HIL Warsaw

II. Identification of the collaboration	
Title of the collaboration	Exotic nuclear deformations studied at HIL and ALTO
Number of the collaboration	23-156
IN2P3 spokesperson	Jonathan WILSON
COPIN spokesperson	Kasia Hadynska-Klek
Scientific Domain	Nuclear Physics

Status of the collaboration	
Status	The collaboration is new for the period January 1st - December 31st, 2023

IV. New collaboration for 2023

IV.1 Proposed scientific program

Description

Exotic nuclear deformations studied at HIL and ALTO

J.N. Wilson (ALTO/IJC Lab, Orsay) and K. Hadynska-Klek (HIL Warsaw)

P. Napiorwoski, K. Wrozek-Lipska, M. Komorowska, K. Krutul-Bitowska (HIL Warsaw)

C. Hiver, G. Pasqualato, I. Matea, M. Lebois (ALTO/IJC Lab, Orsay)

We propose a new collaboration within the framework of COPIN to study exotic nuclear deformations in situations where a highly deformed second minimum in the nuclear potential energy can co-exist at zero spin alongside a ground state with much lower deformation. This occurs both in the region around doubly-magic 40Ca and in the shape isomers of the light-actinides.

Motivation

Highly collective rotational structures have now been identified in a few A~40 nuclei such as 40Ca [1], 36,38Ar [2,3,4] and 42Ca [5]. To date these

nuclei have been populated using fusion-evaporation reactions. However, studies using the Coulomb excitation technique offers some strong and unique advantages. For example, measurements of B(E2) values for the unobserved 2sd->0sd transition and determination of the 0+ band-head deformation can be carried out. The low-spin behaviour of these bands is distinctive as compared to SD bands in other mass regions. In the case of 40Ca the known B(E2) values have been deduced from lifetime measurements using the Doppler shift attenuation method. Our current experimental program provides an alternative and independent way of extracting these values. Another advantage of Coulomb excitation is to extract the relative signs of the interband transition matrix elements, which deliver an additional information on coupling of SD and yrast bands.

The most extreme form of nuclear shape co-existence in the nuclear chart can be found in the actinide region. It has been observed that these isomeric states decayed via spontaneous fission with half livers typically more than 25 orders of magnitude shorter than the nuclear ground state [6]. There is also a severe hindrance of the internal decay of these states via gamma emission and a strong selection rule is in operation due to the highly deformed shape of the isomeric state which sits in the middle of a double-humped fission barrier potential [7]. While the vast majority of earlier experiments have focused on shape isomer decay via fission, very little information has been gathered about their decay via gamma emission to the first minimum. This decay is predicted to dominate in the lower-mass actinides due to the inner barrier being lower than the outer barrier. To date, only one experiment has been performed using high a high efficiency Ge spectrometer [8]. Our goal is to gain valuable information on the excited states within the second minimum, K-isomerism, and the connecting transitions between first and second minima.

Scientific program for 2022/2023

Two upcoming experiments are scheduled at the ALTO facility of IJC Lab using the nu-Ball2/PARIS array and the Warsaw DSSSD to study 40Ca and $^{236}U^{m}$. In early 2022 intense efforts have been underway concerning the design, construction and mechnical integration of the Warsaw DSSSD chamber at the ALTO facility. Recent tests of the chamber have been successful and delivery is expected in november 2022.

In the medium term, development of 44Ti radioactive targets and beams is underway at ALTO for possible experiments over the coming years. This development was the subject of a joint Letter of Intent (LOI) at the last ALTO PAC in 2021. Currently, 10 MBq of 44Ti has been chemically separated at the Arronax cyclotron laboratory in Nantes and this material is now available at IJC Lab to make a first radioactive target for the ALTO facility. Furtheremore, future experiments in the experimental program are foreseen to be performed at HIL, such as the Coulomb excitation of 40Ar.

[1] E. Ideguchi et al. , Phys. Rev. Lett. 87, 222501 (2001)

[2] C. E. Svensson et al., Phys. Rev. Lett. 85, 2693 (2000)

[3] C. E. Svensson et al., Phys. Rev. C 63, 061301 (R) (2001)

[4] D. Rudolph at al., Phys. Rev. C 65, 034305 (2002)

[5] K.HadyÅ„ska-KlÄ™k, Acta Phys.Pol.B44, 617, (2013)

[6] S.M. Polikanov, et al., Soy. Phys. JETP 15 (1962) 1016.

[7] V.M. Strutinsky, NucI. Phys. A95 (1967) 420; Nucl. Phys. Al22 1 (1968)

[8] D. Pansegrau et al., Phys. Lett. B 484 1 (2000)

IV.2 Estimated duration for IN2P3 scientists in COPIN	
Total time requested for 2023	21
List of scientists	1. C. HIVER (7 days) 2. G. PASQUALATO (7 days) 3. J. WILSON (7 days)
IV.3 Estimated duration for COPIN scientists in France	

Total time requested for 2023	30
List of scientists	1. K. HADYNSKA-KLEK (7 days) 2. P. NAPIOROWSKI (6 days) 3. K. WROZEK-LIPSKA (6 days) 4. M. KOMOROWSKA (6 days) 5. K. KRUTUL-BITOWSKA (5 days)

Comment Validation	
Unity Director	Fadi IBRAHIM (IJCLab) - 2022-10-13 17:17:13