Institut national de physique nucléaire et de physique des particules

COLLABORATION AGREEMENT

IN2P3 - COPIN

I. Identification of the laboratories	
Partner	COPIN
IN2P3 laboratories	**IPHC**
Partner laboratories	Lublin (IPMCSU)

II. Identification of the collaboration	
Title of the collaboration	High-Symmetry point groups in nuclear structure and their experimental manifestations
Number of the collaboration	04-113
IN2P3 spokesperson	J. DUDEK
COPIN spokesperson	A. GOZDZ
Scientific Domain	Nuclear Physics

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

III. Status report for the period January 1st to December 31st, 2022

III.1 IN2P3 scientists in COPIN	
Total time approved for 2022	14
Total time used for 2022	14
List of scientists	1. J.Dudek (7 days) 2. B. Gall (7 days)

III.2 COPIN scientists in France	
Total time approved for 2022	14
Total time used for 2022	14
List of scientists	1. A.Gozdz (7 days) 2. A.Pedrak (7 days)

III.3 Scientific results of the above-mentioned collaboration	
Description	

As a realisation of the last year proposed study of the shape competition in multidimensional deformation spaces — and thus often involving several competing minima — we have performed calculations with the Graph Theory algorithm proposed by Dijkstra — thanks to the computer program developed for this purpose. We have analysed particularly rich shape competition cases, which arise in the 4D space of octupole degrees of freedom in certain Actinide nuclei in which special new octupole (so-called four fold i.e. occurring at all the four octupole deformations simultaneously) magic number N=136 appears. The latter aspect was discussed in our ref. [1], whereas the results related to the multiple trajectories connecting multiple minima in the deformation space will be soon submitted for publication.

Addressing the problem of multiple octupole shape minima characterised by various deformation components a_{3 mu} with mu=0,1,2, or 3 brings us to the problem of exotic symmetry minima and — what is strongly related — the issue of the experimental identification of such symmetries. We have invested in this problem in parallel during this year and elaborated the corresponding identification conditions using the group representation theory. The results were published for the case of octupole generated symmetries C_2v, D_2d, T_d and D_3h in ref. [1] and we believe that they will play an important role in the modern nuclear spectroscopy aiming at non-trivial new exotic symmetries.

Publications (October 2021 - October 2022)

1) J. Yang, J. Dudek, I. Dedes, A. Baran, D. Curien, A. Gaamouci, A. Gozdz, A. Pedrak, D. Rouvel, H. L. Wang, and J. Burkat;

Exotic shape symmetries around the fourfold octupole magic number N = 136:

Formulation of experimental identification criteria

PHYSICAL REVIEW C 105, 034348 (2022)

2) W. S. Porter, B. Ashrafkhani, J. Bergmann, C. Brown, T. Brunner, J. D. Cardona, D. Curien, I. Dedes, T. Dickel,

J. Dudek, E. Dunling, G. Gwinner, Z. Hockenbery, J. D. Holt, C. Hornung, C. Izzo, A. Jacobs, A. Javaji, B. Kootte,

G. Kripko-Koncz, E. M. Lykiardopoulou, T. Miyagi, I. Mukul, T. Murbock, W. R. Plaß, M. P. Reiter, J. Ringuette,

C. Scheidenberger, R. Silwal, C. Walls, H. L. Wang, Y. Wang, J. Yang, J. Dilling, and A. A. Kwiatkowski

Mapping the N = 40 island of inversion: Precision mass measurements of neutron-rich Fe isotopes

PHYSICAL REVIEW C 105, Letter, L041301 (2022)

3) J. Yang, J. Dudek, I. Dedes, A. Baran, D. Curien, A. Gaamouci, A. G o zd z, A. P edrak, D. Rouvel,

and H. L. Wang,

Exotic Symmetries as Stabilizing Factors for Super-Heavy Nuclei:

Symmetry Oriented Generalized Concept of Nuclear Magic Numbers

PHYSICAL REVIEW C, accepted

4) J. Yang, J. Dudek, I. Dedes, A. Baran, D. Curien, A. Gaamouci, A. G o zd z, A. P edrak, D. Rouvel,

and H. L. Wang,

Islands of Oblate Hyper-deformed and Super-deformed Super-heavy Nuclei with

D_3h Point Group Symmetry in Competition with Normal-deformed D3h States:

Archipelago of D_3h-Symmetry Islands

PHYSICAL REVIEW C, submitted

Conference Presentations (October 2021 - October 2022)

1) J. Yang,

Systematic Study of Exotic Nuclear Symmetries around 4-fold Octupole Magic Numbers in Actinides and Super-heavy Nuclei;

Invited talk,

28th Nuclear Physics Workshop, 2022, Kazimierz Dolny, Poland

2) J. Dudek

New Directions in Nuclear Spectroscopy: Research of Exotic Point-Group Symmetries

Invited talk,

Thirty Ninth International Workshop on Nuclear Theory, IWNT39-2022, Rila Mountains, Bulgaria

3) J. Dudek

From Exotic Symmetries to Isomers in Stable and Exotic Nuclei

Invited talk,

100 Years of Nuclear Isomers — EMMI Workshop, Berlin 2022

IV. Renewal of the collaboration for 2023

IV.1 Proposed scientific program

Description

The problem of the identification of the exotic point-group symmetries is gaining in actuality given the fact that the biggest nuclear physics world centres have in principle the instrumentation necessary to engage in the corresponding measurements and will be in position to deposit propositions of the relevant experiments. Whereas our publication [1] discusses in details the criteria of experimental verifications of the exotic symmetries, the problem of producing the corresponding realistic theoretical results/predictions remains open. Our group approach to the problem was realised on two fronts in the past.

— One way of proceeding was followed within the Fukuoka Strasbourg collaboration employing the density functional theory approach (spin-parity-particle number projected Hartree Fock with the Gogny effective interactions). This approach was very instructive and we obtained several important results using it — but for the realistic calculations aiming at detailed comparison band-to-band theory vs. experiment — it turned out not to

be optimal.

— Another way of proceeding was established earlier within our Lublin-Strasbourg collaboration. The corresponding approach is more phenomenological, based on the rotor-type Hamiltonian in which we combine the structure-less part quadratic in terms of the angular momentum operators with the higher order terms based on the group theory and modelling the desired symmetries in this way. We have already developed the corresponding computer codes which will need to be adapted to our present-day knowledge about the search of the rotational bands based on exotic symmetries. We intend performing now systematic analysis of rotational bands corresponding to all irreducible representations of the corresponding point groups — and combine them in terms of predictions facilitating experimental analysis and possible preparation of the new experimental proposals in collaboration with interested experimentalists colleagues.

IV.2 Estimated duration for IN2P3 scientists in COPIN	
Total time requested for 2023	14
List of scientists	1. J.Dudek (7 days) 2. D.Curien (7 days)
IV.3 Estimated duration for COPIN scientists in France	
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List of scientists	1. A.Gozdz (7 days) 2. A.Pedrak (7 days)

Comment Validation	
Unity Director	Sandrine COURTIN (IPHC) - 2022-10-13 20:00:09