THEORETICAL NUCLEAR PHYSICS (NUCLEAR STRUCTURE AND REACTIONS) IN IN2P3

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THE FRENCH LOW-ENERGY NUCLEAR PHYSICS THEORY COMMUNITY

The aim of this section is to give an overview of the current status and activities of the different actors (laboratories and researchers) working in the field as well as associated statistics. It has to be noted that some of the researchers counted here are also active in nuclear astrophysics teams. Only their work in nuclear structure and nuclear reactions will be reported here. In addition, only scientists working in IN2P3 laboratories are included in this report with a focus on the last five years activities.

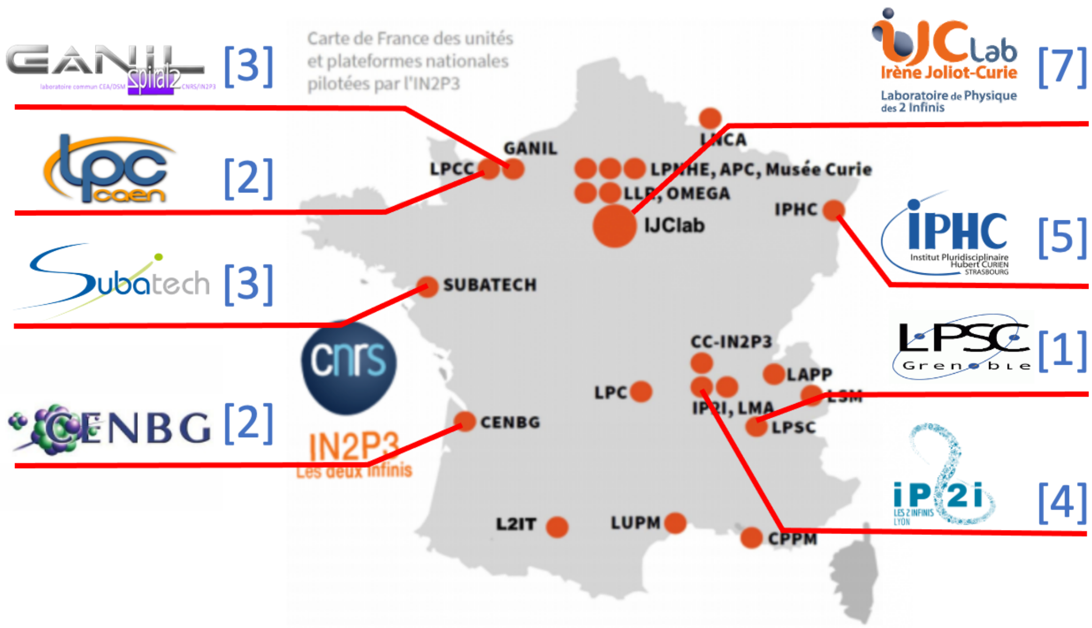

Fig. 1: List of IN2P3 laboratories where theorists work on nuclear structure and nuclear reactions. Numbers [X] indicate the number of permanent scientists (excluding Emeriti, PhD and Postdoc). The complete list of scientists is available in appendix A-1.

Summing up the manpower in different IN2P3 laboratories, there are 27 scientists working in nuclear structure and nuclear reactions (some working also in nuclear astrophysics, in interdisciplinary domains or having experimental activities). Among the 27 persons, 2 are employed by CEA at GANIL. Some statistical analyses regarding (a) the topics, (b) the type of positions, and (c) the age distribution are shown in Fig. 2.

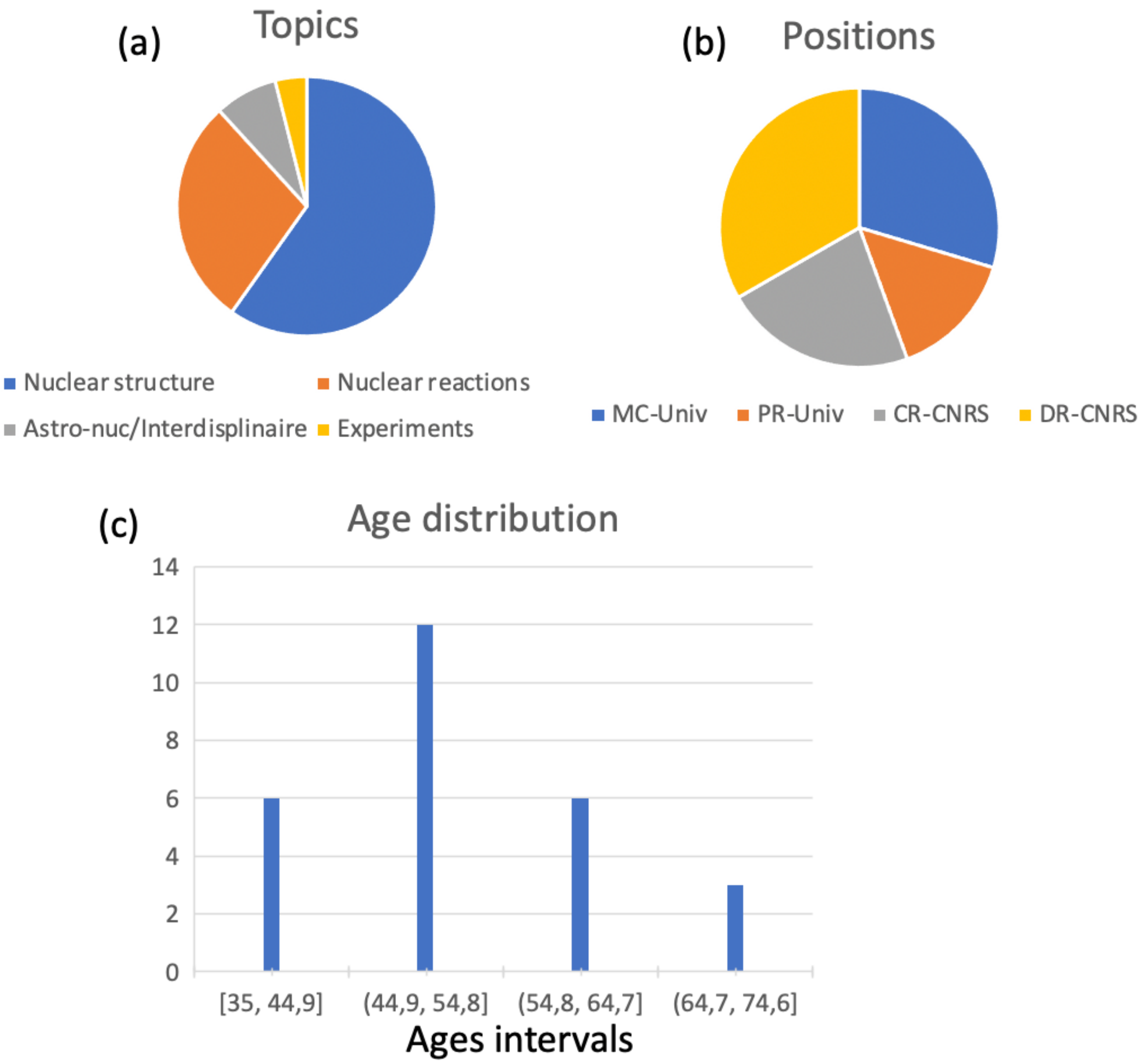

Fig. 2: Statistical details of the 27 scientists working on “nuclear structure and nuclear reactions” (a) repartition per topics, (b) Type of positions, and (c) Age distribution. Emeriti are not included, 2 scientists with age above 65 are employed by CEA but not retired.

SUMMARY OF THE SCIENTIFIC ACTIVITIES ON LOW ENERGY NUCLEAR PHYSICS AT IN2P3 (PERIOD 2016-2021)

BRIEF INTRODUCTION

The main objective of low-energy nuclear physics is to describe static, dynamical and thermodynamical properties of atomic nuclei starting from nucleonic degrees of freedom considered here as elementary building blocks. Protons and neutrons interact through the strong nuclear interaction. This interaction, with the presence of a strong repulsion at small relative distance between nucleons renders the nuclear many-body problem particularly complex to solve, due to its highly non-perturbative nature. A variety of approaches are being now developed by theorists working in IN2P3 laboratories. These approaches are more or less empirical depending on the ingredients that are used to formulate them. They also usually differ in the targeted phenomena they aim to describe. One can classify the theories developed in France approximately into two main groups: those that start from *effective interaction* adjusted specifically to reproduce certain nuclear properties, and those that start from the *bare interactions* between nucleons and try to solve exactly the nuclear many-body problem. The nuclear *energy density functional* (EDF) theory and *shell model* enter into the first class of approaches while the *ab-initio* methods refer to the second class. The main techniques and physics topics developed in each IN2P3 laboratory are listed in appendix A.

The range of applicability of different theories strongly depends on the technical aspects and on the associated numerical complexity. Ab-initio methods are extremely demanding in terms of computational resources and are usually applied to the study of nuclear structure and reactions in the light-nuclei sector. The shell model belongs to the class of configuration-interaction techniques and can be applied in the sector of light-mass to medium-mass nuclei. The EDF approach is technically simpler and offers a more versatile method leading to a unified description of nuclear structure and reactions as well as thermodynamical properties of nuclear system over the whole nuclear chart but the lightest nuclei.

In the last two decades, nuclear physics has been revolutionized by the emergence of novel, so-called “modern” bare interactions issued from QCD in the low-energy, highly non-perturbative chiral sector. This has not only given an impulse to ab-initio techniques but also opened new research avenues with the possible inclusion of three-body forces or the investigation of universal behaviors such as Efimov effect or scale invariance, to quote some of them. In recent years, we have also observed (i) an important effort by the scientists of IN2P3 to build bridges between ab-initio and other approaches. An example is use of techniques inspired by Effective-Field Theory in EDF to render them less empirical; (ii) the will to use new emergent technologies like machine-learning and quantum computing.

A brief overview of the research activities in nuclear theory within the IN2P3 laboratories is provided below.

THEORIES DEVELOPED AT IN2P3 FOR NUCLEAR STRUCTURE

MODERN NUCLEAR INTERACTIONS AND AB-INITIO METHODS

Nuclear theory is currently strongly impacted by the development of nuclear effective field theories (EFT) and ab-initio methods (AIMs) for the solution of the many-body Schrödinger equation. EFT allows for the systematic description of nuclear forces and currents consistently with the Standard Model of particle physics. Ab-initio methods take EFT forces and currents as inputs and calculate observables over a progressively increasing portion of the nuclear chart. Popular AIMs include Faddeev- Yakubovsky (FY) equations, the Hyperspherical Harmonics (HH) method, the Stochastic Variational Method (SVM), the No-Core Shell Model with Resonating Group Method (NCSM+RGM), Self-Consistent Green's Functions (SCGF), Quantum Monte Carlo (QMC), and various forms of many-body perturbation theory (MBPT). Theory groups of IN2P3 laboratories (IJCLab, CENBG, IPHC) are participating actively in these new developments by designing modern interactions and by improving ab-initio methods with the aim of extending their range of applicability. Some of these developments (for instance on MBPT and SCGF) are made in close collaboration with CEA-Saclay. Some of the futures developments in this field within IN2P3 will be:

- The development of modern EFT interactions will be pursued by making use of LECs (low-energy constants) adjusted on experiments or obtained from Lattice QCD calculation. The use of such interaction in AIM and the comparison with experimental data is a stringent test of these novel interactions.
- The very large neutron-neutron scattering length suggests that neutron systems are close to the unitary limit (infinite scattering length) leading to universality of some properties (scale invariance). The physics of systems close to unitarity has already been investigated at IJCLab. This direction and more generally the search of universal effects like Efimov physics will be further investigated.
- The IJCLab team has the expertise on NCSM+RGM techniques including consistently the influence of the three-nucleon force and applied to the few-body sector (A< 8). In the near future, a special attention will be paid to the treatment of resonant states with the NCSM+RGM with applications both in nuclear structure and in nuclear reactions involving light nuclei.
- Efforts were recently made by CENBG in collaboration with IJCLab to implement the modern pionless and chiral EFT in the NCSM. This effort will be continued with the aim to perform applications to heavier nuclei (A<40), to further improve this approach and to confront this state-of-the-art ab-initio technique with experimental observation.

More generally, the investigation of the consequences of these EFTs to nuclear properties with AIMs will be pursued in order to improve our understanding of the interaction and associated error estimates. The theory will be systematically tested against experiment and used for applications such as energy production, astrophysical reactions and nuclear tests of fundamental symmetries.

SHELL-MODEL

The shell-model approach is mainly developed in the IPHC and CENBG IN2P3 laboratories. The shell-model technique can be classified into traditional technique where a set of valence nucleons interacts within a set of shells. The effective interaction is specifically adjusted to reproduce some properties. This approach is specifically dedicated to the study of nuclear structure properties and associated decay processes with the advantage of properly accounting for all symmetries of the nuclear Hamiltonian. Shell-model provides usually rather predictive nuclear spectra with a range of application extending to medium mass nuclei.

The recent growth in computation performance and progress in effective interactions have motivated further extensions of the model to *more exotic nuclei and/or heavier nuclei*. Two main directions will be pursued: the description of exotic nuclei and the description of weak process.

Structure and decay of exotic nuclei

It makes already few decades that the nuclear structure community is focused on the very short-lived neutron-rich and proton-rich nuclei, produced and studied nowadays at various radioactive ion beam facilities around the world. The description of these nuclei remains a challenge for nuclear theory and the shell-model is one of the pioneers in the investigation of the newly discovered nuclei and prediction of not yet observed nuclei. At the current stage, the following developments are on the way:

- Large-scale calculations in extended model spaces comprising a few oscillator shells to deal with the changing shell structure and the onset of deformation in very neutron-rich nuclei;
- Development of the accurate description of isospin-symmetry breaking using charge-dependent Hamiltonians;
- Construction of fully microscopic interactions for valence-space calculations as a path towards regions where no experimental data are available;
- Development of numerical techniques and state-of-the-art computations;
- Search for additional guidelines and short-cuts using symmetry-based approaches to the nuclear many-body problem.
- An effort is continuously made and will be continued to introduced shell-model methods that properly treat resonances and more generally the effect of the continuum. To quote some of the technique, one can mention the Shell-Model in the continuum and more recently the Gamow Shell model (GANIL).

These developments will provide support to existing and future experimental campaigns at GANIL, ISOLDE, etc.

Weak-interaction processes and physics beyond the Standard Model

At present, many-body calculations for nuclear structure are needed to connect experimental particle physics probes and underlying fundamental theories beyond the Standard Model. In particular, the nuclear shell-model provides the best precision being thus a unique tool to provide nuclear matrix elements necessary for the tests of the symmetries in weak processes.

The efforts are invested mainly in two domains (i) Study of realistic Fermi matrix elements for beta decay between 0^+ states or between the mirror states in T=1/2 nuclei. (ii) Study of the very rare double-beta decay (2νββ and hypothetical 0νββ processes) serving as a probe of the nature of the neutrino and a mean to get the neutrino mass scale. In parallel to the shell-model study, connections with the interacting boson model developed at GANIL are being made.

NUCLEAR ENERGY DENSITY FUNCTIONAL THEORY

Following the pioneering work of Vautherin (IPN Orsay) and Gogny (CEA-DAM), the nuclear Energy Density Functional theory has a long history in France and, today, a large fraction of the nuclear theory community is involved in these activities. The EDF is the only framework able to treat the whole nuclear chart and can address a large variety of processes in nuclear structure, nuclear reactions and nuclear thermodynamics. The EDF is similar to the density functional theory (DFT) used in condensed matter and atomic physics. In this theory, the complex many-body problem is replaced by a simpler problem of independent particles (or quasiparticles to account for superfluidity). Still, by adjusting the parameters of the functional to the experimental observations, the approach has a very good predictive power for many aspects of nuclei. Functionals in nuclear physics are often constructed starting from effective interactions. The EDF theories are currently developed at IJCLab-Orsay, IP2I-Lyon, Subatech-Nantes, LPSC-Grenoble and CENBG-Bordeaux with close collaborations with CEA and CEA-DAM. In this section, we focus on formal and technical developments to describe nuclear structure and excitation spectra.

The EDF activity in France is currently articulated along the following lines (a) the development of new effective interactions and new density functionals; (b) the improvement of existing techniques and codes to describe nuclear structure and excitation spectra; (c) the development of the theory in the so-called “beyond mean-field” sector to improve the description of some properties such as symmetries of the nuclear Hamiltonian, low-energy spectra and/or collective excitations; (d) the description and understanding of many experimental observations. Achievements and future directions of these different aspects are summarized below.

Development of new effective interactions and new density functionals:

The development of EDFs in order to improve their predictive power represents a continuous effort of the French nuclear physics community. Difficulties in the formulation the EDF approach beyond mean-field [BMF] (like instabilities) and/or the EFT guidance have pointed out the necessity to provide a more robust framework for the EDF and, eventually, develop a constructive framework for the effective interaction rendering the EDF less empirical. Several directions have been explored:

- *Enriching the functional at the mean-field level:* the problem of symmetry restoration in EDF and finite-size instabilities has pointed out the necessity to (i) modify the fitting protocol in order to have instability-free functionals, (ii) avoid the appearance of density dependent terms if the functional is meant to be applied in configuration mixing. Many proposals have been made to enrich the functional by adding terms in a similar way as in the EFT case, or by exploring the possible non-locality of the functional and/or proposing new three-body interactions. These developments have been made in IP2I and IJCLab.
- *Tailoring functionals for beyond-mean-field approaches:* An alternative strategy consists in developing density functional that already includes many-body effects (like second-order terms in perturbation theory). This gives a constructive approach where parameters are directly adjusted at a given level of approximation, therefore accounting the BMF effects already in the functional. Another direction is to make use of subtraction procedures on the self-energy.
- *Bridging EDF with EFT/ab-initio*: a last direction is to use the recent progress in EFTs and ab-initio as a guidance for the EDF. This first includes the benchmark of EDF with ab-initio results in sectors that are not accessible experimentally. This has led also to design new functional theories guided by the low-density or unitary gas limit. Finally, an effort is now being pursued to define a proper power counting for the EDFs with a spirit close to the EFT.

The last two items are mainly developed in IJCLab.

Improvement of existing techniques and codes to describe nuclear structure and excitation spectra at the mean-field level:

In the last years, some specific efforts are being made to improve the existing model already at the mean-field level. Among the development we mention:

- The standardization and release of the Hartree-Fock (HF) and Hartree-Fock-Bogolyubov (HFB) codes written in space with the possibility to access wider deformations (IP2I). Besides the standardization, it is planned to perform optimization of the functional on a larger scale, i.e. on a wider set of nuclei.
- The development of the Finite-Amplitude-Method (FAM) for nuclear collective excitation: as an alternative to the RPA or/and QRPA, the FAM is anticipated to render possible the access to collective excitation of nuclei with various deformations. An effort is currently made at IJCLab to develop the FAM approach (collaboration with CEA-Saclay).
- Description of odd nuclei: the description of such nuclei within the EDF approach requires the treatment of time-odd terms and the breaking of time-reversal symmetry. Extension of existing codes are now being made. This will considerably extend the range of applicability of the approach. Works are in progress now at CENBG and IP2I.

- Description of clustering effects: a significant effort has been made to understand how clusters might in nuclei using the relativistic EDF approach in IJCLab. These studies will be pursued using constrained HF and HFB techniques.

Development of beyond mean-field approaches:

"Beyond Mean-Field" encompasses here all approaches that require more than a single trial many-body state and/or that overcome the leading order of the many-body Dyson equation. This includes methods like the Generator Coordinate Method (IP2I, IJClab) that goes beyond the HF and HFB by recoupling several trial states; the second RPA (IJCLab) that extends the standard RPA (seen as the small amplitude limit of time-dependent EDF); and the HTDA method that can be interpreted as a multiparticle-multihole (mp-mh) approach based on a variational technique (CENBG).

- *Variational mp-mh technique*: this technique, also called Highly-truncated diagonalization approach, allows one to go beyond the independent particle picture while treating some internal correlations in nuclei. Novel developments have been recently made at CENBG to include superfluid effects in spherical and deformed nuclei. Such approach can be used to predict the inertia parameters of low-energy modes such as 2^+ states.
- *Development of large-scale generator coordinates methods (GCM)*: this technique is a general method that consists in mixing several many-body states obtained at the mean-field level, each of them describing different accessible configurations in collective space. The collective space can correspond to different shapes of the nucleus or to a more abstract space such as the gauge space associated to the particle number conservation. This approach can be used both to restore symmetries that have been broken at the mean-field level (particle number, parity, total angular momentum) or to obtain the spectroscopic information of systems with mass A>16. It is mainly developed at IP2I and to a lesser extent at IJCLab. In the last decade important efforts have been made both on formal and technical aspects. To avoid some pathologies observed in GCM, specific effective interactions or regularization have been proposed that can cure approximately the observed problems. On the other hand, new numerical techniques have been developed to perform more systematically GCM calculations using state-of-the-art codes developed at the mean-field level. In particular, the new generation of GCM codes allows us to restore simultaneously several symmetries. This direction is of particular interest for experimental observation especially in the heavy and super-heavy sector where no other theories can be applied.
- *Development of second Random-Phase approximation*: The second RPA is an extension of the RPA that includes the coupling of the individual degrees of freedom to more complex internal degrees of freedoms. With this extension it is possible to improve the description of collective-excitation fragmentation and lifetimes. An

important progress was made recently by the IJCLab team by applying a subtraction method of the self-energy allowing for stable and controlled calculations. Applications are now being made on monopole, dipole and quadrupole excitations in nuclei giving interesting results and allowing for studying beyond-mean-field effects on excited states. This theory will now be further applied to nuclei from the lightest to the heaviest and extensions are being made to compute neutron matrix elements appearing in the expression of the neutrinoless double-beta decay half-life.

THEORIES DEVELOPED AT IN2P3 FOR NUCLEAR REACTIONS

The number of scientists involved in the description of nuclear reactions is lower than the one of scientists involved in nuclear structure or nuclear astrophysics. Maybe, as a consequence of this low number, several experimentalists close to phenomenology are now making simulations for nuclear reactions, especially around the Fermi energy. These scientists are counted in the present survey.

Several theories introduced above for nuclear structure are also developed and used to treat dynamical problems. One could in particular mention ab-initio theories (IJCLab and IPHC) to describe reactions involving very light systems and the time-dependent EDF approach (IJCLab) applicable to small and large amplitude collective motion in reactions with medium-mass and heavy nuclei.

AB-INITIO TREATMENT OF REACTIONS

Low-energy nuclear reactions involving light nuclei are sensitive probes of the bare nuclear force (two-body and there-body). Ab-initio reactions model, like the NCSM+RGM (IJCLab) discussed above, can describe both the low-energy continuum of exotic nuclei and nuclear reactions. This model is able to treat exactly the A-body problem in the continuum with the nuclear interaction as the only input, and remains reasonably accurate for restricted model spaces as the dimensionality of the many-body problem grows. The greatest challenge today is to tackle p- to sd-shell nuclei. This tool will be crucial for refining our understanding of nuclear forces and for bringing theoretical support to experiments with calculations for light-to-medium-mass exotic nuclei. Prototype examples of past and ongoing works are the study of the lightest halo nucleus ^{6}He and the description of the ^{2}H(^{3}H,n)^{4}He transfer reaction, that plays a major role in Big Bang nucleosynthesis and in fusion energy generation. Among the future developments, we mention: a complete study of the ^{6}He halo nucleus with (i) the clarification of the three-body interaction; (ii) the study of the beta-delayed deuteron emission of ^{6}He, and (iii) ^{4}He(2n,γ)^{6}He for r-process. The description of breakup for nuclei with A>3 will be addressed with the aim to study the 3N force in the final state-interaction.

TIME-DEPENDENT DENSITY FUNCTIONAL THEORY

The development of transport theories including correlations beyond the independent particle or quasi- particle picture will be actively pursued (IJCLab, Subatech). At low energies, the time-dependent density functional theory (TDDFT) methods, developed at IJCLab, have reached nowadays a certain maturity in the nuclear context and can describe a large variety of phenomena in a common framework. Thanks to the increase of computational resources, such approaches can nowadays be applied in full three dimensions with complete realistic effective interaction equivalent to those used in state-of-the-art nuclear structure studies. The extension to include initial quantum fluctuations has been applied to describe experimental spectra of spontaneous fission. More generally, these techniques have been applied to describe collective excitations, deep inelastic and fusion.

Recently, several methods were introduced to go beyond the independent particle picture by considering several many-body states. Among the proposed methods, one could mention for example the GCM applied along an adiabatic potential-energy landscape or the Stochastic Mean-Field (SMF) that follows independent non-adiabatic trajectories. The future developments along these line will be (i) the standardization of TDDFT solvers; (ii) the development of Multi-Configuration TDHF (MC-TDHF) and MC-TDHFB approaches that will describe the coupling of several non-adiabatic mean-field trajectories. Both investigations will be made in close collaboration with the CEA-DAM

At higher beam energies close to the Fermi energy, direct nucleon-nucleon collisions become less suppressed by Pauli blocking. Semi-classical transport models to describe both the dissipation induced by in-medium collisions and the associated fluctuations are currently being implemented at IJCLab and Subatech, with the aim to describe multi-fragmentation processes and, more generally, dissipative reactions. In addition, phenomenological models are developed at LPC-Caen. An effort is currently made to introduce quantum effects with the goal to describe lower beam energies with a special focus on predictive observables. The formalism and associated numerical tools aim at providing a new strategic simulation framework to cover the incident-energy range of new experimental facilities, from low to intermediate energies, with a special focus on predictive observables. At variance to present antisymmetrized-molecular-dynamics approaches, the planned project will add a complementary description of clustering based on an extended one-body theory and better suited to relate to collective properties and transport mechanisms. This activity is made in close collaboration with experimental groups.

USE OF NEW TECHNOLOGIES: QUANTUM COMPUTING AND MACHINE LEARNING

In recent years, new technologies are emerging, such as machine learning and quantum computing, that can become rapidly disruptive technologies for the nuclear many-body problem. Both technologies are currently starting to be used for specific problems occurring in nuclear physics. First steps in the use of machine learning have been initiated in the EDF context as an accelerator of calculations for massive production of theoretical results for the whole nuclear chart at IJCLab. It is anticipated that the use of machine learning will be reinforced in the future. An example of applications can be related to the meta-modeling in the nuclear enery-density-functional theory. Another application is the use of search/data mining algorithms to reduce the Hilbert space for the nuclear many-body problem.

Independently, at IJCLab, efforts are being made on the quantum computing side to formulate the many-body nuclear problem on quantum machines. This includes the preparation of Hartree-Fock and Hartree-Fock Bogolyubov states, the propagation of complex quantum systems and the study of error effects and their correction which are inherent to the quantum processor units. This activity will be pursued in the future with the aim to develop new methods to solve the ab-initio and the nuclear EDF problem. The French nuclear physics community is proactive in developing quantum technologies applications for nuclear systems with the aim to (i) prepare of the quantum computing transition; (ii) use of quantum computing to simulate complex quantum systems, and (iii) use of quantum machine learning.

SCIENTIFIC PRODUCTION

To prepare the present document, a survey of the different publications has been made in the last 5 years (2016-2021):

- Regular articles published in international journals with review: 370
- Article published as Letters (mainly Physical Review Letter and Physics Letters B) or Natures article: 65
- Review articles: 14
- Number of other publications (including proceedings): 78

A list of highlights (letters and review articles) in the last 5 years is given in appendix B. A selection of highlights will be presented during the CS IN2P3 session.

We also collected the information on invitations in workshop and international conferences:

- Number of invited talks: 244
- Other talks: 102

We mention that each group has numerous national and international collaborations (listed by countries in appendix A).

EXCHANGE WITH EXPERIMENTAL GROUPS

The theory nuclear physics community has regular exchange with experimentalist. As a result of these exchanges, we can mention:

- In the last 5-year period, around 100 articles were co-signed with experimental group
- Theorists often provide reference calculations for experimental programs. As a result, theorists are involved in many experimental proposals or Letters of Intent (LoI), that are submitted to nuclear physics facilities (GANIL-SPIRAL2, ALTO, NSCL, FRIB, …)
- Nuclear theory was also very active in the Nuclear Physics IN2P3 prospective that are currently in progress.
- The participation to European projects with experimentalists (such as for instance the ENSAR2 project) is important.
- Finally, theoreticians are also members of program advisories committees in different facilities (GANIL, ALTO, Jyväskylä Accelerator Laboratory)

It is also important to mention that many topics of past, current, and future experimental programs are strongly supported and guided by the theory community in France. To quote some examples:

- Nuclear structure effects: spin-orbit and tensor effects, appearance of bubble nuclei, continuum effects and disappearance of magic numbers, neutron-proton pairing…
- Nuclear deformation: shape coexistence and related spectroscopic effects, tetrahedral shapes, onset of clustering…
- Nuclear collective excitations with the search of new exotic modes.
- Nuclear fission: fission barrier, fission dynamics and dissipation.
- (Multi) Fragmentation process: development of instabilities, description of phase-transitions.
- …

TRAINING AND RESEARCH MANAGEMENT

IN2P3 theorists contribute to the training of young scientists by giving lectures at university and at international schools and by supervising PhD students and post-doc. In the last five years, 23 PhD students have made or are currently making a PhD thesis in nuclear theory, in France. In addition, 16 Postdocs have been hosted by our groups. A complete list is given in Appendix A for each laboratory.

Besides the training aspects, theorists of IN2P3 are members of many national and international committees. At the national level, this includes the participation to specific IN2P3 aspects as “Chargé de mission”, as well as strong implication in CNRS/Universities committees (like scientific committees). At the international level, nuclear theoreticians are spokesperson of several international collaboration agreements (LIA, IN2P3 agreements) as well as members of board of international conference center like ECT* or spokesperson of ENSAR2 Joint Research Activity (TheoS), to quote some of them. Again, a more complete list can be found lab by lab in appendix A.

DISCUSSION ON THE “ATELIER DES DEUX INFINIS”-7-8

On June 7-8, the French theory community working in the physics of the two infinities (particles physics, hadronic physics, cosmology, astroparticle, nuclear physics and nuclear astrophysics) has attended a common meeting (online). Most of the IN2P3 domains were covered (see the atelier website for the complete program). Overall, there were 127 registered participants, mainly from French laboratories including non-IN2P3 scientists working in France (INP, CEA, CEA-DAM, …). Here, as requested by the Scientific Council, I give a short feedback on the “nuclear structure and nuclear reactions” session.

The motivation of the session was to make an overview of current work in the field and, in particular, of futures developments and prospective. A call of contributions was made. For the nuclear physics session there were 11 contributions that were representatives of the field (around 30 contributors for the 11 contributions). The total duration of the session dedicated to low energy nuclear physics was 2h. Because of the limited time, some of the contributions were grouped together for the oral presentation. Finally, the program of the session was organized with two types of talks: long talks (20’) presenting specific many-body technique and short talks (5’). The motivation of the short talks was to highlight some emerging fields or more transversal aspects that might be of interest for other communities. A snapshot of the program is given below:

Ab-initio methods and progress in bare interactions	*Guillaume Hupin*	11:15 - 11:33
Configuration Interaction methods for nuclear structure and reactions	*Kamila Sieja*	11:33 - 11:51
Modern energy-density functionals and effective interactions	*Marcella Grasso*	11:51 - 12:09
Mean-Field and Beyond Mean-Field approaches for nuclear structure	*Michael Bender*	12:09 - 12:27
Nuclear dynamics with nuclear density functional theory	*David Regnier*	12:27 - 12:45
Towards description of light antiprotonic atoms (in relation with PUMA experiment)	*Rimantas Lazauskas*	12:45 - 12:50
Nuclear physics for neutrinoless double beta decay	*Frederic NOWACKI*	12:50 - 12:55
The Unitarity Limit and Universality	*Ubirajara van Kolck*	12:55 - 13:00
Quantum computing of atomic nuclei	*Denis LACROIX*	13:00 - 13:05
Final Discussion of the session		13:05 - 13:15

The presentations were of very good level and accessible to a general audience giving, at the same time, a fair description of the current and future directions. Although most of the time was allocated to presentations, few specific aspects were addressed during the session and also in the final discussion session of the workshop. During the discussion, the following points were for example raised: the possibility to use lattice QCD inputs in low-energy constants for the nuclear physics problem; the position of the French community with respect to the understanding of short-range correlations in nuclei; the standardization of numerical tools (codes) as well as the possible sharing of codes with specific methods (ex: hydrodynamical models); the use of nuclear physics inputs for nuclear astrophysics problem and, related to this, the predictive power versus the ability to extrapolate results to unexplored regions. More technical aspects were also discussed during the presentations.

Overall, the nuclear physics theory community has responded very positively to this prospective exercise and the coordination of the different talks worked very well. A fair picture of the current status of the "nuclear structure and reactions" activities in France has been given during the workshop.

APPENDICES

The Appendix A presents a list of more specific information on theory group for each IN2P3 laboratory. The appendix B presents the list of article published as letters or review articles in the last 5 years.

APPENDIX A: SOME DETAILLED INFORMATION ON LABORATORIES

A-1 SOME COLLECTED SPECIFIC INFORMATION ON SCIENTISTS WORKING IN THE TOPIC IN IN2P3 LABS-AND MAIN TOPICS DEVELOPED IN EACH LABS

Acronymes

MC: Maître de conférence, PR : Professor, CR : Chargé de Recherche, DR : Directeur de Recherche

EDF: energy density functional; EFT: effective field theory, IBM: Interacting Boson model

The numbers below correspond to the last 5 years. The present numbers are the information provided by different laboratories. If some information is missing, sometimes it is due to the fact that there were not provided. Laboratories are shown in alphabetic order.

CENBG-BORDEAUX:

Main Topics developed: EDF, Shell Model, Use of Modern Interaction, Fission models

Members*:* Bonneau Ludovic [MC], Smirnova Nadezda [MC]

PhD-Students: (last 5 years)

- Latsamy Xayavong, “Calculs théoriques de corrections nucléaires aux taux de transitions beta super-permises pour les tests du Modèle Standard“, Oct. 2013 - Dec. 2016
- Dao Duy Duc, “Hartree-Fock approximation for deformed nuclei with a general two-nucleon potential and pairing correlations with a consistent residual interaction“, Nov. 2016 – Nov. 2019
- Zhen Li, “Nuclear shell model and applications “, Nov. 2020 - Now

Postdocs: (in the last 5 years)

- Mario Sanchez Sanchez, Chiral EFT (Oct. 2018 – Dec. 2020)

Granted projects:
Master project IN2P3: Nadezda Smirnova, ENFIA (Exotic Nuclei, Fundamental Interactions and Astrophysics); *PHC RILA du Ministère des Affaires Etrangères* : Ludovic Bonneau, ISOMER, 4 people in France + 2 people in Bulgaria.

Teaching activities:
For each teacher-researcher of the group, about 200 h of teaching per year from BSc to MSc.

National collaboration: IPHC, GANIL, IJCLab
International collaborations: Bulgaria, Algeria, Vietnam, Russia, Laos, China, USA, South Korea
Participation to committees and research administration: *(not provided)*

GANIL-CAEN:

Main Topics developed: Shell Model with continuum, IBM model, Macrosocpic Fission model

Members: David Boilley (MC), Piet Van Isacker (CEA), Marek Płoszajczak (CEA)

PhD-Students: (last 5 years)

- Alexis Mercenne, "Nuclear reactions in the Gamow shell model and solutions of the pairing Hamiltonian based on the rational Gaudin model" (2013-2016)
- Bartholomé Cauchois, « Uncertainty analysis: Towards more accurate predictions for the synthesis of superheavy nuclei », (2015-2018)
- Jose Pablo Linares, « Systematic studies of continuum-coupling correlations in the vicinity of the particle emission threshold", (2020-)

Postdocs: (in the last 5 years)

- Panagiotis Georgoudis "geometric collective model, interacting boson model, conformal symmetry in nuclear physics", (2017-2018, and 2018-2021)
- Guoxiang Dong: radiative capture reactions in the framework of the Gamow shell model. (2015-2016)

Granted projects:

Teaching activities:
-For each teacher-researcher of the group, about 200 h of teaching per year from BSc to MSc.
-Lectures at summer schools: ICTP (Trieste, twice) & SERB (Uttar Pradesh)

National collaboration: CEA-DAM
International collaborations: China, Japan, Germany, Poland, USA, Israel, Italy, Scotland, Spain
Participation to committees and research managdement: *(not provided)*

National: Member of the editorial committee of the Presses universitaires de Caen, since 2020, Commission de la recherche et conseil académique de l'université de Caen – Normandie ; Représentant du GANIL à l'école doctorale PSIME de Normandie université, Commission des relations internationales de l'université de Caen Normandie ; Conseil scientifique de la Zone Atelier Territoires Uranifères (ZATU)

*International: Selection committee of the Erasmus Mundus Joint Master Degree in nuclear physics; Science and Technology Facilities Council (SFTC), United Kingdom; Expert Panel Science and Technology 2, FWO, Belgium; MP was the Director, French-U.S. Theory Institute for Physics with Exotic Nuclei (FUSTIPEN), GANIL, Caen, France***.**

IJCLAB-ORSAY:

Remarks: after the creation of the IJCLab, the historical IPN Orsay group split into two parts. One part (Phynet team) [4 permanent members] is integrated in the "Pole nucléaire" and one part is in the "Pole Theory" [3 permanents members].

Main Topics developed: EDF, Ab-initio methods, EFT and NN interaction, transport theories

Members*:* Grasso Marcella [DR], Guillaume Hupin [CR], Elias Khan [PR], Denis Lacroix [DR], Paolo Napolitani [CR], Michael Urban [CRCN], Ubirajara van Kolck [DR]
Emeritus: Jaume Carbonell, Nguyen Van Giai, Peter Schuck, Niel Rowley

PhD-Students: (last 5 years) – Note that thesis related to nuclear astrophysics are excluded

- Olivier Vasseur, «Extended SRPA with a correlated ground state», [2016-2019]
- Geoffrey Zietek, cotutelle avec N. Pillet CEA DAM, «Rôle de la force tenseur dans les approches effectives, application aux noyaux impair-impair N=Z et à la fission nucléaire», [jan 2021-2024]
- Thomas Czuba, «Méthode dynamique au-delà du champ moyen», financement Univ. P-Saclay, [2019-2022]
- Florian Mercier , «Description relativiste de la structure nucléaire et des radioactivités», [2019-2022]
- Andrès Ruiz-Guzman, «Ordinateurs quantiques appliqués aux noyaux» [2020-2023]
- Yann Beaujeault-Taudière, «Étude des excitations multipolaires dans les noyaux déformés et superfluides via la méthode des amplitudes finies», [2018-2021]
- Kilian Fraboulet, «Méthode de Théorie des champs appliquées à la physique nucléaire», [2018-2021]
- Antoine Boulet «Density functional theory for fermi systems with lage s-wave scattering length» [2016-2019]
- Julien Ripoche «Projected Bogoliubov Many-Body Perturbation Theory: Overcoming formal and technical challenges» [2016-2019]
- R. Lasseri [2015-2018], «Distribution spatiale de fermions fortement corrélés en interaction forte : formalisme, méthodes et phénoménologie en structure nucléaire»
- P. Marevic [2015-2018], «Towards a unified description of quantum liquid and cluster states in atomic nuclei within the relativistic energy density functional framework»
- Mario Sanchez Sanchez, "Effective field theories of strong-interacting systems in nucleon scattering and heavy-quark bound states", Oct 2014-Nov 2017
- Hung Viet Dinh, "Dynamique de formation et évolution des agrégats dans le milieu nucléaire", Oct 2019-present
- Yang Xiao, "Two-Nucleon Force in Chiral Effective Field Theory", Oct 2019-present

Postdocs: (in the last 5 years)

- Betzalel Bazak, contact effective field theories in nuclear and atomic physics, Oct 2015-Sep 2017
- C.J. Yang, «Bridges between density functional theories and effective field theories» (2014-2017)
- J. Bonnard, neutron drop calculations for testing density-functionals tailored for low-density neutron matter (2016-2018)
- S. Burrello, power counting in the energy density functional (2019- feb 2021)
- D. Regnier, «developement d'approches microscopique dynamique » (2018-2019)
- E. Ydrefors, "Protonium annihilation densities in a unitary coupled channel model"(2017-2019)

Granted projects:

Participation or coordinators to the master projects IN2P3: BRIDGES (Bridging Nuclear Ab Initio and Energy Density Functional Theories); ACMES (Au-delà du Champ Moyen Etendu); ENFIA (Exotic Nuclei, Fundamental Interactions and Astrophysics); MAAN (theory for the PUMA experiment).

PI of International collaboration agreements and or LIA (Laboratoire International Associés): agreements with Dubna, Coordinators of the LIA with Italy, China and Brasil. CEFIPRA (France-India) collaborative research project.

80PRIME Grant on quantum computing (2020-2021); PI of the QC2I project (Quantum computing of the two infinities); GENCI HPC grants.

European project: TheoS JRA / ENSAR2 project; participation to the STRONG 2020 project.

Teaching activities:

For each teacher-researcher of the group, about 200 h of teaching per year from BSc to MSc; Teaching "Nuclear Reactions" Master 2; teaching to several international schools.

Editorial activities: Editor of Int. J. Mod. Phys. E, Few-Body Systems, special issue Frontiers in Physics, Member of Editorial Board, Phys. Rev. C

National collaboration: Subatech, LUTH, LPC-Caen, IP2I, CEA-Saclay, CEA-DAM, IPHC, Atos, Lip6 Sorbonne

International collaborations: China, USA, India, Italy, Japan, Russia, Spain, Tunisia, Turquey, Brasil,

Participation to committees and research manadgement: *(not provided)*

National:

- Chargée de mission théorie et phénomenologie, IN2P3 (2019-
- Scientific Council, LPC Caen, France (2017-)
- Director of the Research Department, IPN Orsay, France (2016-2018)
- PAC ALTO, IPN Orsay, France (-2017)
- Co-responsable du GT1 du GDR resanet.
- membre du conseil scientifique de la graduate school internationale QMat (Université de Strasbourg)
- Président du département de physique de la faculté des sciences d'Orsay (200 EC)
- Membre comité de sélection Université de Strasbourg
- membre du conseil scientifique de l'IP2I
- membre fondateur et directeur de l'école doctorale PHENIICS (180 PhD)
- Membre du CS de l'ESNT Saclay
- Membre du CS de l'IPHC Strasbourg
- Responsable du projet QC2I [2021-]
- 2020 : rapporteur pour le CSTD du DPhN (Irfu)
- Chargé de mission relations internationales et communication, IPN Orsay, July 2012-Dec 2016.
- Member of the evaluation committee for the Institut de Physique de Nice, HCERES, winter 2016/2017.
- Co-coordinator of the Working Group GT3, GDR RESANET, CNRS, 2018-present.
- Member of Scientific and Technical Council of DPhN, CEA, 2020.

International :

- Chair of the Scientific Board, ECT* Trento, Italy
- IN2P3 French-Italian 'Laboratoire International Associé' LIA COLL-AGAIN (-2018) and IRP COLL-AGAIN (2019-2020) (many participants in both countries)
- co-convener européen pour « Nuclear structure and dynamics » du Long Range Plan 2017 de NuPECC
- Membre du PAC ALTO
- Membre du PAC GANIL.
- Scientific leader du JRA Theos – ENSAR2.
- Steering committee du NA NUSPRASEN –ENSAR2
- Member of the National Advisory Committee, Institute for Nuclear Theory (INT-Seattle)2014-2017.
- Member of the Scientific Board, ECT*, Trento (Italy), July 2014-June 2018.
- Member of the Feshbach Prize selection committee, American Physical Society, Summer 2020.
- Member of about 1 organizing committee/year, various international workshops and conferences.
- Member of about 1 international advisory committee/year, various international conferences.
- Reviewers for various international funding agencies.

IPIP2I LYON

Main Topics developed: EDF, Configuration mixing

Members*:* Bender Michael (DR), Bennaceur Karim (MC), Davesne Dany (PR), Margueron Jérôme (DR)
Emeritus: Meyer Jacques (PR emeritus)

PhD-Students: (last 5 years)

- Baillot Nicolas (2015-2018): Equation d'état de la matière à densité supranucléaire et application à l'émission thermique des étoiles compactes.
- Batail Lysandra (oct. 2019 -)

- Becker Pierre (oct. 2014 – sept. 2017): Développement d'une interaction nucléaire effective de nouvelle génération.
- Da Costa Philippe (oct. 2019 -): Interaction à trois corps semi-régularisée pour les calculs de champ moyen.
- Proust Paul (oct. 2020 -): Construction d'une interaction nucléaire effective généralisée et applications à l'astrophysique et aux noyaux lourds.
- Somasundaram Rahul (2019-).
- Zhao Qiang (2015-2018).

Postdocs: (in the last 5 years)

- Ryssens Wouter (nov. 2016 – août 2018): Beyond-mean-field studies of spectroscopic properties of even-even, odd and odd-odd nuclei.
- Baillot Nicolas (2018-2019).
- Grams Guilherme (2019-2021).

Granted projects:
ANR "NEWFUN" " New Energy Functional for Heavy Nuclei"

Teaching activities:
For each teacher-researcher of the group, about 200 h of teaching per year from BSc to MSc+40h teaching at the Ecole Nationale d'Architecture de Lyon.

National collaboration: CEA-Saclay, IJClab
International collaborations: York, Jyvaskyla, Brasil
Participation to committees and research manadgement: *(not provided)*

National:

- Directeur du GDR Resanet
- Membre de Conseil Académique et de la Commission Recherche de l'université Lyon
- Président du Conseil Scientifique de L'Espace de Structure et de réactions Nucléaires Théorique (ESNT), Saclay
- Co-coordinateur du GT2 du GdR RESANET de l'IN2P3
- Membre élu du Conseil d'Unité de l'IP2I
- Membre de la commission 01 du CNRS

International

- Membre du Programme Advisory Committee du Jyväskylä Accelerator Laboratory, Finlande (M. Bender, 2016-2019).

IPHC STRASBOURG

Main Topics developed:

Members*:* Dufour Marianne (MC), Lazauskas Rimantas (CR), Molique Hervé (MC), Nowacki Frédéric (DR) Sieja Kamila (CR)
Emeritus: Bartel Johann, Dudek Jerzy

PhD-Students: (last 5 years)

- Bouthong Bounseng, “Calculs microscopiques pour les noyaux exotiques de masse moyenne et lourde”, Thèse Université Strasbourg, Sept. 2013- Juin 2016
- M. Valdes, “Calcul de sections efficaces du système à trois corps (e^-e−, e^+e+, \bar{p}p¯) avec les équations de Faddeev-Merkuriev”, Thèse Université de Strasbourg, Sept. 2014- Sept. 2017 ; report number tel-01729000
- Irene DEDES, *Approche stochastique du problème du pouvoir prédictif dans la modélisation du champ moyen* (September 2014 – defended September 2017)

Postdocs: (in the last 5 years)

- Hua Lei WANG, Optimization of algorithms for calculating total potential energies in multidimensional deformation spaces, (September 2018 – September 2019), financed by his university of origin in China
- Duc Duy Dao (12/2019-01-2022): Beyond Mean-Field techniques for shell-model description of nuclear structure
- David Rouvel (depuis 2014 , convention rectorat Strasbourg)

Granted projects:
National:
IN2P3 Master projects: NRULN 2017-2020, « Ab-initio description of few-body collisions relevant for the GBAR project »(2017 et 2020, MAAAN (R. Lazauskas) 2020, Gamma Strength (2017-2020).
International:

- Coordinator of Several International Agreements with Germany, Poland, Spain.
- International Emerging Action “RNC”, France-Belgique, financement IN2P3 (porteur K. Sieja), 2021-2022.
- Participation to the France-Bulgariaagreement (PI-CENBG) « Etude des états isomériques dans les noyaux atomiques lourds »
- Participation to QUSTEC (Quantum Science and Technology on the European Campus); « Hilbert Space Engineering of Nuclear Spin Qudits »

Teaching activities:
For each teacher-researcher of the group, about 200 h of teaching per year from BSc to MSc (2 MC), and participation of CNRS scientist to licence, master courses.

National collaboration: CENBG, GANIL, IJCLab, IPCMS (Nuclear spin in Lanthanide-organic complexes used for Quantum Information Processing)

International collaborations: Belgium, Italy, Germany, Spain, Lithuania, Japan, Poland, Ukraine

Editorial activities: Editor of Few-Body Systems, Physica Scripta, special issues 40-year anniversary of the 1975 Nobel Prize to A. Bohr, B. Mottelson and L. Rainwater, edited during 2016/2017/2018; of Frontiers in Physics, of European Physical Journal, editor of special issue of Universe on “Advances in Nuclear Physics”

Participation to committees and research manadgement: *(not provided)*

National: group coordinator within HISPEC/DESPEC GSI related collaboration

LPC-CAEN

Main Topics developed: EDF, Statistical models, Phenomenological models for reactions

Members*:* Francesca Gulminelli [PR], Dominique Durand [DR-Partially Experimentalist]
Postdocs: (in the last 5 years)

- S.Mallik, transport theory (May 1, 2019/30 April 30, 2020)

Granted projects:
Bilateral agreement CEFIPRA no.5804-F « Phase transitions in sub-saturation nuclear matter and applications to core collapse supernova and nuclear experiments » (2 permanent researchers, 2 postdocs) 2017-2021

Teaching activities:
For each teacher-researcher of the group, about 200 h of teaching per year from BSc to MSc.

National collaboration: GANIL,
International collaborations: India
Participation to committees and research manadgement: *(not provided-The participation are counted in nuclear astrophysics)*

LPSC-GRENOBLE

Main Topics developed: Nuclear structure models: IBM, quasiparticle-phonon model, EDF

Members*:* Gabriela Thiamova [MC]

PhD-Students: (last 5 years)

- Ivan Grachev, Identification of excited states and collectivity in 88Se, 2014-2017

Teaching activities:
For each teacher-researcher of the group, about 200 h of teaching per year from BSc to MSc. (1MC and 1 PR)

National collaboration: (not provided)
International collaborations: (not provided)

Participation to committees and research manadgement: Member of the Scientific Management Committee of the French-Czech LEA NuAG collaboration program; Member suppléant CNU29

Teaching activities:
For each teacher-researcher of the group, about 200 h of teaching per year from BSc to MSc.

SUBATECH NANTES

Main Topics developed: Transport theories, phenomenological models for reactions and thermodynamics

Members*:* Bonnet Eric (CR) [DR-Partially Experimentalist], De la Mota Virginia (MC), Eudes Philippe (PR)
Emeritus : Royer Guy (PR Émérite depuis 2020)

PhD-Students: (last 5 years)

- Grégoire Besse, Description théorique de la dynamique nucléaire lors de collisions d'ions lourds aux énergies de Fermi (Oct. 2014-Sept. 2017)

Granted projects:
Projet IN2P3: ACME
Teaching activities:
For each teacher-researcher of the group, about 200 h of teaching per year from BSc to MSc. (1MC and 1 PR)

National collaboration: GANIL, IJCLab
International collaborations: Croatia, China
Participation to committees and research manadgement: *(not provided)*

HIGHIGHTS ON PUBLICATIONS

Publications [Highlight] (only Letters and Review articles are shown here-collected for all laboratories)

Letters and nature's article:

- *Electromagnetic properties of neutron-rich nuclei adjacent to the Z=50 shell closure,* M. Rejmund et al., Phys. Lett. B **753** (2016) 86.
- *Can tetraneutron be a narrow resonance?, K. Fossez et al., Phys. Rev. Lett. 119 (2017) 032501.*
- *Gamow--Teller transitions and neutron-proton-pair transfer reactions*, P. Van Isacker and A.O. Macchiavelli, Phys. Lett. B **780** (2018) 414.
- *Is seniority a partial dynamic symmetry in the first $g_{9/2}$ shell,* A.I. Morales et al., Phys. Lett. B **781** (2018) 706.
- *Evidence of octupole-phonons at high spin in ^{207}Pb,* D. Ralet et al., Phys. Lett. B **797** (2019) 134797.
- *Convenient location of a near-threshold proton-emitting resonance in ^{11}Be,* J. Okołowicz et al., Phys. Rev. Lett. **124** (2020) 042502.
- *Manifestation of the Berry phase in the atomic nucleus ^{213}Pb*, J.J. Valiente-Dobón et al., Phys. Lett. B **816** (2021) 136183.
- Electric dipole strength and dipole polarizability in 48Ca within a fully self-consistent second random-phase approximation, D. Gambacurta, M. Grasso, O. Vasseur, Phys. Lett. B 777, 163 (2018)
- Gamow-Teller strengths in 48Ca and 78Ni with the charge–exchange subtracted second random–phase approximation, D. Gambacurta, M. Grasso, J. Engel, Phys. Rev. Lett. 125, 212501 (2020)
- Towards a power counting in nuclear energy-density-functional theories through a perturbative analysis, S. Burrello, M. Grasso, C.J. Yang, Phys. Lett. B 811, 135938 (2020))
- Microscopic Phase-Space Exploration Modeling of 258Fm Spontaneous Fission, Y. Tanimura and D. Lacroix, Phys. Rev. Lett. 118, 152501 (2017).
- Symmetry-Assisted Preparation of Entangled Many-Body States on a Quantum Computer, D. Lacroix, Phys. Rev. Lett. 125, 230502 (2020)
- Ab initio calculations of ^{5}H resonant states, R. Lazauskas, E. Hiyama, J. Carbonell, Phys. Lett. B791 (2019) 335
- Bound state equation for the Nakanishi weight function, J. Carbonell, T. Frederico, V. A. Karmanov, Phys. Lett. B 769 (2017) 418-423
- A proton density bubble in the doubly magic Si-34 nucleus, Mutschler, A.; Lemasson, A.; Sorlin, O.; et
- Theory Explain the Phenomenon of Parity Inversion in 11Be ?, A. Calci, P. Navrátil, R. Roth, J. Dohet-Eraly, S. Quaglioni, G. Hupin Phys. rev. lett. 117 (24), 242501 (2016)
- He3(α, γ)Be7 and H3(α, γ)Li7 astrophysical S-factors from the no-core shell model with continuum, J. Dohet-Eraly, P. Navrátil, S. Quaglioni, W. Horiuchi, G. Hupin, F Raimondi, Phys. Lett. B 757, 430-436 (2016)
- How Many-Body Correlations and Clustering Shape C. Romero-Redondo, S. Quaglioni, P. Navrátil, G. Hupin, Physical rev. lett. 117 (22), 222501 (2016)
- Nuclear Force Imprints Revealed on the Elastic Scattering of Protons with A. Kumar, R. Kanungo, A. Calci, P Navrátil, A. Sanetullaev, M. Alcorta, Phys. rev. lett. 118 (26), 262502 (2017)
- Ab initio predictions for polarized deuterium-tritium thermonuclear fusion, G. Hupin, S. Quaglioni, P. Navrátil, Nature communications 10 (1), 1-8 (2019)
- Signals of Bose-Einstein condensation and Fermi quenching in the decay of hot nuclear systems", P. Marini, … , P. Napolitani, et al., Phys. Lett. B 756 (2016) 194.

- “Nuclear Physics Around the Unitarity Limit'”, S. König, H.W. Griesshammer, H.-W. Hammer, and U. van Kolck, Phys. Rev. Lett. 118 (2017) 202501 [Editors' Suggestion].
- “Ground-State Properties of Unitary Bosons: From clusters to matter”, J. Carlson, S. Gandolfi, U. van Kolck, and S.A. Vitiello, Phys. Rev. Lett. 119 (2017) 223002.
- “New Leading Contribution to Neutrinoless Double-Beta Decay”, V. Cirigliano, W. Dekens, J. de Vries, M.L. Graesser, E. Mereghetti, S. Pastore, and U. van Kolck, Phys. Rev. Lett. 120 (2018) 202001.
- “Four-Body Scale in Universal Few-Boson Systems”, Phys. Rev. Lett. 122 (2019) 143001 [Editors' Suggestion].
- “Baryon-Number Violation by Two Units and the Deuteron Lifetime”, F. Oosterhof, B. Long, J. de Vries, R.G.E. Timmermans, and U. van Kolck, Phys. Rev. Lett. 122 (2019) 172501 [Editors' Suggestion].
- “Nuclear jets in heavy-ion collisions,” P. Napolitani and M. Colonna, Phys. Lett. B 797 (2019) 134833.
- “Clustering of Four-Component Unitary Fermions”, W.G. Dawkins, J. Carlson, U. van Kolck, and A. Gezerlis, Phys. Rev. Lett. 124 (2020) 143402.
- *V. Manea, et al, First glimpse of the N = 82 shell closure below Z = 50 from masses of neutron-rich cadmium isotopes and isomers,*
  Phys. Rev. Lett. 124 (2020) 092502
- N. Paul et al, Are There Signatures of Harmonic Oscillator Shells Far From Stability? - First Spectroscopy of 110Zr, Phys. Rev. Lett. 118 (2017) 032501.
- R. Lazauskas et al., “Ab initio calculations of ^{5}H resonant states”, Phys.Lett.B 791 (2019), 335-341
- 78Ni revealed as a doubly magic stronghold against nuclear deformation, R. Taniuchi et al., NATURE 569 (2019) 53
- Electric and magnetic dipole strength at low energy, K. Sieja, Phys. Rev. Lett. 119 (2017) 052502

Review articles:

- ***Book:*** “*Gamow Shell Model: The Unified Theory of Nuclear Structure and Reactions*”, N. Michel and M. Płoszajczak, Lecture Notes in Physics, Vol. 983 (2021), Springer International Publishing, ISSN 0075-8450, ISSN 1616-6361.
- ***Book:*** *“Recent Progress in Few-Body Physics”*, N.A. Orr et al., Springer Proceedings in Physics, Vol. 238 (2020), ISSN 0930-8989, ISSN 1867-4941.
- ***Review:*** *Shape coexistence in the microscopically guided interacting boson model,* K. Nomura et al., J. Phys. G **43** (2016) 024008.
- ***Review:*** *From bound states to the continuum*, C.W. Johnson et al., J. Phys. G.: Nucl. Part. Phys. **47** (2020) 123001.
- Effective density functionals beyond mean field, M. Grasso, Prog. Part. Nucl. Phys. 106, 256 (2019). [Review]
- Future of Nuclear Fission Theory, M. Bender et al, J. Phys. G: Nucl. Part. Phys. 47 (2020) 113002 [Review]
- Description of four- and five-nucleon systems by solving Faddeev-Yakubovsky equations in configuration space, R. Lazauskas and J. Carbonell, Frontiers in Physics 7:251 (2020) [Review]
- From effective field theories to effective density functionals in and beyond the mean field M. Grasso, D. Lacroix and B. van Kolck, Phys. Scr. 91, 063005 (2016). [Review article]
- The quest for light multineutron systems, F. Miguel Marqués and Jaume Carbonell, Eur. Phys. Journal A (2021) 57:105 https://doi.org/10.1140/ep ja/s10050-021-00417-8 [Review article]
- The Faddeev-Yakubovsky symphony; R. Lazauskas, J. Carbonell, Few Body Syst. 60 (2019) no.4, pag. 62, Review Issue in memory of L.D. Faddeev (19-2017)
- “Nuclear Effective Field Theory: Status and perspectives”, H.-W. Hammer, S. König, and U. van Kolck, Rev. Mod. Phys. 92 (2020) 025004.
- “The BCS-BEC crossover: From ultra-cold Fermi gases to nuclear systems.”
  G. Calvanese Strinati, P. Pieri, G. Röpke, P. Schuck, and M. Urban, Phys. Reports 738 (2018) 1-76.
- “Status of Alpha-Particle Condensate Structure of the Hoyle State”, A. Tohsaki, H. Horiuchi, P. Schuck, and G. Röpke, Rev. Mod. Phys. 89 (2017) 011002.
- The neutron-rich edge of the nuclear landscape.Experiment and Theory, F. Nowacki, A. Obertelli, A. Poves, Progress in Particle and Nuclear Physic (2021)