Lectures:

"Symmetries in Nature - Symmetries in Physics - Selected Aspects of Symmetry in Nuclei"

presented in the frame of the

Marian Smoluchowski Scientific Consortium - Leading National Research Center in Cracow

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by
Prof. dr hab. Jerzy Dudek

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Schedule: **3.04 - 7.04.2017**
Location: Institute of Nuclear Physics PAN, Kraków

About the Course:

The proposed series of lectures addresses the non-specialists in the domain of symmetry - on the level of the PhD and/or researchers principally those working in the field of the experimental nuclear physics and its applications. [Young researchers working in theoretical physics may find these general lectures instructive as well.]

About the Programme:

We propose to begin by presenting the symmetries observed in nature in the living objects, mainly plants and certain insects. We will arrive at the notion of the so-called golden-ratio and the Fibonacci numbers which govern the symmetries observed in those objects attracting the profound attention not only among the biologists and physicists but also architects, historians, even mystics … This discussion, illustrated by a rich graphical material will bring us to the issues of: Why do the symmetries occur? Under which circumstances? What are the driving forces which impose on a given system one symmetry or another?

In the physics discussion we will address some spectacular nuclear properties, in particular the effect of nuclear super-fluidity and related impact on various nuclear observable phenomena.

We will turn to the symmetries of certain nuclear systems. For this purpose we will recall the properties of the nuclear forces governing the nucleon-nucleon interactions and we will arrive at the un-expected predictions and conclusions related to the geometrical symmetries in the universe of the smallest objects such as atomic nuclei. We will address the issue of understanding `How come that the compact nuclear systems may manifest the symmetries characteristic for complex molecules which, from the comparative point of view are… virtually empty! We will argue that this in principle should never happen i.e. `the nuclei should remain spherical' - and yet appears as a common nuclear feature.

Illustrations of the newest achievements and results in this domain will be presented using simple language and without any advanced mathematical formalism.

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Lecture 1: 3 April (Monday) 13:30 – 15:00 room 5301

General introduction to the notion of symmetries in nature; geometrical symmetries in the world of living objects; presenting numerous examples of their presence and varieties established during the centuries. After presenting the illustrations of the status quo we formulate and discuss some natural researcher's questions: What are the driving forces in nature that impose, sometimes fully `strange and unexpected' geometrical symmetry?

Lecture 2: 4 April (Tuesday) 13:30 – 15:00 room 5301

Historical evolution in the human interests in symmetries in nature: The magic numbers of nature (known as Fibonacci numbers) and their relation to the celebrated in all domains of human intellectual activity golden ratio, the special number known by historians, architects, medical doctors, philosophers, mystics and last but not least: physicists. We present some mathematical aspects and turn to the applicative ones: Golden ratio and applications in medicine.

Lecture 3: 5 April (Wednesday) 14:30 – 16:00 room 4402

Geometrical symmetries on atomic and subatomic level. As known form introductory physics courses, many-body interactions, in order to be in accordance with the relativity principle, should be invariant under translations and rotations of the reference frame. And yet: Why many-body systems such as atomic nuclei are generally non-spherical? We will present experimental facts related to their non-sphericity - together with the consequences for theories and theoretical modelling.

Lecture 4: 6 April (Thursday) 13:30 – 15:00 room 5301

It has been nearly 40 years back that A. Bohr, B. Mottelson and J. Rainwater obtained their Nobel Prize for the discovery of the nuclear collective motion which involves, first of all, the so-called "shape vibrations". This discovery influenced strongly the big part of nuclear structure physics over many years, which followed; the aspects related to the geometrical symmetries will be discussed. The discussion will include the phenomenon of nuclear super-fluidity and its impact on the effect of symmetries in sub-atomic scale. Why nuclear super-fluidity cannot fully restore the spherical symmetry?

Lecture 5: 7 April (Friday) 13:30 – 15:00 room 5301

Finally the news of today. It turns out that the geometrical symmetries, nicknamed "high-rank", attracted a strong interest in very recent years, and this for several reasons. Firstly, they shed a totally new light on the issue of the nuclear stability - a determining factor within the physics of exotic nuclei - the research intensified today in the biggest leading world centres. Secondly, the presence of the high-rank symmetries in certain nuclei is expected to lead to the existence of the full new class of the so-called waiting-point nuclei with the determining role in the nucleosynthesis, stellar processes and nuclear astrophysics. Thirdly, the symmetries in question lead to the very exotic quantum features, which have to do with the unprecedented degeneracy of the nucleonic energy levels in nuclei. Finally, it has been only two years ago that, within Fukuoka-Strasbourg collaboration, we have learned about the unique experimental signals, which will allow us to find the first case of presence of the related important new physical effects in subatomic physics.

Registration for the lectures: Bogdan.Fornal@ifj.edu.pl

About the Lecturer:

Professor Jerzy DUDEK is Excellence Class Professor at the University of Strasbourg, France and Honorary Professor of the Marie Sklodowska-Curie University, Poland. He studied physics at the Jagiellonian University, and next completed his Ph.-D. thesis and habilitation at the University of Warsaw, Poland. He was invited professor at-, and had long collaboration contacts with various foreign institutions. Among the most important are: The Niels Bohr Institute of the University of Copenhagen, Denmark; University of Liverpool, UK; University of Manchester, UK; University of Bonn, FRG; University of Tubingen, FRG; Max-Planck Institute, Heidelberg, FRG; University of Fukuoka, Japan; University of Tennessee at Knoxville and Oak Ridge National Laboratory, USA; Florida State University, USA.

Professor Dudek, specialist in theoretical sub-atomic physics, is among the most cited 1% physicists in the world. So far, over 50 young physicists have prepared their Ph.-D. or Master diplomas under his supervision. Among various fields of sub-atomic physics research to which Professor Dudek importantly contributed count: Microscopic theories of nuclear isomerism and exotic nuclear configurations, in particular theories of fission-isomers and physics of super- and hyper-deformed states and bands, structure of the so-called yrast-trap isomers, various forms of subatomic symmetries including nuclear point-group symmetries and symmetry- breaking phenomena, nuclear mean-field theory of collective nuclear rotation and interplay with the single-nucleonic and quasi-particle degrees of freedom, spontaneous symmetric breaking phenomena in the intrinsic nuclear frames, the so-called pseudo-symmetries in nuclei, nuclear behaviour at the extreme conditions: high-spins, extreme-isospins, high-temperatures and high- deformation limits, nuclear microscopic mechanisms within self-consistent Hartree-Fock theories, time-reversal and chiral-symmetries and symmetry breaking, transitions between nuclear-superfluid on normal phases, etc., to mention the most important.