Sub-theme 6.3. Biophysics and Computational Physics

Rationale

Developments in experimental spectroscopy have, for the first time, revealed quantum effects, in biological system. Quantum mechanics has already proved its remarkable power in understanding the complex micro-phenomena at low temperature, in the fields of physics and chemistry. The current and the most relevant question being asked is how to apply quantum mechanics to events under warm and wet conditions such as in biological systems. Recent evidence of quantum tunnelling, quantum coherence and entanglement in processes such as DNA mutation and photosynthesis show that quantum phenomena indeed play a vital role in biological processes. This motivates to explore the question of how and in what ways quantum mechanics is driving some of the most elegant and inexplicable processes of life. The answers, if and when found, will have great impacts on medical and health sciences.

A quantitative analysis of the bioprocesses requires an improved version of computational techniques. The huge increase in the power of computers in recent years has made an impact on the role of computational physics. In many cases, the entire problems can now be solved computationally without the need for any experimental inputs. Computer graphics and visualisation now play an important role in the scientific process as they can provide a greater understanding of physical processes. Advances in microelectronics, numerical analysis and computer science have greatly enhanced the importance of computational physics and its applications.

Aim

The aim of this sub-theme is to investigate the life-processes in plants and animals at the micro level and explore the possibility of extending the concepts to the field of medical and other sciences.

Description

This sub-theme focuses on mutation, mutation and quantum tunnelling, enzyme action, quantum nano structure (casimir effect), mathematical modelling, microtubules, quantum network in biology, photosynthesis, quantum computing, and quantum information. It also includes the societal and development impact of quantum biological research outputs. The simultaneous applications of computational physics further compliment and augment the process of research activities and output in the above fields.

Potential Collaborators

Universities, research institutions, Ministry of Science and Technology, pharmaceutics industries etc.

Expected Output

- Better understood molecular systems governing life processes
- Improved technologies to measure quantum systems and quantum effects
- New type of quantum biosensors to understand and manipulate enzymes and other biomolecules.
- Photosynthesis-based technologies for energy collection**.**
- Optimum industrial solutions in quality and process control
- Synthesis of quantitative information generation
- Computational understanding of gene expression data
- Development of software tools to assist in drug discovery process

Research Areas

6.3.1. Quantum Biology

This research area focuses on quantum tunnelling to explain the phenomenon of mutation. It also deals with the mechanism of enhanced catalytic rates in enzymes that can be explained by

quantum tunnelling. Nano-machines, which can be approached by quantum limit, quantum electro dynamical effects such as the casimir effect, and physics of certain enzymes that crawl along DNA and considered as molecular motors, will be investigated. Moreover, the concepts of microtubules inside cells that permit long-range quantum coherence, enable quantum information processing to take place at the sub-cellular level, theoretical and experimental basis of photosynthesis, which may lead to the development of artificial photo-systems, will be studied from the physics point of view. The research area also deals with quantum computing and quantum information through quantum coherence and sustenance in the biological system that would help in efficient modelling of the quantum system for energy transfer.

6.3.2. Computational Physics

This area of research encompasses the science of using computers to assist in the solution of physical problems and to further physics research. Large scale quantum mechanical calculations in nuclear, atomic, molecular, and condensed matter physics can be performed. Similar calculations can be done in such fields as hydrodynamics, astrophysics, plasma physics, meteorology and geophysics. Simulation and modelling of complex physical systems such as those that occur in condensed matter physics, medical physics, and industrial applications are quite possible. One can also focus on experimental data processing, image processing, and data mining/analysis. Development of an efficient software tool to analyse gene expression data can lead to the discovery of a gene responsible for a disease process. This research can accelerate a drug discovery processes.

Beneficiary

Researchers, research institutions, national and overseas universities, and the wider citizen