Contribution ID: **95**

Type: **Keynote**

Theory of Nuclear Fission

Tuesday 9 July 2024 09:00 (50 minutes)

The process of spontaneous or induced fission, by which an atomic nucleus breaks into two or more fragments, presents, more than eight decades after its discovery, a very interesting research topic in the field of low- and medium-energy nuclear physics. From a modern perspective, nuclear fission can be considered a representative example of large-amplitude collective motion in a self-bound mesoscopic system, that exhibits both classical and quantal characteristics. In addition to important technological applications, primarily in energy production, fission is also relevant for the stability of superheavy elements, production of short-lived exotic nuclides far from stability, nuclear astrophysics, and the mechanism of nucleosynthesis.

A wealth of experimental results on nuclear fission have been accumulated, and a basic understanding of the mechanism gained. Several successful phenomenological approaches and methods have been developed that reproduce, to various degrees of accuracy, low- and medium-energy fission observables. Recently, significant advances in the microscopic description of various aspects of the fission process have been reported. These include studies of nuclear shell effects on fission observables, dynamical pairing correlations, symmetry restoration, fission in odd-mass nuclei, the energy dissipation mechanism and total kinetic energy distribution, neck dynamics, properties of fragments beyond scission, generation of fragment angular momentum, fragment distributions and their impact on r-process nucleosynthesis, element production, fission in compact stars, etc. Even though microscopic methods have been very effective in modelling specific observables, a unified framework for the description of the entire fission process remains a formidable challenge for nuclear theory.

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Session Classification: Nuclear Fission I

Track Classification: Nuclear Fission