中央大學物理學系
Department of Physics, National Central University

Colloquium

Uncovering the Physical Principles of Life with Artificial Cells - Symmetry Breaking and Energy Conversion of Active Cytoskeleton

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Abstract :
What is life? How do complex living systems self-organize from lifeless molecules? By constructing life-like systems from molecular building blocks, we aim to address these fundamental questions. Living systems convert chemical energy into mechanical work, enabling them to maintain structures and change shape. From immune response to cancer invasion, the coordination of core cellular behaviors—such as migration and division—is essential. These single-cell behaviors are driven by the non-equilibrium mechanics of molecular machinery, including the cytoskeleton and motor proteins, which generate active stresses. While the biochemical regulation of these processes is well characterized in cell biology, the role of mechanical forces remains less understood. To address this gap, minimal cell-mimetic model systems have been developed, allowing precise manipulation and quantitative analysis. This talk will highlight our contributions to uncovering the physical principles of cell migration and division by addressing the following questions: How do cytoskeleton-generated forces coordinate migration and division? How does energy consumption influence cytoskeletal assembly and division? Finally, I will outline future research directions to explore the physics of self-organized waves and advance microscale bioengineering.