Title: Microscopic Geared Mechanisms

arXiv ID: 2409.17284v1

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Summary: The miniaturization of mechanical machines is critical for advancing nanotechnology and reducing device footprints. Traditional efforts to downsize gears and micromotors have faced limitations at around 0.1 mm for over thirty years due to the complexities of constructing drives and coupling systems at such scales. Here, we present an alternative approach utilizing optical metasurfaces to locally drive microscopic machines, which can then be fabricated using standard lithography techniques and seamlessly integrated on the chip, achieving sizes down to tens of micrometers with movements precise to the sub-micrometer scale. As a proof of principle, we demonstrate the construction of microscopic gear trains powered by a single driving gear with a metasurface activated by a plane light wave. Additionally, we develop a versatile pinion and rack micromachine capable of transducing rotational motion, performing periodic motion, and controlling microscopic mirrors for light deflection. Our on-chip fabrication process allows for straightforward parallelization and integration. Using light as a widely available and easily controllable energy source, these miniaturized metamachines offer precise control and movement, unlocking new possibilities for micro- and nanoscale systems.

Title: Size-dependent multiexciton dynamics governs scintillation from perovskite quantum dots

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Summary: The recent emergence of quantum confined nanomaterials in the field of radiation detection, in particular lead halide perovskite nanocrystals, offers potentially revolutionary scalability and performance advantages over conventional materials. This development raises fundamental questions about the mechanism of scintillation itself at the nanoscale and the role of particle size, arguably the most defining parameter of quantum dots. Understanding this is crucial for the design and optimisation of future nanotechnology scintillators. In this work, we address these open questions by theoretically and experimentally studying the size-dependent scintillation of $CsPbBr_3$ nanocrystals using a combination of Monte Carlo simulations, spectroscopic, and radiometric techniques. The results reveal and unravel a complex parametric space where the fine balance between the simultaneous effects of size-dependent energy deposition, (multi-)exciton population, and light emission under ionizing excitation, typical of confined particles, combine to maximize the scintillation efficiency and time performance of larger nanocrystals due to greater stopping power and reduced Auger decay. The remarkable agreement between theory and experiment produces a fully validated descriptive model that unprecedentedly predicts the scintillation yield and kinetics of nanocrystals without free parameters, providing the first fundamental guide for the rational design of nanoscale scintillators.

Title: How we simulate DNA origami

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Summary: DNA origami consists of a long scaffold strand and short staple strands that self-assemble into a target 2D or 3D shape. It is a widely used construct in nucleic acid nanotechnology, offering a cost-effective way to design and create diverse nanoscale shapes. With promising applications in areas such as nanofabrication, diagnostics, and therapeutics, DNA origami has become a key tool in the bionanotechnology field. Simulations of these structures can offer insight into their shape and function, thus speeding up and simplifying the design process. However, simulating these structures, often comprising thousands of base pairs, poses challenges due to their large size. OxDNA, a coarse-grained model specifically designed for DNA nanotechnology, offers powerful simulation capabilities. Its associated ecosystem of visualization and analysis tools can complement experimental work with in silico characterization. This tutorial provides a general approach to simulating DNA origami structures using the oxDNA ecosystem, tailored for experimentalists looking to integrate computational analysis into their design workflow.

Title: Simulation of charged nanotubes self-assembly during evaporation of a sessile droplet on a substrate

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Summary: The ability to control the morphology of the nanotube deposit formed during the evaporation of a sessile droplet on a substrate is of theoretical and practical interest. Such deposits is required for various applications including nanotechnology, medicine, biotechnology, and optronics. In the experiment of Zhao et al. [J. Colloid Interface Sci. 440, 68 (2015)], an annular deposit was formed near the contact line. The deposition geometry is caused by the coffee-ring effect. This deposit is unusual in its morphology. It changes gradually in space from a disordered structure in the inner part of the

ring to an aligned structure of nanotubes close to the periphery. To understand the mechanisms that lead to this, we have developed a mathematical model that takes into account the effects of advection, diffusion, and electrostatic interactions on particle transport. Results of numerical calculations have confirmed that all these factors together have an influence on the formation of such a variable morphology. Qualitative agreement with the experiment is shown for some values of the model parameters.

Title: Programmable multifunctional integrated microwave photonic circuit on thin-film lithium niobate

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Summary: Microwave photonics, with its advanced high-frequency signal processing capabilities, is expected to play a crucial role in next-generation wireless communications and radar systems. The realization of highly integrated, high-performance, and multifunctional microwave photonic links will pave the way for its widespread deployment in practical applications, which is a significant challenge. Here, leveraging thin-film lithium niobate intensity modulator and programmable cascaded microring resonators, we demonstrate for the first time a tunable microwave photonic notch filter that simultaneously achieves high level of integration along with high dynamic range, high link gain, low noise figure, and ultra-high rejection ratio. Additionally, this programmable on-chip system is multifunctional, allowing for the dual-band notch filter and the suppression of the high-power interference signal. This work demonstrates the potential applications of the thin-film lithium niobate platform in the field of high-performance integrated microwave photonic

filtering and signal processing, facilitating the advancement of microwave photonic system towards practical applications.