Tactoid-Mediated Nucleation to molecular self-assembly: Linking Quantum Optical Control to Synaptic Function

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Abstract: Molecular optoelectronic films and neuronal synapses, though distinct systems, are both governed by nanoscale intermolecular interactions that determine emergent function. In organic films, chromophore self-assembly often alters optical properties, limiting device performance. Strong light–matter coupling provides a way to study and control these weak interactions. It creates quantal states that spread excitations, recover monomer-like behavior, and form tactoids; anisotropic domains that act as seeds for controlled assembly. Similarly, synapses function as nanoscale molecular machines. Postsynaptic scaffolds and neurotransmitter receptors cluster into nanodomains that govern probabilistic transmission and plasticity. Synaptic communication events involve transient analogous protein clustering, shaping Signal processing and acting as structural risk factors. Conceptually, these biological nanodomains mirror tactoid-mediated assemblies, suggesting that controlling weak intermolecular interactions can guide self-organization and functional assembly in neural systems. This project proposes to leverage light–matter strong coupling as a tool to investigate weak interactions and self-organization in neuronal molecules in size size ranges of 1-100nm. By integrating optical control, tactoid nucleation, and high-resolution nanoscale mapping, we aim to uncover general principles of molecular assembly in both biological and synthetic systems. These insights will inform the rational design of non-interacting molecular devices and inspire strategies to modulate synaptic architecture, establishing a foundation for next generation neuromimetic materials and therapeutics. Ultimately, this approach enables the study of fundamental nanoscale behaviors of matter and their functional consequences, with light–matter interactions serving as a precise probe of self-organization at the smallest scales.

For more information, see:

https://www.nanoorg.in/

https://ipc.iisc.ac.in/~at/PEOPLE.html

https://enlife.in/