Nano Res Appl 2018, Volume 4
DOI: 10.21767/2471-9838-C5-021

Complexity and multi-functionality of superconducting meta-materials

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Super conducting meta-materials are ultralow loss, artificial, man-made media which are designed to achieve properties not available in natural materials. SQUID (Super conducting Quantum Interference Device) based metamaterials have additional functionality and control properties with exciting new collective properties both in the classical and quantum realms. A SQUID is a unique non-linear oscillator that can be manipulated through multiple external means. This domain flexibility is retained by SQUID based metamaterials and meta-surfaces i.e., extended units that contain a large arrangement of SQUIDs in various interaction configurations. Such units are essentially assemblies of weakly coupled nonlinear oscillators where numerous, classical as well as quantum complex, spatio temporal phenomena may be explored. In this presentation we will focus on SQUID based metamaterials and present basic properties related to their individual and collective responses to external drives. We will show that a SQUID based system acts as a genuine meta material with right as well as left handed properties; demonstrate that Josephson nonlinearity leads to wide band tunability, intrinsic nonlinear as well as flat band localization. We will further present exciting dynamical response properties such as multi stability and self-organization and the emergence of counter intuitive chimera states of selective, partial organization. In the truly quantum regime we will explore the interaction of electromagnetic pulses with superconducting qubit units where the coupling between the two yields properties such as self-induced transparency and super radiance. The appearance of these complex phenomena will be linked to possible technological applications.

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