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Fractional transport and photonic sub-diffusion in aperiodic dielectric metamaterials LUCA DAL NEGRO, YU WANG, SANDEEP INAMPUDI, Boston University, ECE Department — Using rigorous transfer matrix theory and full-vector Finite Difference Time Domain (FDTD) simulations in combination with Wavelet Transform Modulus Maxima analysis of multifractal spectra, we demonstrate all-dielectric aperiodic metamaterial structures that exhibit sub-diffusive photon transport properties that are widely tunable across the near-infrared spectral range. The proposed approach leverages the unprecedented spectral scalability offered by aperiodic photonic systems and demonstrates the possibility of achieving logarithmic Sinai sub-diffusion of photons for the first time. In particular we will show that the control of multifractal energy spectra and critical modes in aperiodic metamaterials with nanoscale dielectric components enables tuning of anomalous optical transport from sub- to super-diffusive dynamics, in close analogy with the electron dynamics in quasi-periodic potentials. Fractional diffusion equations models will be introduced for the efficient modeling of photon sub-diffusive processes in metamaterials and applications to diffraction-free propagation in aperiodic media will be provided. The ability to tailor photon transport phenomena in metamaterials with properties originating from aperiodic geometrical correlations can lead to novel functionalities and active devices that rely on anomalous photon sub-diffusion to control beam collimation and non-resonantly enhance light-matter interaction across multiple spectral bands.

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