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Quantum-coherence driven self-organized criticality and non-equilibrium light localization. PANKAJ JHA, KOSMAS TSAKMAKIDIS, YUAN WANG, XIANG ZHANG, Univ of California - Berkeley — In its 28 years since its introduction in 1987, self-organized criticality (SOC) has had a major impact across a broad range of seemingly dissimilar fields of science. However, until now, it has primarily been applied to classical systems, and it remains a fundamental open question whether the theory also finds a place in complex systems driven by quantum coherence (QC). Here, on the basis of a many-body quantum-field theory and corroborating Maxwell-Bloch-Langevin computations, we report on the first example of fractal SOC driven, in the nano-world, by quantum coherence. We show that a quantum-coherently controlled active nano-plasmonic heterostructure allows, in the regime where the light speed is very close to zero, for the phase-synchronization in space of a continuous ensemble of nano-optical oscillators, giving rise to a fundamentally new kind of non-equilibrium light localization. We observe all hallmarks of SOC in this quantum many-body photonic nano-system of interacting heavy bosons, and we identify two critical points, one signifying the onset of spontaneous spatial self-organization, followed in time by another one that signifies the onset of activity. Our analysis reveals a quantum-coherence driven self-organized double-critical property in photonics and a new type of robust light localization, far out of thermodynamic and optical equilibria, with a broad range of potential applications in nano-optics and condensed-matter photonics.

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