Metamaterial Photonic Time Crystals and Parametric Machines

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Time crystals are an eagerly sought phase of matter in which time-translation symmetry is broken. Quantum time crystals with discretely broken time-translation symmetry have been demonstrated in trapped ions, atoms and spins while continuously broken time-translation symmetry has been observed in an atomic condensate inside an optical cavity. Here we report that a classical metamaterial nanostructure, a two-dimensional array of plasmonic metamolecules supported on flexible nanowires, can be driven to a state possessing all key features of a continuous time crystal: continuous coherent illumination by light resonant with the metamolecules' plasmonic mode triggers a spontaneous phase transition to a state in which transmissivity oscillations result from a many-body interaction among the metamolecules, and which is characterized by long-range order in space and time. As the state can be manipulated optically, the phenomenon is of interest to topological and non-Hermitian physics and applications in frequency conversion, memory, modulation, nonreciprocity, amplification and a range of parametric phenomena.