Optical Nonreciprocal Forces, Ergodicity and Entropy of Space-Time Crystals

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The time crystal is an eagerly sought phase of matter, a many-body strongly correlated system with broken time-translation symmetry and ergodicity. We demonstrate that a classical metamaterial nanostructure - a two-dimensional array of plasmonic metamolecules supported on nanowires - exhibit complex picometer scale dynamics in presence of light. It can be driven to a state possessing all the key features of a continuous space-time crystal: continuous coherent illumination by light resonant with the metamolecules' plasmonic mode triggers a spontaneous first order phase transition to a superradiant-like state of transmissivity oscillations, resulting from many-body interactions among the metamolecules. The space-time crystal is characterized by long-range order in space and time, broken ergodicity and reduced spectral entropy that are driven by non-reciprocal non-Hamiltonian forces of light pressure.