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Optical Nonreciprocal Forces, Ergodicity and Entropy in Metamaterial Time Crystals

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***Abstract* – In a remarkable similarity with nonreciprocal nonequilibrium process in nature, nonreciprocal forces of light can underpin breaking of time translation symmetry and ergodicity, and exert control over entropy in a nanowire metamaterial.**

Nonreciprocal nonequilibrium process are attracting growing interest in sociology, animal dynamics, chemistry and nanotechnology, and may have played a critical role in the origin of life.

It is less widely appreciated that in open systems light can induce nonreciprocal 'predator-prey' like forces between nanoparticles, due to differential scattering. Such forces give access to the continuous time crystal state of matter, which has been demonstrated in a metamaterial array of plasmonic nanowires wherein light triggers a spontaneous mobilization transition to the robust synchronized oscillatory state, breaking time translation symmetry[1,2].

Here, we report an experimental and computational study of the transient dynamics of light-induced mobilization and demobilization transitions in such time crystals. By analysing time resolved phase trajectories of the system of nanowires, we show that the mobilization transition is accompanied by ergodicity breaking and a decrease in the entropy of motion.

The reported insights into the transient dynamics of nonreciprocally driven time crystals are of interest to the emerging field of optical "timetronics" – an information and data technology relying on the unique functionalities of time crystals, while the platform of interacting nanowire oscillators may be useful for modeling various nonreciprocal processes, many-body dynamics and even early stage matter-to-life transitions.

REFERENCES

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