Adiabatic classical discrete time crystals

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We report on experiments and simulations on adiabatic classical discrete time crystals. Steel spheres are placed above a magnetic hexagonal pattern and exposed to an external field, which is periodically changing direction along a control loop. The conformation of three spheres above one unit cell adiabatically responds with half the frequency ($\omega_{\text{response}} = \omega_{\text{drive}}/2$) of the external field creating a time crystal with hexagonal close packed symmetry at arbitrary low frequency. The adiabatic time crystal occurs because of the non trivial topology of the stationary manifold. We reveal with computer simulations that the coupling of steel spheres in different unit cells causes many body effects with period doubling in different directions of the driving space time lattice. The non-ergodic suppression of transitions between equivalent minima of the space periodic pattern thereby ensures the possibility of time crystals close to equilibrium.

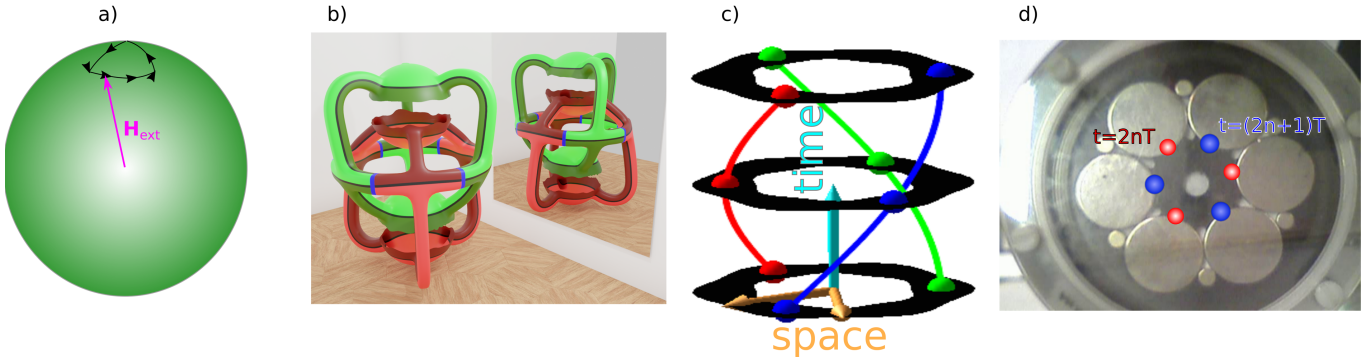

FIG. 1: a) The driving external field orientation varies periodically along a loop b) the stationary manifold $\mathcal{M}$, c) the primitive hcp-unit cell of the macroscopic space time crystal and d) a stroboscopic image of the experimental time crystal

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