UNIVERSITÄT DUISBURG ESSEN | PHYSIK

Physikalisches Kolloquium

Mittwoch, 04.12.2024
13:00 Uhr
MC 122 und Zoom

https://uni-due.zoom-x.de/j/64228670246?pwd=RjVQeFNIUkRKRkpiNVpKYXhJaFNLdz09 (gilt für alle Vorträge)

Time Crystal in Semiconductor Electron-Nuclear Spin System

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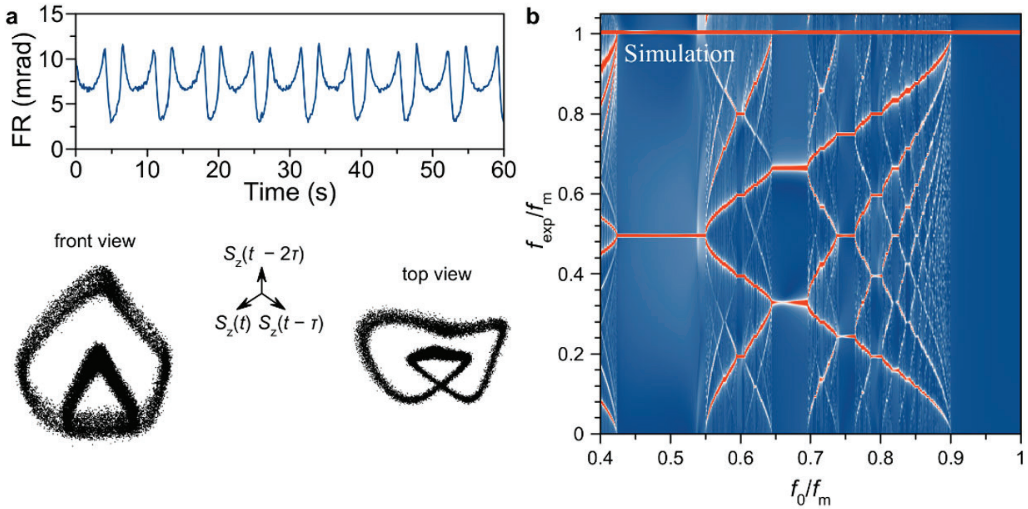

Fig. 1. (a) Periodic oscillations of the electron spin polarization – robust CTC state. At the bottom, different views of the three-dimensional phase plot of the spin polarization cycle, with the coordinates successively delayed by τδt = 5δt, where the measurement time step δt = 89 ms. The black points mark the recorded data. (b) Simulated contour plot of FFT spectra for the modulated version of the CTC as a function of inverse modulation frequency fm. It demonstrates different regimes, including horizontal synchronization plateaus and bifurcation jets.

We demonstrate the realization of continuous time crystals (CTCs) in semiconductor material using a many-body electron-nuclear spin system. A CTC represents the spontaneous breaking of translational symmetry in time, manifested here as robust limit-cycle dynamics (Fig. 1a) over an extensive range of parameters, including variations in laser power, temperature, and magnetic field. Remarkably, the coherence time of these oscillations is limited only by the measurement duration, indicating an ideal temporal ordering akin to „time atoms“ within the CTC [1].
By periodically driving the system through modulation of external parameters like excitation power and pump polarization, we induce parametric resonances signaling a transition from continuous to discrete time crystal (DTC) behavior (Fig. 1b). Key phenomena include synchronization and the formation of Arnold tongues, where the system‘s oscillations lock onto the modulation frequency. Beyond entrainment, we observe fractional subharmonic responses organized in bifurcation jets, creating a devil’s staircase structure in the frequency spectrum. Notably, as the system nears an entrainment region, it undergoes a chaotic transition, revealing the intricate boundary between synchronized and chaotic dynamics [2].
These results deepen our understanding of nonlinear systems and highlight potential applications in semiconductor technology. This work offers insights into complex, synchronized phenomena in natural and technological systems by bridging experimental realizations with theoretical predictions.

[1] A. Greilich et al., Nat. Phys. 20, 631 (2024), https://doi.org/10.1038/s41567-023-02351-6
[2] A. Greilich et al., arXiv:2406.06243v1 (2024)