



Colloquium Notice

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Melting and Re-Freezing in Markovian and non-Markovian Open Quantum Time Crystals

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Time crystals - many-body systems whose observables oscillate persistently, spontaneously breaking time-translation symmetry - have moved from curiosity to laboratory reality, but almost exclusively on atom-cavity and optical-lattice platforms, and almost exclusively under the Born–Markov assumption of a memoryless environment. This talk challenges both restrictions.

I begin with detection. Discrete time-crystalline (DTC) order is conventionally read out optically, through spin-dependent fluorescence or magnetization. We showed [1] that a periodically driven spinless Hubbard ladder, emulable in a gate-defined quantum-dot array, hosts a dissipative DTC visible directly in the charge current, as a subharmonic peak in its Fourier transform, and that the system can be tuned reversibly out of and back into the time-crystal phase. Extending this to spinful transport [2], we used dynamical symmetries to identify analytically when DTC and discrete time-quasi-crystal order survive coupling to electrodes — a general and invasive environment providing single-particle gain and loss — and showed that the spin-polarized current is itself a direct measure of time-crystallinity. Turning to molecular platforms [3], we predicted DTC behavior in arrays of exchange-coupled single-molecule magnets, where the response frequency is set by the anisotropy-defined level structure and is essentially independent of the exchange coupling, while the many-body character surfaces as a pulse-like magnetization envelope.

The second half concerns bath memory. Real reservoirs have a finite correlation time. We find [4] that non-Markovianity re-freezes a dissipative time crystal that Markovian damping would melt: information backflow opens a spectral bottleneck that suppresses decay channels while leaving oscillation frequencies nearly fixed, with the damping rate vanishing as a power law in the memory time. Finally [5], we prove that the Floquet spectrum of a post-Markovian DTC splits exactly into the ordinary Markovian spectrum plus a replica of the purely unitary spectrum, uniformly contracted by $\exp(-T/\tau_m)$. Once the memory time exceeds the Markovian lifetime, this replica sets the subharmonic decay, which then becomes independent of drive amplitude, interaction strength, dissipation rate and system size — a rigid, calibration-free read-out of the reservoir correlation time. The time crystal thereby witnesses the non-Markovianity of its own environment.

References

- [1] S. Sarkar and Y. Dubi, *Nano Lett.* **22**, 4445 (2022)
 - [2] S. Sarkar and Y. Dubi, *Commun. Phys.* **5**, 155 (2022)
 - [3] S. Sarkar and Y. Dubi, *ACS Nano* **18**, 27988 (2024)
 - [4] R. Ghosh, S. Sarkar, and Y. Dubi, *Freezing a molten dissipative time crystal with non-Markovianity* (2026, under review)
 - [5] R. Ghosh, V. Mukherjee, and Y. Dubi, *Experimentally relevant witness for non-Markovianity in discrete time crystals* (2026, in preperation)
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Wednesday
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Starts at 12:15 PM
Coffee at 12:00 PM
Physics Conference Room, SB B326
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