Hawking time crystals

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After a brief introduction to black-hole lasers and continuous-time crystals, we propose a time crystal based on a quantum black-hole laser, where the genuinely spontaneous character of the symmetry breaking stems from the self-amplification of spontaneous Hawking radiation [1]. The resulting Hawking time crystal (HTC) is characterized by the periodic dependence of the out-of-time density-density correlation function, while equal-time observables are time-independent because they embody averages over different realizations with a random oscillation phase. The HTC can be regarded as a nonlinear periodic analogue of the Andreev-Hawking effect, exhibiting anticorrelation bands resulting from the spontaneous, quantum emission of pairs of dispersive waves and solitons into the upstream and downstream regions. Remarkably, the time-crystal formation is understood in terms of two time operators: one associated to the initial black-hole laser and another associated to the final spontaneous Floquet state [2,3].

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[3] J. R. Muñoz de Nova, F. Sols, Simultaneous symmetry breaking in spontaneous Floquet states: temporal Floquet-Nambu-Goldstone modes, Floquet thermodynamics, and the time operator. Quantum 9, 1850 (2025).