21st International Conference on

Advanced Energy Materials and Research

July 11-12, 2019 | Zurich, Switzerland

Photonic time crystal in exciton-polariton condensates

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A many body state, which has symmetry different from the true quantum ground state of the Hamiltonian is referred to a state with spontaneous symmetry breaking. The usual crystals in the material science own a kind of discrete spatial translation symmetry and show the spontaneous symmetry breaking of continuous spatial translation symmetry. Recently, a new kind of crystal, called a time crystal, was shown a crystalline structure formed in the time domain due to the spontaneous breaking of continuous time translation symmetry. Time crystals could only exist in non-equilibrium many body systems. A exciton-polariton condensate existing in a microcavity is intrinsically out of equilibrium so that continuous pumping is needed to balance the fast polariton decay and maintain a steady-state state. Here, we propose a photonic time crystal occurring in exciton-polariton condensates and a method to realize it experimentally. We find that a resonantly-pumped exciton-polariton condensate subjected to an external periodic potential could show a spontaneous time-symmetry breaking and lead to the formation of a time crystal. We also study the effects of light frequency detuning on the periodicity of the time crystal. The proposed time crystals of a resonantly-pumped exciton-polariton condensate provide a new horizon for exploring properties of matter and its possible application in quantum computations.

Recent Publications

1. Ting-Wei Chen and Szu-Cheng Cheng*, "Surface gap solitons in exciton polariton condensates.", 2018, Physical Review E, 98, 032212.
2. Szu-Cheng Cheng and Ting-Wei Chen*, "Dark gap solitons in excitonpolariton condensates in a periodic potential", 2018, Physical Review E, 97, 032212.
3. Ting-Wei Chen and Szu-Cheng Cheng*, Polariton solitons and nonlinear localized states in a one-dimensional semiconductor microcavity.", 2018, Physical Review E, 97, 012218.
4. Szu-Cheng Cheng* and Shih-Da Jheng, "Physical Realization of von Neumann Lattices in Rotating Bose Gases with Dipole Interatomic Interactions.", 2016, Scientific Reports, 6, 31801.
5. Ting-Wei Chen, Shih-Da Jheng, Wen-Feng Hsieh, Szu-Cheng Cheng*, "Nonequilibrium and nonlinear defect states in microcavity-polariton condensates.", 2016, Physical Review E, 93, 052214.
6. Ting-Wei Chen, Wen-Feng Hsieh and Szu-Cheng Cheng*, "Stable gray soliton pinned by a defect in a microcavity-polariton condensate", 2015, Optics Express, 23, 24974.

Biography

Szu-Cheng Cheng is a Professor and Chairman for the Department of Optoelectric Physics of Chinese Culture University in Taiwan. He has his expertise in theoretical studies of photonic crystals and Bose-Einstein condensates. He is a Member of the American Physical Society and the American Optical Society. His multiple-fluxes vortex-lattice model shows new pathways for creating new matter state. He has built this model after years of experience in research and teaching in education institutions. He is a specialist in condensed matter physics. Currently, his research interest is on the physical phenomena of exciton-polariton condensates in microcavity of quantum wells.

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