Realization of a continuous time crystal in an erbium doped solid

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Abstract: Time crystals are many-body states that spontaneously break translation symmetry in time the way that ordinary crystals do in space. While experiments have demonstrated the existence of discrete or continuous time crystals, these manifestations have typically relied on periodic forces or effective modulation from cavity feedback. The original vision for time crystals was that they would embody self-sustaining motions without any external periodic influence. In this talk, we present both theoretical and experimental evidence indicating that many-body interactions can lead to a phase with spontaneously broken time translation symmetry. By using a continuous-wave laser to drive an erbium-doped crystal, we experimentally revealed a new dynamical phase of intrinsic optical instability, where the transmission through the sample became unstable for intense laser inputs. Furthermore, the erbium ions can spontaneously repeat its pattern in time, forming a phase of continuous time crystal. These states are inherently self-organized, and is self-protected by many-body interactions, showing a coherence time beyond that of individual erbium ions.