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Three-Dimensional Quantum Bubble Collisions

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First-order phase transitions proceed through the nucleation and subsequent collision of bubbles. In false vacuum eternal inflation, such collision events are ubiquitous and provide a possible avenue to observationally test the multiverse. They also play an important role in early high temperature phase transitions.

I will present results for the full three-dimensional nonlinear dynamics of pairwise bubble collisions, including for the first time the effects of (initially small) quantum fluctuations. This significantly extends the standard treatment of these collisions, where the field profile is assumed to possess a spatial SO(2,1) symmetry and the dynamics reduces to one spatial dimension. However, quantum fluctuations are present and break the assumed symmetry, although the breaking may initially be very small. I will show that accounting for the dynamics of these fluctuations leads to a dramatic breakdown of the SO(2,1) symmetry in a wide class of potentials. Initially, the fluctuations experience a linear parametric instability, which can be interpreted as an inhomogeneous version of Bogoliubov particle production. At the onset of mode-mode coupling, the bubble walls in the collision region dissolve, leaving behind a population of localized oscillating blobs of field known as oscillons. This has implications for the production of gravitational waves and black holes in bubble collisions.

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