# Kerr parametric oscillators as synthetic two-level systems

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A Kerr parametric oscillator (KPO) is a nonlinear oscillator parametrically driven by varying its spring constant near twice the resonance frequency. If the drive is strong enough, the KPO re- sponds in one of two possible phases relative to the drive and can therefore be considered a synthetic two-level system. We explore the dynamics of single and coupled KPO using micro- mechanical oscillators in the presence of stochastic noise.

Stochastic noise can trigger activated switches between the two phases of a single KPO. During such a transition, the system follows a fluctuating trajectory in phase space instead of following a straight path. This makes it hard to establish a reasonable definition of "lifetime" or measure the switching rate in a meaningful way. We address this issue by comparing several rate counting methods, finding good agreement between almost all of them[1].

Extending the system to a weakly coupled pair of KPOs, we analyse the normal-mode solutions taken by the resonators, which are envisioned to match the states of an Ising Hamiltonian. When activating the parametric drive, we find a deterministic frequency dependence of the preferred state. In the presence of stochastic noise however, the picture changes. Activated switches be- tween the phase states of the individual KPOs now lead to transitions between the symmetric and anti-symmetric normal modes of the pair, with the system spending more time in a symmetric configuration than in an anti-symmetric one, independent of frequency[2]. Our experiments can be seen as first step towards understanding larger networks of KPOs, intended for Ising simulation.

**References:**

[1] G. Margiani, S. Guerrero, T. L. Heugel, C. Marty, R. Pachlatko, T. Gisler, G. D. Vukasin, H.-K. Kwon, J. M. L. Miller, N. E. Bousse, T. W. Kenny, O. Zilberberg, D. Sabonis, and A. Eichler, *Appl. Phys. Lett.* **121**, 164101 (2022).

[2] G. Margiani, J. del Pino, T. L. Heugel, N. E. Bousse, S. Guerrero, T. W. Kenny, O. Zilberberg, D. Sabonis, A. Eichler, arXiv:2210.14731 (2022)