Temperature-induced stochastic resonance in time-modulated Kerr non-linear photonic cavities

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Injecting noise in a modulated non-linear system can lead to stochastic resonance which corresponds to periodic transitions between stable states. Here, for the first time, we present stochastic resonance resulting from temperature-induced noise. We show that a Kerr non-linear photonic cavity driven by a modulated pump exhibits frequency conversion maximized at the stochastic resonance.

To achieve stochastic resonance, one needs:
• a non-linear system with at least two stable states;
• a time modulation (time-dependent potential);
• noise in the system.

Features:
• noise induces hopping between stable states;
• stochastic resonance if transition rate equals to half of the modulation period;
• stochastic resonance possible by varying either noise intensity or modulation frequency.

Use stochastic resonance to maximize frequency conversion

Context and challenge

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• noise induces hopping between stable states;
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Results

The outgoing power is tuned by changing the temperatures and maximized at stochastic resonance. At critical coupling, the output is minimum, almost all the incoming power is absorbed by the cavity. Frequency conversion is optimized by considering a large coupling factor compared to the internal dissipation rate.

Techniques and methods

a) At small temperatures, the transition probability is close to zero. As temperature increases (b), the system can jump between stable states until reaching synchronicity with the modulation frequency (c): stochastic resonance. For higher temperatures (d), it is very easy to overcome the potential barrier separating stable states, the synchronicity is lost. At stochastic resonance, the ratio outgoing/incoming power is maximum.
• Temperatures are equals and T=400K.
• The total dissipation rate γ is constant but the ratio between external and internal losses varies.

Outgoing over incoming power minimal at critical coupling. Almost all incoming power is absorbed by the cavity.

Frequency conversion maximized for high couplings, reaching almost 40%.


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