Dynamical Casimir Effect in Coupled Cavities

A. S. M. de Castro, D. Cius

UEPG

Edney R. Granhen

UNIFESSPA

V. V. Dodonov

UNB

In this work we consider two ideal coupled cavities under quantum parametric excitation due to geometric changes modeled by the Hamiltonian operator (assuming dimensionless variables, setting $\hbar = \omega_0 = 1$).

$$H = \omega_1 n_1 + \omega_2 n_2 - i\chi_1 t (a_1^2 - a_1^{\dagger 2}) - i\chi_2 t (a_2^2 - a_2^{\dagger 2}) + g(a_1 a_2^{\dagger} + a_2 a_1^{\dagger}),$$

$$\chi_{mt} = (4\omega_{mt})^{-1} d\omega_{mt}/dt,$$

where $a_m$ and $a_m^{\dagger}$ are the cavity annihilation and creation operators, and $n_m \equiv a_m^{\dagger} a_m$ is the photon number operator. The frequencies of wall vibrations are chosen to be exactly twice the cavities normal frequencies $\omega_{mt} = 1 + \varepsilon_m \sin(2t + \phi_m)$ with a small modulation depth, $|\varepsilon_m| \ll 1$ and the cavities can vibrate in different regime of dephasing ($\Delta \phi = \phi_1 - \phi_2$) on the geometric changes. Assuming the condition of time independent weak coupling between the cavities ($g \ll 1$) under rotating wave approximation, we analyze the time evolution of quantum correlation properties and photon creation from proper initial Gaussian states in different regimes of quantum parametric excitation. We also consider the squeezing properties of initial Gaussian states for both modes and their relation with photon statistics for different dephasing conditions in the parametric excitation. We define two different dynamical regimes of strong and weak modulation depth ($\varepsilon_1 = \varepsilon_2 = \varepsilon$) according to the value of the ratio $\varepsilon/g$. Preliminary results show that in both cases of weak and strong modulation depth there is no entanglement between the modes if the dephasing is given by $\Delta \phi = \pi$, but if $\Delta \phi = \pi/2$, the entanglement between the coupled modes occurs fast in time in the case of strong modulation depth and slowly for the weak one.