

Theory of microwave amplifier based on single Josephson junction

We present a theory describing the recently proposed and realized microwave amplifier based on the negative resistance of a damped Josephson junction [P. Lahteenmaki et al., *Sci. Rep.* 2, 276 (2012)]. The standard linear response theory based on expansion around the limit cycle [A. Kamal et al. *Phys. Rev. B* 86, 144510 (2012)] yields nearly perfect results for the gain characteristics of the device, but it fails to describe a reported noise suppression at the working frequency of the amplifier. In order to capture the latter effect, we extend the linear response theory to account for a subtle interplay between linear fluctuations around the limit cycle and nonlinear dynamics of the phase along the limit cycle. Detailed comparison of our predictions with the experiment and implications of these findings on the prospects of achieving the originally intended quantum-limited amplification will be discussed.

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