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Nearly noiseless amplification of microwave signals with a Josephson parametric amplifier

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A degenerate parametric amplifier transforms an incident coherent state by amplifying one of its quadrature components while deamplifying the other. This transformation, when performed by an ideal parametric amplifier, is completely deterministic and reversible; therefore the amplifier in principle can be noiseless. We attempt to realize a noiseless amplifier of this type at microwave frequencies with a Josephson parametric amplifier (JPA). To this end, we have built a superconducting microwave cavity containing many dc-SQUIDs. This arrangement creates a non-linear medium in a cavity and it is closely analogous to an optical parametric amplifier. In my talk, I will describe the current performance of this circuit, where I show I can amplify signals with less added noise than a quantum-limited amplifier that amplifies both quadratures. In addition, the JPA also squeezes the electromagnetic vacuum fluctuations by 10 dB. Finally, I will discuss our effort to put two such amplifiers in series in order to undo the first stage of squeezing with a second stage of amplification, demonstrating that the amplification process is truly reversible.

M. A. Castellanos-Beltran, K. D. Irwin, G. C. Hilton, L. R. Vale and K. W. Lehnert, Nature Physics, published on line, http://dx.doi.org/10.1038/nphys1090 (2008).