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Strong field dynamics and quantum noise in Josephson traveling wave parametric amplifiers (JTWPAs) KEVIN O'BRIEN, NSF Nano-scale Science and Engineering Center, UC Berkeley, CHRIS MACKLIN, Quantum Nanoelectronics Laboratory, UC Berkeley, YUAN WANG, NSF Nano-scale Science and Engineering Center, UC Berkeley, IRFAN SIDDIQI, Quantum Nanoelectronics Laboratory, UC Berkeley, XIANG ZHANG, NSF Nano-scale Science and Engineering Center, UC Berkeley — Josephson traveling wave parametric amplifiers (JTWPAs) with resonant phase matching have demonstrated high gain over a broad bandwidth with near quantum-limited noise performance. Several amplifier non-idealities were observed in experiments, including a rapid drop in gain at a certain pump power and a near, but non-unity intrinsic quantum efficiency. To understand these non-idealities, we solve the full nonlinear wave equation for the JTWPA for a sinusoidal drive, finding higher harmonic generation and observing a blow-up at an input pump current below the junction critical current. We find analytic traveling wave solutions in the form of snoidal waves which propagate without distortion. A snoidal drive scheme may increase the drive power at which the blow-up occurs. The quantum noise properties of JTWPAs are critically important for their role as low noise amplifiers. We calculate the noise figure and find that coupling to higher order sidebands imposes an upper limit for the quantum efficiency, in good agreement with empirical results. We further show that this limit can be increased by modest changes to the phase matching of the pump and the dispersion relation.

Kevin O'Brien
NSF Nano-scale Science and Engineering Center, UC Berkeley

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