A graphene-based voltage-tunable Josephson parametric amplifier

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In recent years, 2D materials have shown their potential for quantum technologies. Applications range from single photon emitters, detectors, to quantum dots or superconducting circuits. The use of van der Waals materials brings new functionalities and enhanced performances. In the field of superconducting quantum circuits, graphene can allow gate tunability [1] and very efficient photons detectors [2]. The recent demonstration of a quantum bit based on a graphene Josephson junction has been a major milestone in this context [3].
In this work, we report the demonstration of the other key element of superconducting quantum circuit: a Josephson parametric amplifier. Tuning the critical current of the graphene Josephson junction with a simple gate voltage allows to tune the working frequency of the amplifier by about 1GHz around 5.5 GHz. We show that the performances of such amplifier (gain, saturation, noise) are on par with traditional implementations using superconducting tunnel junctions, with the additional electrical tunability in our device.
This development shows that van der Waals materials brings new opportunities in the field of superconducting quantum technologies and that they can be considered as realistic platforms for such applications.

References

[1] F. E. Schmidt et al, *Nature Communications* 9, 4069 (2018)
[2] G.-H. Lee et al, *Nature* 586, 42 (2020)
[3] J. I. Wang et al, *Nature Nanotechnology* 14, 120 (2019)

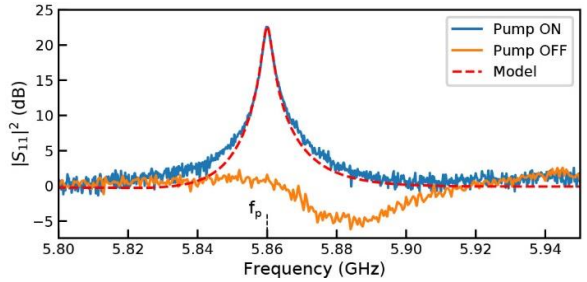

*Figure 1: **Parametric amplification**. Reflection of the device without (orange) and with (blue) an additional pump tone (at frequency f_p). In the absence of the pump, the dip indicates the resonance of the circuit. A gain exceeding 20 dB is achieved in the presence of the pump. The behavior is well reproduced with a model of parametric amplification using experimentally determined parameters (red dotted line).*

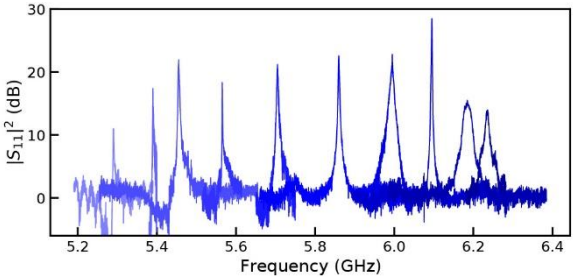

*Figure 2: **Tunability of the parametric amplifier**. Gain profile for different setpoints of the graphene Josephson junction. Tuning the gate voltage, we can change the working frequency from about 5.3 GHz (near the Dirac point) to 6.3 GHz at large carrier density.*

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