Spin-wave Amplifier Based on Parametric Pumping with Surface Acoustic Waves

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Spin-waves hold promise for applications in energy-efficient computing and radio-frequency signal processing [1,2]. However, the attenuation of spin-waves, among other limitations, has restricted the translation of laboratory proofs-of-concept into practice. In this work, we demonstrate the amplification of a coherent spin-wave by parametric pumping with a surface acoustic wave (SAW) of twice its frequency. A sustained gain of 6 dB is achieved with an acoustic pump power below the onset of parametric instability.

Spin and acoustic waves are generated in an yttrium-iron-garnet (YIG) film using transducers as illustrated in Fig. 1a. After passing through the SAW beam, the spin-wave is detected at an opposing transducer. Plotted in Fig. 1b is the gain (above propagation and transduction losses) in the spin wave signal as a function of the SAW power. The gain increases with SAW power up to about 10 dBm beyond which parametric instabilities set in. To conserve momentum in the parametric interaction, a second "idler" spin-wave is generated and propagates away at a distinct angle from the signal spin-wave to be detected at a third transducer. The strength of this idler wave, as expected, is proportional to both the input spin-wave power as well as the pump power (Fig. 1c). The data shown in Fig. 1 correspond to forward volume spin-waves of 1 GHz frequency and 30° angle of incidence, pumped by a SAW of 2 GHz. We will present additional experimental results for different angles of incidence and demonstrate agreement with simulation and theoretical predictions [3,4].

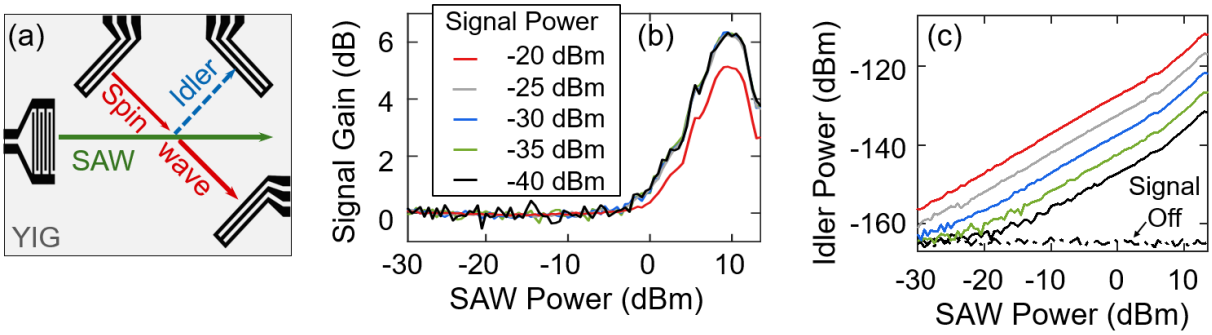

Figure 1. (a) Illustration of the experimental device. (b) Amplification of spin-waves of varying signal levels as a function of acoustic pump power. (c) Corresponding idler power.

Parametric pumping by SAW provides practical advantages to realizing a spin-wave amplifier. Pumping with a traveling acoustic wave is highly selective to amplification of specific spin-wave modes and wave vectors per energy and momentum conservation laws. Further, SAW transducers with high efficiency can be fabricated in compact form factor and are already widely used in modern communication systems. The ability to amplify spin-waves will allow for use of spin-wave media compatible with conventional integrated circuit manufacturing processes (e.g., metallic thin films)—thus, bringing spin-wave devices closer to application.

References

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