From magnon Bose-Einstein condensation to a magnonic qubit

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There is an enormous need for faster and more efficient information processing. Quantum computing is widely discussed as future computing technology, especially with regard to computing power and scaling properties.

Macroscopic quantum states of matter such as Bose-Einstein condensate (BEC) are excellent candidates for quantum information processing, particularly due to their inherent coherency. The wave function of the BEC describes a highly populated boson state and thus justifies a semiclassical approach.

In this talk, I will start with the principles of the magnon BEC. I will show that using the raping cooling mechanism as a new and universal approach enables BEC of magnons in nanostructured systems [1]. We can also prepare the magnon BEC in confined systems employing parallel parametric pumping [2]. Novel methods to manipulate the dynamics of magnon BEC based on the spin Hall effect and the lateral confinement will be discussed [2-3].

Further, I will present the way to enable room-temperature quantum computing functionalities using a two-wavevector component magnon BEC in magnetic films [4]. It is based on the fact that the dispersion characteristics of the magnons in an in-plane magnetized magnetic film have two energy minima at finite opposite wavevectors, where the magnon condensation occurs. Similar to a qubit in quantum computing, the superposition of a two-component magnon BEC can be described as a state on the surface of a Bloch sphere. We developed novel methods to initialize and manipulate such magnon BECs as a qubit representative. For instance, I will show that the magnon qubit can be initialized by wavevector selective parallel pumping enabling the single magnon BEC formation in one of the lowest energy states. Furthermore, by translating the concept of Rabi oscillations into the wavevector domain, I will demonstrate that the two components of the magnon BEC exchange their densities with time. All proposed methods are supported by numerical simulations [4].

Our investigations greatly extend the freedom to study the dynamics of magnon BEC in confined systems and to design integrated circuits for magnon BEC-based applications at room temperature. Moreover, they bridge the fields of quantum computing and macroscopic quantum states of magnons.

References:

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