Exploiting quantum magnonic states via spin fluctuations

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Magnons are the bosonic spin excitations of ordered magnets. They become the primary carriers of spin, energy, and information in magnetic insulators giving rise to the fields of magnonics and magnon spintronics. One of the key ideas in these fields is to exploit the unique bosonic features of magnons in emulating and outperforming transport phenomena that underlie the central importance of electronics in contemporary science and technology. Novel opportunities such as condensation and squeezed states, known for some bosonic platforms, promise disruptive physics and functionalities using magnons.

Conventionally, magnons are visualized as comprising of a single spin-flip and thus, spin 1. Recently, it has been shown theoretically that interactions and anisotropies result in the emergence of novel excitations comprising several spin-flips acting together [1]. These excitations, named 'squeezed-magnons' [1], bear similarities to the squeezed states of light known in the field of quantum optics. Their composite nature provides them with a non-integer net spin larger than 1, which can be probed via spin current shot noise [1]. The previous measurement of thermal spin current fluctuations [2] offers hope for the detection of the corresponding shot noise, with recent experimental efforts offering further insights [3]. While the quantum of transport is accessible to the current shot noise, quantum correlations among the carriers can be probed better via cross-correlations between the current fluctuations. Exploiting this principle, we theoretically show that spin current cross-correlations give access to the bosonic bunching of the magnons [4], which is a property of the many-body bosonic wavefunction, instead of an individual magnon.

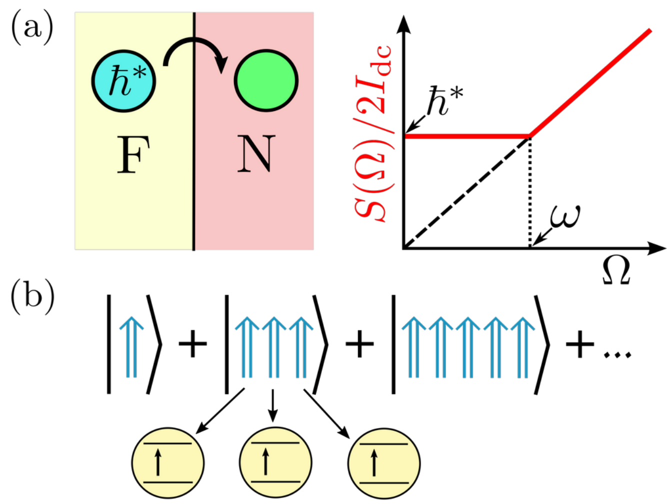

Fig. 1: (a) Spin current shot noise $S(\Omega)$ provides access to the non-integer spin of a squeezed-magnon. (b) Coherently exciting and entangling 3 qubits using the composite nature of a squeezed-magnon.

Finally, we discuss how the composite nature of squeezed-magnons can be exploited in generating on-demand entanglement of multiple qubits for error correction protocols [5]. Besides providing an alternative method for sensing the quantum nature of squeezed-magnons, it highlights their potential utility in quantum information science.

References:

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