Walther-Meißner-Institut

Bayerische Akademie der Wissenschaften

Walther-Meißner-Seminar

Walther-Meißner-Institut, Seminar Room 143

Date: **Special Date: Tuesday 14, February 2017, 13:30 h**

Speaker: **Dr. Ahmad A. Awad**

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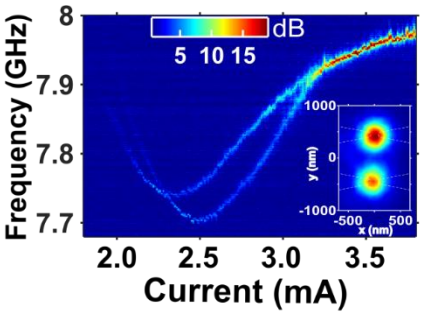
Title: **Long-range mutual synchronization of spin Hall nano-oscillators**

Abstract:



The spin Hall effect [1] arises when an electric charge current passes through a non-magnetic metal with strong spin-orbit coupling, thus generating a transverse spin current. Such transverse pure spin currents can exert an effective spin transfer torque on adjacent magnetic layers, resulting in the generation of auto-oscillations and spin waves. Such a device is referred to as a spin Hall nano-oscillator (SHNO) [2]. These devices hold great promise as extremely compact, broad-band, and versatile microwave oscillators and have unique opportunities for magnonic devices.

The synchronization of nano-contact based spin torque oscillators has been demonstrated [3] and shown to, among other aspects, improve their RF emission characteristics. SHNOs exhibit a strong nonlinearity, which increases their phase noise, but at the same time, strengthens their propensity for injection locking [4] to external sources, and ultimately the possibility of mutual synchronization.

Here, we present the first experimental demonstration of the mutual synchronization of nano-constriction SHNOs. The mutual synchronization is observed both as a strong increase in the power and coherence of the electrically measured microwave signal, Fig. 1(main panel). The mutual synchronization is also optically probed using scanning micro-focused Brillouin light scattering microscopy (μ-BLS), Fig. 1(inset), providing the first direct imaging of synchronized nano-magnetic oscillators.

Our results [5] on mutual synchronization of SHNOs opens up many research and application opportunities where coherent phase locking is needed, e.g. for energy efficient spin wave computing on the nanoscale.

[1] J. E. Hirsch. (1999) Phys. Rev. Lett. **83**, 1834.
[2] V. E. Demidov, et al., (2012), Nature Mater. **11**, 1028, & V. E. Demidov, et al. (2014), Appl. Phys. Lett. **105**, 172410.
[3] F. B. Mancoff, et al., (2005**),** Nature 437, 393. S. Kaka, et al., (2005)**,** Nature **437**, 389. S. Sani, et al. (2013), Nat. Commun. **4**, 2731. A. Houshang, et al., (2016), Nat. Nanotechnol. **11**, 280.
[4] V. E. Demidov, *et al.* (2014), Nat. Commun. **5**, 3179.
[5] A. A. Awad, et al., (2016), Nature Phys. AOP. doi:10.1038/nphys3927

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