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(G*) POS-G68 – The Einstein-de Haas Effect in Yttrium Iron Garnet at 3 MHz

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The classical Einstein-de Haas (EdH) effect [1] is a AC mechanical torque arising from a time rate of change of net magnetization, and represents the intrinsic relationship between magnetism and mechanical angular momentum. Nanofabrication of torque sensing devices is opening new avenues for exploration and applications of the EdH effect. The scale-up of resonance frequencies with continued miniaturization of mechanical torque sensing resonators enhances EdH torques, which increase linearly with drive frequency, relative to frequency-independent magnetic cross-product torques. Previously, miniaturized EdH experiments have been performed at the microscale using mechanical modes in the audio frequency range (13 kHz) [2]. The present work brings the measurements to radio frequencies.

Single-crystal Yttrium Iron Garnet (YIG) disks with magnetic vortex ground states are mounted on nano-scale mechanical resonators with a torsional resonance mode close to 3 MHz. For DC bias fields below about 200 A/m the maximum cross-product torques remain smaller than the EdH torques [3]; no control of the field geometry to null cross-product torques is required. Quadrature lock-in measurements allow cross-product and EdH torque signals to be recorded simultaneously, owing to a 90° relative phase shift arising between the driving torques, and referenced to the phase of the driving field. The simultaneous measurement scheme enables determination of the magnetomechanical ratio, g', without requiring separate experimental inputs. Results from measurements around the full vortex hysteresis loop, and comparisons with micromagnetic simulations of cross-product and EdH torques, also will be discussed.

[1] A. Einstein and W.J. de Haas, Proceedings - KNAW **18**, 696 (1915).

[2] T.M. Wallis, J. Moreland, and P. Kabos, Appl. Phys. Lett. **89**, 122502 (2006)

[3] K. Mori, M.G. Dunsmore, J.E. Losby, D.M. Jenson, M. Belov, and M.R. Freeman, Phys. Rev. B **102**, 054415 (2020)

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