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Magnetic van der Waals membranes in motion

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Atomically thin membranes are ideal building blocks for nanoelectromechanical systems (NEMS) because of their unique mechanical properties and their low mass. We make membranes by transferring atomically thin layers on top of silicon oxide substrates that are pre-patterned with (circular) holes. The suspended membranes are characterized by a laser interferometer set-up that gives access to information on the dynamics in the frequency- and time-domain. The interferometer setup is equipped with a moveable x-y stage so that the membrane motion can be visualized with a lateral resolution of 140 nm and a displacement resolution of 11 fm/$\sqrt{\text{Hz}}$; additionally, the nonlinear response of the motion can be used to extract the mechanical parameters such as the Young's modulus. Recently, it has become clear that nanomechanics can probe thermodynamic properties such as thermal conductivity, specific heat, and thermal expansion [Dynamics of 2D material membranes, 2D Materials 8 (2021) 042001]. Specifically, we have detected the Néel temperature of antiferromagnetic FePS3 membranes as (magnetic) phase transitions are typically accompanied by abrupt changes in the specific heat, resulting in accompanying changes in the strain of the material. This strain change modifies the resonances frequencies which together with the Q-factor of the resonance are detected as a function of temperature. In this way, the free-hanging van der Waals materials are probed without the need of electrical contacts and without the interaction with substrate, purely by mechanical means.

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