

# Spin-to-charge conversion in Antiferromagnetic van der Waals Heterostructure

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Van der Waals (vdW) heterostructures, created through the vertical stacking of diverse two-dimensional (2D) materials, offer an ideal platform for the deliberate design of emergent phenomena and cutting-edge device applications. The recent discovery of atomically thin magnetic vdW materials has opened new avenues for exploring 2D magnetism in magnetic vdW heterostructures. Here, low-temperature magnetotransport studies combined with Raman spectroscopy have been performed on FLG/FePS<sub>3</sub> heterostructures, revealing a potential magnon-to-charge conversion at the interface. The three spin-phonon coupled modes of FePS<sub>3</sub> exhibit a departure from anharmonic behavior around 120 K, similar to its pristine form with enhanced deviation from anharmonicity,  $\Delta\omega$ . In the heterostructure, the magnon mode of FePS<sub>3</sub> shows a blueshift in frequency as the temperature rises, while magnon stiffness decreases with lowering temperature. Magnetotransport measurements indicate that FLG shows negative magnetoresistance at low fields, resulting from the coupling of surface electrons in FLG with magnons in FePS<sub>3</sub>, sustaining negative MR up to around 100 K. This magnon-to-charge conversion enhances the electron-magnon coupling strength at the interface and the conversion weakens with decreasing layer thickness, leading to diminished electron-magnon coupling and a suppression of negative MR in heterostructures with thinner FePS<sub>3</sub>. Additionally, the observed negative magnetocapacitance effect in the FLG/FePS<sub>3</sub>/FLG heterostructure suggests a coupling between magnons and interfacial electric displacement [1]. These findings may pave the way for electric field control of magnons, facilitating the development of magnon-based logic devices.

## References:

[1] S. Maity and S. Datta, Phys. Rev. B 111 (2025) L140407