Antiferromagnetic ordering in van der Waals two-dimensional magnetic material $MnPS_3$ probed by Raman spectroscopy

Kangwon Kim[1]
Soo Yeon Lim[1], Jungcheol Kim[1], Jae-Ung Lee[2], Sungmin Lee[3], Pilkwang Kim[3], Kisoo Park[3], Suhan Son[3], Cheol-Hwan Park[3,*], Je-Geun Park[3,*], and Hyeonsik Cheong[1,*]

[1]*Department of Physics, Sogang University, Seoul 04107, South Korea*
Department of Physics, Ajou University, Suwon 16499, South Korea
Department of Physics and Astronomy, Seoul National University, Seoul 08826, South Korea

hcheong@sogang.ac.kr

Magnetic ordering in the two-dimensional (2D) limit has been one of the most important issues in condensed matter physics for the past several decades. The recent discovery of new magnetic van der Waals materials heralds a much-needed easy route for the studies of two-dimensional magnetism: the thickness dependence of the magnetic ordering has been examined by using Ising- and XXZ-type magnetic van der Waals materials [1, 2]. Here, we investigated the magnetic ordering of $MnPS_3$, a two-dimensional antiferromagnetic material of Heisenberg-type, by Raman spectroscopy from bulk all the way down to bilayer. The phonon modes that involve the vibrations of Mn ions exhibit characteristic changes as temperature gets lowered through the Néel temperature. In bulk $MnPS_3$, the Raman peak at ~155 cm^{-1} becomes considerably broadened near the Néel temperature and upon further cooling is subsequently red-shifted. The measured peak positions and polarization dependences of the Raman spectra are in excellent agreement with our first-principles calculations. In few-layer $MnPS_3$, the peak at ~155 cm^{-1} exhibits the characteristic red-shift at low temperatures down to the bilayer, indicating that the magnetic ordering is surprisingly stable at such a thin limit.

References

[1] J.-U. Lee *et al.*, Nano Letters, **16**(20) (2016) 7433.
[2] K. Kim *et al.*, Nature Communications **10**(1)(2019) 345.

Figures

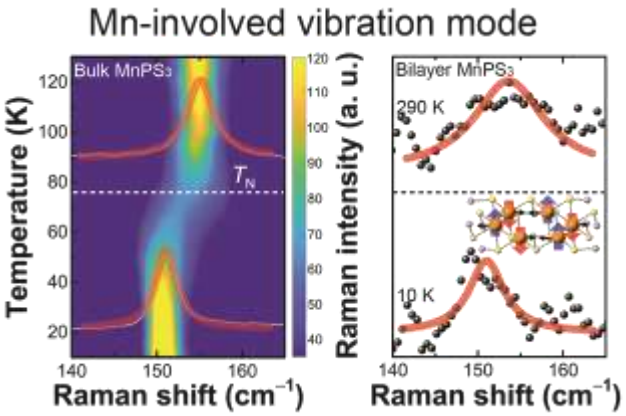

Figure 1: Temperature dependence of Raman spectra for bulk $MnPS_3$ and Raman spectra of bilayer $MnPS_3$ at 290 and 10 K.