Ho_2IrSi_3: A new geometrically frustrated antiferromagnetic compound with large crystalline electric field splitting

Sudip Chakraborty,[1] Santanu Pakhira,[2] Shovan Dan,[3] and Chandan Mazumdar[1]

[1] *CMP Division, Saha Institute of Nuclear Physics, A CI of Homi Bhabha National Institute, 1/AF Bidhannagar, Kolkata 700064, India*

[2] *Ames National Laboratory, Iowa State University, Ames, Iowa 50011, USA*

[3] *CMP Division, Tata Institute of Fundamental Research, Homi Bhabha Road, Colaba, Mumbai 400005, India*

Geometrically frustrated magnets are considered of great interest as they provide a plentiful opportunity for discovering complex spin textures. The recent discovery of magnetic skyrmion in the frustrated centrosymmetric triangular antiferromagnet Gd_2PdSi_3 [1] have drawn a lot of interest in R_2TX_3 (R=rare earth, T=transition element, X=p block element) series which are known to show diverse novel magnetic ground states.
In this work, we have synthesized a new intermetallic polycrystalline material Ho_2IrSi_3 in single phase forming in edge sharing triangular lattice geometry (space group: *$P6_3$/mmc, No. 194*). The dc magnetic measurements, together with heat capacity data suggest the system to order antiferromagnetically at ∼3.4 K. A rather high value of negative Weiss temperature estimated from the dc magnetic susceptibility data in comparison to its Neel temperature suggest presence of a large fraction of magnetically frustrated spins (frustration parameter, $f =\mid \theta_p \mid / T_{\rm N} \sim 5$). As expected for an antiferromagnet (AFM), the isothermal magnetisation, $M(H)$, exhibit linear behavior in low field region and no hysteresis. However, $M(H)$ at low temperatures tends to saturate at high field, with a value of 7.1 $\mu_{\rm B}$/Ho-ion at T=2 K and H=70 kOe. This is rather large value for a simple AFM system, indicating the additional contributions from the frustrated spins under the influence of high field. As the system form in triangular lattice geometry, one may expect a competing ferromagnetic (FM) and AFM interaction, where the FM components tends to overwhelm with increasing strength of applied magnetic field [2]. The long range nature of magnetic ordering is reflected in the lambda-like peak in heat capacity data, although the magnetic entropy at $T_{\rm N}$ is only 20% of Rln17, expected for Ho-ion. The value is even lower than that expected from a doublet ground state, suggesting a large fraction of Ho-spins are indeed remain frustrated. The magnetic ordering also appears to be quite fragile, as a relatively weak external field of 10 kOe is sufficient to suppress the magnetic ordering below 2 K. One of the major finding of this work is very large splitting of crystalline electric field parameters, as reflected in unusually prominent broad peak in the heat capacity data.

References:

[1] T. Kurumaji et al., **Science**, 365, 914 (2019)
[2] Sudip Chakraborty et al., **Phys. Rev. B**, 106, 224427 (2022)