

Universality of defect-skyrmion interaction profiles

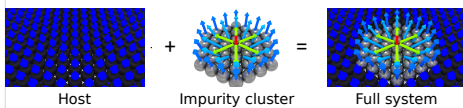
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Introduction

- Owing to their topology, magnetic Skyrmions are considered as potential particles for future information technology.
- Skyrmions require smaller current densities compared to those needed for the manipulation of domain walls¹.
- Skyrmions interact with defects, affecting their creation, stability and motion.
- Defects could lead Skyrmions to pinning².
- PdFe atomic bilayer on Ir(111)^{3,4} is investigated to determine the impact of 3d and 4d defects on the energetics, electronic and magnetic properties of Skyrmions.

KKR-Method

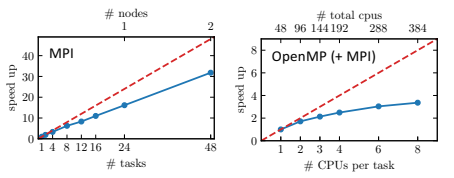
Calculations performed with the full-potential, relativistic KKR Green function method⁵. Skyrmions and impurities can be treated **fully within DFT**, using the embedding technique⁶:



which makes use of the Dyson equation

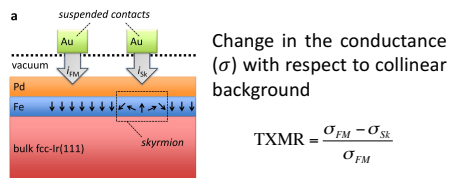
$$G_{Sk}(E) = G_{FM}(E) + G_{FM}(E)\Delta V G_{Sk}(E).$$

- Isolated Skyrmions can be treated without the need for supercells.
- KKR can simulate system with ~200 atoms.

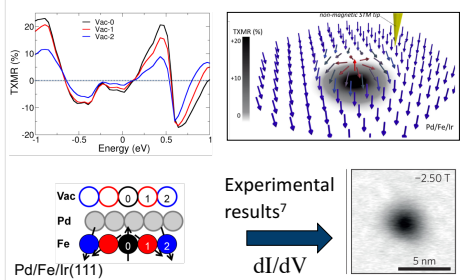


Tunneling spin-mixing magnetoresistance (TXMR)

Electrical detection of magnetic Skyrmions³

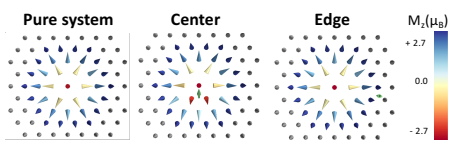


Local transport properties are sensitive to the spin-mixing (non-collinearity)

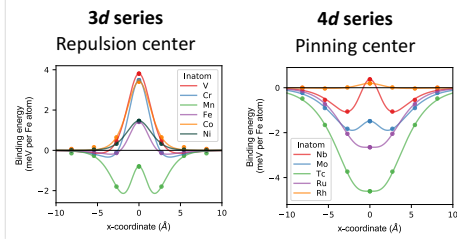


Skyrmion-defect interaction

- PdFe atomic bilayer on Ir(111).
- Impact of 3d and 4d inatoms and adatoms defects⁸.
- Impurities lower the magnetic exchange within the Fe layer favoring the skyrmion creation.

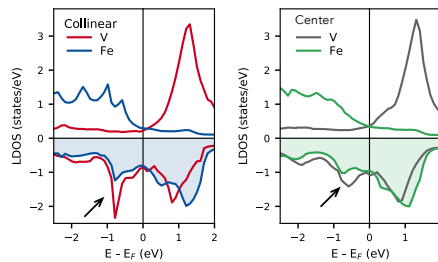


- Large impurity magnetic moments lead to a repulsion of the skyrmion whereas small ones attract it.
- Biding energy is related to the chemical nature of the defects



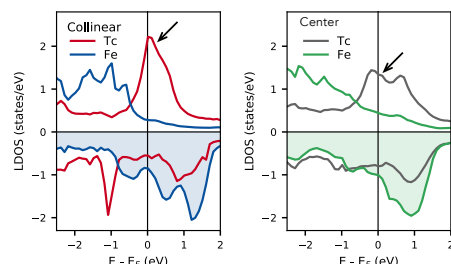
Electronic structure

- V-inatom at the center suppresses the bonding states.



Collinear configuration is more favorable

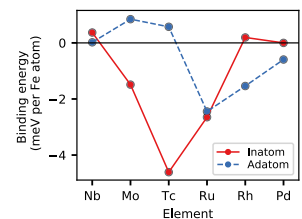
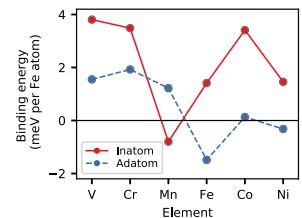
- Tc-inatom at the center occupies the bonding states.



Non-collinear configuration is more favorable

Universality of the energy-profile

- Impurities located close to the skyrmion center



- Qualitatively similar to the universal trend of cohesion or surface energies of transition metals⁹.
- Universality** of the interaction profile allows to predict the interaction for other elements.
- Co-adatom is inert: non-ability of recent STM experiments to use it for skyrmions manipulation¹⁰.

Conclusions and Outlook

- Protocol for electrical detection of magnetic skyrmions confirmed experimentally⁷.
- Identification of the pinning mechanism of single magnetic skyrmions as function of the chemical nature of the impurities.
- Universality of the energy-profile can predict the skyrmion-defect interaction for other elements of the periodic table.
- The energy landscape produced by different defects can be used to engineer new spintronics devices with man-made defects to guide the skyrmion motion.

Acknowledgments

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