# The Effect of Interfacial Roughness on a Skyrmion Structure

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## 1. Introduction

Recently, magnetic skyrmions draw a lot of interests because of their fascinating properties for spintronic devices such as topological stability, high density, and energy efficiency[1]. Although skyrmions are topologically stable, they are inevitably influenced by the interfacial roughness and the thermal fluctuation since they are formed in a monolayer-scaled-thickness thin film. To study such atomistic effects on skyrmion, a numerical method based on the atomistic model for spin dynamics is necessary. In this work, we investigate the effect of roughness on a skyrmion by atomistic simulation [2].

## 2. Simulations

As a model system, 2-monolayers Conanodisk with 60 nm diameter is used in our atomistic simulations. As shown in Fig. 1(a), Co film has face centered cubic (FCC) structure with the lattice constant of 2.5 Å and the interfacial Dzyaloshinskii-Moriya interaction (DMI) appears only at the bottom layer (red colored line) [3][4]. The atomistic material parameters for Co are obtained from experiments [2]: the atomic moment is 1.72 $\mu_B$, the exchange contant $J_{ij}$= $2.0\times10^{-21}$ J/link, the atomistic magnetocrystalline anisotropy $k_u$ = $2\times10^{-23}$ J/atom with the direction perpendicular to the nanodisk plane. The magnitude of DMI is $1.87\times10^{-22}$ J/link, and it is applied as the tensor form of magnetic interaction between neighbor spins. As shown in Fig. 1(b), the radomly formd atomic defects at the bottom monolayer give rise to the interfacial roughness[5].To obtain the stable skyrmion structure, the initial skyrmion configurations which are formed artifically are relaxed during 500 ps with damping constant $\alpha$ = 0.5 under 0 K.

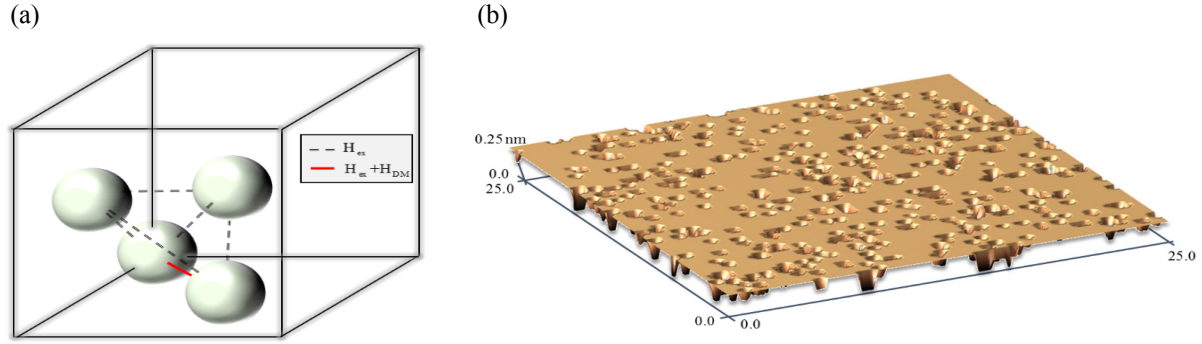


**Fig. 1.** (a) Unitcell of Co layer and its magnetic interaction. (b) Surface morphology of the interfacial bottom monolayer.

## 3. Result and Discussion

As shown in Fig. 2, the skyrmion size varies dramatically with roughness, the number of atomic defects; the area of skyrmion decreases exponentially with the number of atomic defects. Which is attributable to the fact that the interfacial defects decrease the number of the spin-orbit coupling between the heavy metal atoms and Co atoms. Consequently, the magnitude of DMI on the whole Co layer decreases with the number of interfacial defects.

These results suggest the fundamental reason about the difference between theoretical value of DMI and experimental one.

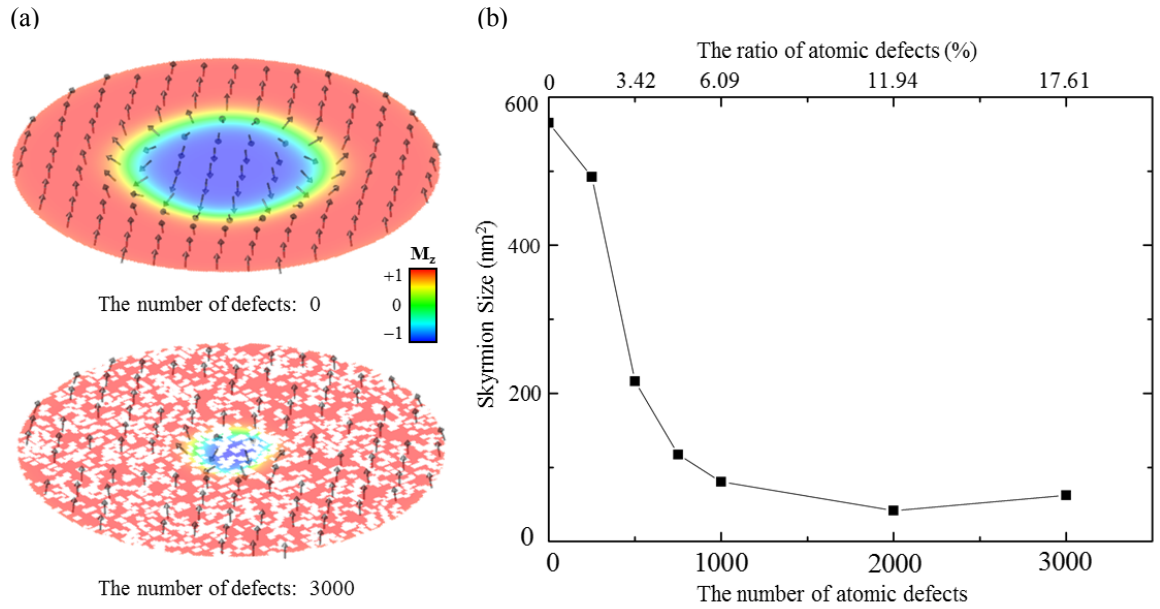


**Fig. 2.** (a) Atomic spin configurations of the skyrmios with different numbers of defects. (b) Area of the skyrmion as a function of the number of defects. The upper X axis indicates the ratio of the total number of atoms at the interface.

## 4. References


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