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Microscopic Origin of Dzyaloshinskii-Moriya Interaction

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It has been demonstrated that the Dzyaloshinskii-Moriya interaction (DMI) at the interface between a ferromagnetic (FM) and a heavy nonmagnetic metals (HM) has an essential role for forming chiral spin objects such as the skyrmion and the Néel-type domain wall [1,2]. The objects can be widely utilized for the next generation data storage devices [1-3]. However, the microscopic origin of the interfacial DMI is still controversial issue [4,5]. In this study, we experimentally examine the microscopic origin of the DMI. Our nucleation measurement result based on the droplet model demonstrates the strong temperature dependence of DMI-induced effective field in the Co/Pt bilayer. On the other hands, the x-ray magnetic circular dichroism measurement exhibits that the perpendicular orbital moment and the dipole moment increase at low temperature while the in-plane orbital moment is almost temperature-independent. The theoretical investigation based on the tight-binding model qualitatively reproduces the experimental results, showing that orbital-to-orbital electron hopping with the inversion symmetry breaking is related to the perpendicular orbital moment. Furthermore, the density functional theory calculation exhibits that the orbital anisotropy and the dipole moment has clear correlation with DMI. This microscopic study will provide the way to figure out various DMI-related phenomena in FM/HM systems.

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