



Comment on “Spin and Orbital Polarizations of Au(111) Surface State Determined by Photoelectron Momentum Microscope”

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Matsui et al. recently reported spin- and angle-resolved photoemission spectroscopy (SARPES) measurements of the Au(111) surface state and discussed the spin texture of the Rashba-split surface-state bands.¹⁾ In their paper, they pointed out that previous studies have reported inconsistent clockwise (cw) and counterclockwise (ccw) assignments of the spin orientation in Rashba surface states, as viewed from the vacuum side, and emphasized the importance of resolving this discrepancy. This issue is not limited to Au(111),^{2–6)} but is also relevant to SARPES studies of noble-metal (111) Rashba surface states, including Ag(111) and Cu(111).^{7,8)}

In this Comment, we point out that, in comparing such cw/ccw assignments, it is essential to distinguish the definition of the “spin direction”. In particular, the apparent discrepancy between the assignment in Ref. 1 and those in Refs. 6 and 8 for noble-metal (111) Rashba surface states can be understood by distinguishing the direction of the spin magnetic moment from the expectation value of the Pauli spin operator, or equivalently, the direction of the spin angular momentum.

For an electron, the spin magnetic moment μ_s is antiparallel to the spin angular momentum S , and is given by

$$\mu_s = -g_s \mu_B \frac{S}{\hbar},$$

where g_s , μ_B , and $\hbar$ denote the electron spin g -factor, the Bohr magneton, and the reduced Planck constant, respectively. Therefore, even for the same physical spin texture, the cw/ccw assignment is reversed depending on whether the spin arrows represent S or μ_s .

In Appendix A of Ref. 1, Matsui et al. discussed the calibration of the spin-detection sign using remanently magnetized Ni(110). In particular, Fig. A.1(b) shows the “spin” direction in relation to the magnetization direction and the majority/minority spin bands. Since this calibration is based on the magnetization direction, the spin arrows in Fig. A.1(b) are interpreted as representing the direction of the spin magnetic moment rather than the spin angular momentum. The cw/ccw assignment for the Au(111) Rashba

surface state in Ref. 1 is then understood to follow this convention. On the other hand, in Refs. 6 and 8, the spin texture was represented in terms of the spin angular momentum. Taking this distinction into account, the cw/ccw assignment in Ref. 1 and those in Refs. 6 and 8 can be understood as the same physical spin texture expressed using different definitions of the spin direction.

Although the present Comment does not attempt to determine which convention was used in every previous report, this example shows that an apparent discrepancy in cw/ccw assignments can arise from different definitions of the spin direction. Therefore, when comparing spin textures in Rashba systems, topological surface states, and related spin–orbit-coupled electronic states, it is important to specify whether the spin arrows or cw/ccw labels represent the spin angular momentum or the spin magnetic moment.

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