# Observation of flat bands, mirror-odd and mirror-even spin texture in epitaxially strained $RuO_2$

Yichen Zhang[1], Seung Gyo Jeong[2], Luca Buiarelli[2], Seungjun Lee[3], Yucheng Guo[1], Jiaqin Wen[1], Hang Li[4], Sreejith Nair[2], In Hyeok Choi[5], Zheng Ren[1], Ziqin Yue[1,6], Alexei Fedorov[7], Sung-Kwan Mo[7], Junichiro Kono[1,8,9,10,11], Jong Seok Lee[5], Tony Low[3], Turan Birol[2], Rafael M. Fernandes[12], Milan Radovic[4], Bharat Jalan[2], Ming Yi[1,8,11]

[1]*Department of Physics and Astronomy, Rice University, Houston, Texas 77005, USA*
[2]*Department of Chemical Engineering and Materials Science, University of Minnesota-Twin Cities, Minneapolis, Minnesota 55455, USA*
[3]*Department of Electrical and Computer Engineering, University of Minnesota-Twin Cities, Minneapolis, Minnesota 55455, USA*
[4]*Photon Science Division, Paul Scherrer Institute, Villigen 5232, Switzerland*
[5]*Department of Physics and Photon Science, Gwangju Institute of Science and Technology (GIST), Gwangju 61005, Republic of Korea*
[6]*Applied Physics Graduate Program, Smalley-Curl Institute, Rice University, Houston, Texas 77005, USA*
[7]*Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA*
[8]*Rice Center for Quantum Materials, Rice University, Houston, Texas 77005, USA*
[9]*Department of Electrical and Computer Engineering, Rice University, Houston, Texas 77005, USA*
[10]*Department of Materials Science and NanoEngineering, Rice University, Houston, Texas 77005, USA*
[11]*Smalley-Curl Institute, Rice University, Houston, Texas 77005, USA*
[12]*Department of Physics, University of Illinois Urbana-Champaign, Urbana, Illinois 61801, USA*

Recently, rutile $RuO_2$ has gained significant renewed interest due to the predicted prominent altermagnetic spin splitting. Accumulating experimental evidence shows that, on the contrary, $RuO_2$ in its bulk and thick film form lacks magnetism. However, the magnetic nature of $RuO_2$ remains poorly explored in the ultrathin limit where epitaxial strain from a substrate could be significant. Here, using spin-resolved angle-resolved photoemission spectroscopy supported by ab-initio calculations, we provide the first observation of the electronic dispersions characterized by flat bands near the Fermi level and the coexisting mirror-odd and mirror-even momentum-dependent spin texture in 2.7 nm $RuO_2$ epitaxial heterostructures. We unbiasedly analyze all the nonmagnetic and magnetic possibilities giving rise to such spin texture based on symmetry analyses. The work provides key insights into the topological and magnetic properties of ultrathin $RuO_2$ epitaxial layers and serves as a foundation for deepening the understanding of symmetry breaking in strain-engineered $RuO_2$.