Observation of distinct spatial distributions of the zero- and non-zero energy vortex modes in $(Li_{0.84}Fe_{0.16})OHFeSe$

Tianzhen Zhang[1†], Weicheng Bao[2,3†], Chen Chen[1†], Yining Hu, Wentao Yang, Dongming Zhao, Yajun Yan, Dong Li, Peipei Shen, Xiaoli Dong, Zhongxian Zhao, Qianghua Wang[*], Tong Zhang[*], Donglai Feng[*]

[1] *State Key Laboratory of Surface Physics, Department of Physics, and Advanced Materials Laboratory, Fudan University, Shanghai 200438, China*

[2] *National Laboratory of Solid State Microstructures & School of Physics, Nanjing University, Nanjing, 210093, China*

[3] *Zhejiang University of Water Resources and Electric Power, Hangzhou 310018, China*

+E-mail: tianzhen_zhang@fudan.edu.cn

Keywords: Vortex imaging; Vortices in meso- and nanoscale systems; Vortex matter vs. pairing symmetry; Topological superconductors/ hybrids (FM-SC)/Semiconductor – SC; Superconductivity in 2D and interface superconductivity

The energy and spatial distributions of vortex bound state in superconductors carry important information about superconducting pairing and the electronic structure. Although discrete vortex states, and sometimes a zero-energy mode, had been observed in several iron-based superconductors, their spatial properties are rarely explored. In this study, we used low-temperature scanning tunneling microscopy (STM) to measure the vortex state of (Li, Fe)OHFeSe with high spatial resolution. We found that the non-zero energy states display clear spatial oscillations with a period corresponding to bulk Fermi wavelength; while the zero-energy mode doesn't show such oscillation, which suggests its distinct electronic origin. Furthermore, the oscillations of positive and negative energy states near E_F are found to be clearly out-of-phase. Based on a two-band model calculation, we show that our observation is mostly consistent with an s_{++} wave pairing in the bulk of (Li, Fe)OHFeSe, and superconducting topological states on the surface.

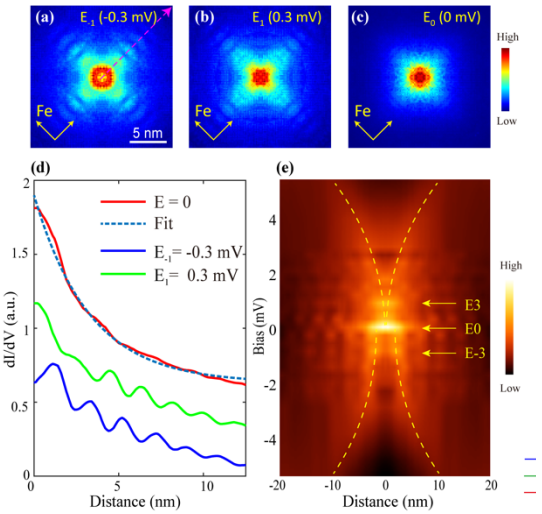

Fig.1(a,b,c) Four-fold symmetrized dI/dV maps of the E_{-1}, E_1 , E_0 states, respectively. (d) Vortex state profile: Line cuts taken along the Fe-Fe direction of the dI/dV maps of E_1, E_0, E_{-1} states. (e) Color plot of the symmetrized dI/dV line cuts taken at various energies.

Reference:

[1] Tianzhen Zhang, et al. Observation of distinct spatial distributions of the zero- and non-zero energy vortex modes in $(Li_{0.84}Fe_{0.16})OHFeSe$, submitted to PRL