

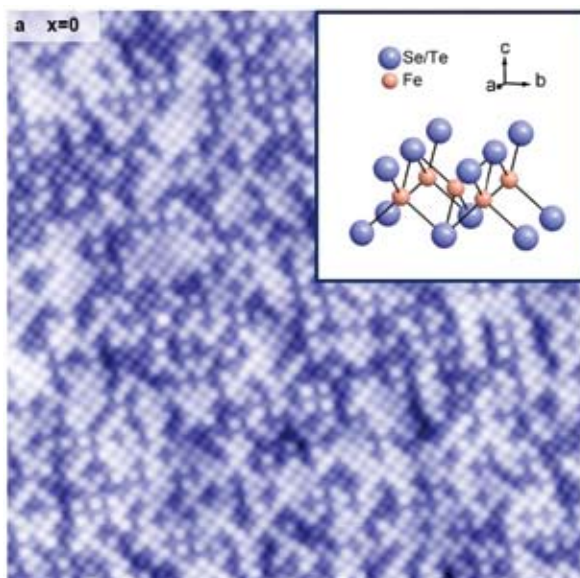
A Majorana-like State Discovered in the Iron-based Superconductor

In superconductors, fermionic electrons are paired into bosons, and condensed into the ground state. An impurity can break the electron pairs into quasi-particles with energy states inside the superconducting gap. The characteristics of such in-gap states reflect accordingly the properties of the superconducting ground state. A zero-energy in-gap state is particularly interesting, because it can be the consequence of unconventional pairing symmetry or nontrivial topology.

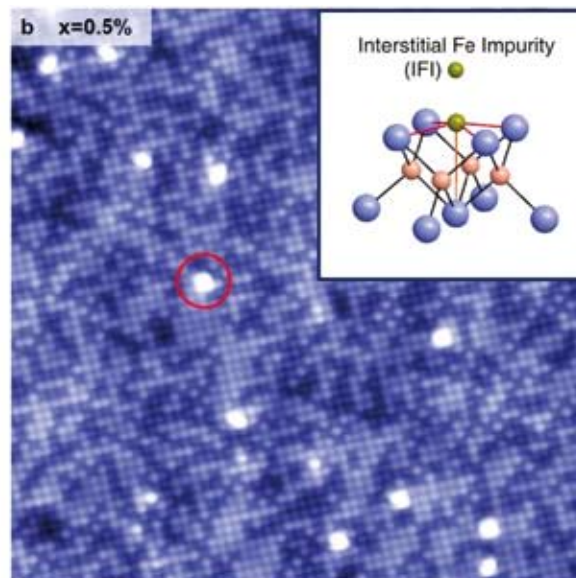
Scanning Tunnelling Microscopy/Spectroscopy (STM/S) is a powerful technique to study the impurity effect at low temperature with ultra-high spatial and energy resolution. However, the impurity study in recently found Iron-based superconductors is a challenging task, because the cleaving surface of the single crystals of these materials usually contains many kind of impurities and most of impurity-induced state are too weak to do further interpretations. After studying the impurities and impurity-induced states using STM/S for many kinds of iron-superconductor families and over hundreds of samples, recently YIN Jiaxin in groups led by Prof. PAN Shuheng and Prof. DING Hong from the

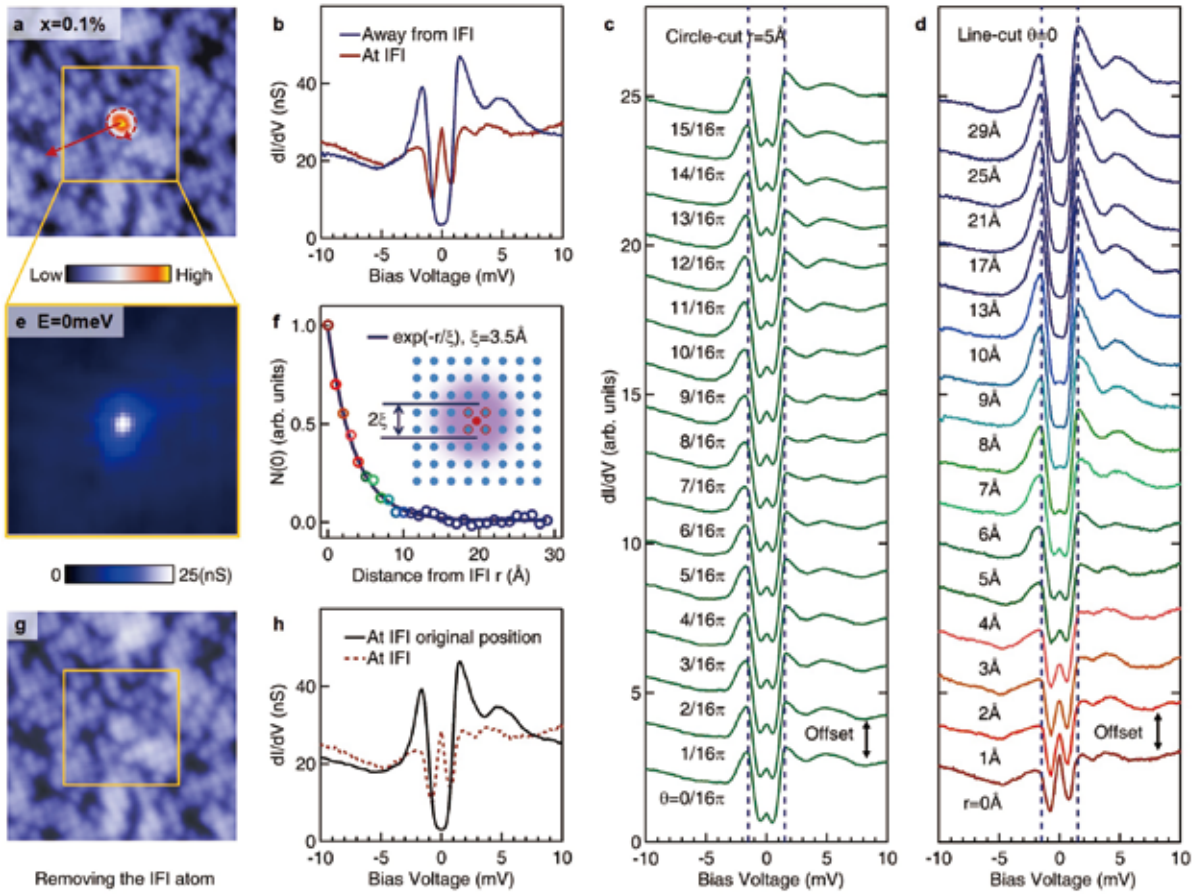
Institute of Physics (IOP), CAS have discovered a sharp impurity state at the interstitial Fe impurity site in iron superconductor Fe(Te,Se).

They found this impurity state has many unique properties. It is bound to the interstitial Fe impurity with a very short decay length of $\sim 10 \text{ \AA}$. Moreover, it is isotropic and only exists in the superconducting state. More noticeably, this state locates at zero energy and such zero-energy bound state is robust against a magnetic field up to 8 Tesla, as well as perturbations by neighboring impurities. As a sharp contrast, for conventional impurity state, it usually manifests as two peaks, symmetrically with respect to zero energy, and even if the two peaks both happen to be at zero energy, they would be Zeeman-split or shifted away from zero energy by either magnetic field or impurity-impurity interactions. Moreover, the robust zero-energy bound state bears all the characteristics of the Majorana bound state proposed for topological superconductors. All these indicate that the superconducting state and the scattering mechanism of the interstitial Fe impurities in Fe(Te,Se) are highly nontrivial.

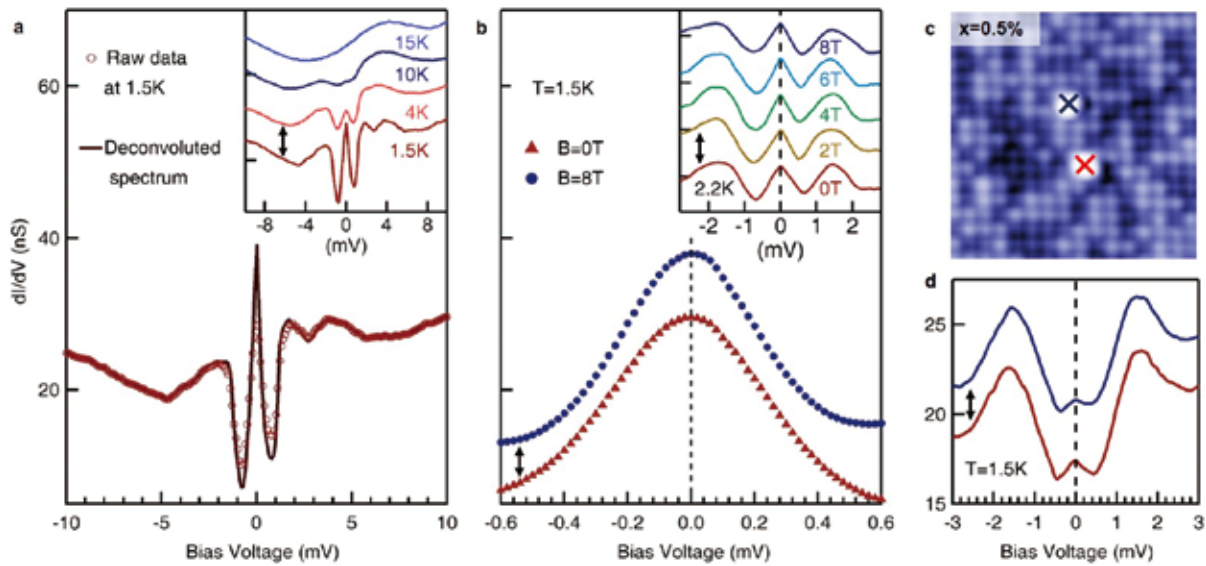


Observation of excess Fe impurity at the interstitial position.





Interstitial Fe impurity (IFI) induced zero bound state (ZBS).



Perturbations of the ZBS by temperature, magnetic field and impurity-impurity interactions.

This study, “Observation of a robust zero-energy bound state in iron-based superconductor Fe(Te,Se)”, was published in *Nature Physics* on July 1st, 2015. The project

is supported by the *National Natural Science Foundation* of China, the Ministry of Science and Technology of China, the CAS, and some grants from US.