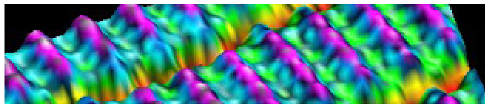



# Everything Old is New Again

## Finding the Source of Magnetism in Iron-Based Superconductors

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Iron and magnetism have a long and rich history, dating to the days when the ancients realized that lodestone, a naturally magnetized mineral, could attract a piece of iron. That revelation gave rise to the compass, which helped guide explorers cross oceans and served as an early example of the practical applications made possible by scientific discovery. In recent years, researchers like Physics Professor Pengcheng Dai and his colleagues have found that the story of magnetism and iron has some new and exciting chapters still to write, as evidenced in their latest paper, "Nature of Magnetic Excitations in Superconducting $BaFe_{1.9}Ni_{0.1}As_2$," which appeared online in *Nature Physics* on March 25.

Physics graduate student Mengshu Liu is the first author on the paper, which takes the Dai group deeper into the fascinating world of superconductors. In these materials, electrons—which by nature repel one another—group themselves in pairs and allow electric current to move along uninterrupted below the superconducting transition temperature $T_c$. The challenge has been finding materials that can reach and sustain this phenomenon at high temperatures (high-$T_c$), where the applications (levitating trains, for example) would have the most impact. For many years the focus of superconductivity research was the cuprates: materials made from copper and oxygen that become superconducting at temperatures well above liquid nitrogen temperature (77 K). In 2008, however, iron re-asserted itself when scientists created compounds made of iron and arsenic and found they exhibited superconductivity at temperatures up to 55 K, thus creating a second class of high-$T_c$ superconductors.

For this latest work in *Nature Physics*, Liu et al studied samples comprising barium, iron, nickel, and arsenic. They were curious about a central question that has surrounded iron-arsenic superconductors since their discovery: how does the magnetism originate? Is it the result of weakly-correlated electrons, as in chromium? Strong electron correlations? Or maybe, as with the cuprates, localized electrons, which tend to stay in one place?

Working at the Rutherford Appleton Laboratory in the United Kingdom, the group performed inelastic neutron scattering experiments on superconducting $BaFe_{1.9}Ni_{0.1}As_2$ and its parent non-superconducting $BaFe_2As_2$ to find some answers. This technique scatters neutrons from a sample, causing a change in their energy. The process allows scientists to measure a material's excitations in terms of spin, for example, or magnetism. They found that samples of both iron-arsenic materials had fluctuating magnetic moments similar to those found in copper oxides. The experimental results show a common theme in both classes of high-$T_c$ superconductors: magnetic excitations are partly-localized in character, an indicator of the importance of strong electron correlations in high-$T_c$ superconductivity. As scientists gather more information about the properties of superconductors, particularly across different types of materials, they lay the groundwork for potential applications that can take advantage of this promising natural phenomenon.

In addition to Liu and Dai, the paper's co-authors include Leland Harriger, another UTK physics graduate student; Huiqian Luo of the Beijing National Laboratory for Condensed Matter Physics; Meng Wang of UTK and the Beijing National Laboratory for Condensed Matter Physics; Russell Ewings and Tatiana Guidi of the ISIS Facility at Rutherford Appleton Laboratory; Hyowon Park, Kristjan Haule, and Gabriel Kotliar of Rutgers University; and Stephen Hayden of the University of Bristol (UK).