

Terahertz pulse-driven collective mode in the nematic superconducting state of $\text{Ba}_{1-x}\text{K}_x\text{Fe}_2\text{As}_2$

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The superconducting Higgs mode [1], i.e., the collective oscillation of the amplitude of the superconducting order parameter, and other exotic collective modes such as the Bardasis-Schrieffer mode [2], i.e., fluctuations between s-wave and d-wave superconducting order parameters, are among the most fascinating, but also the most elusive, excitations in superconductors.

The superconducting Higgs mode has now been detected using intense terahertz (THz) pulses in both conventional and unconventional superconductors [1], giving rise to the emerging field of “Higgs spectroscopy”. Yet, these pioneering studies have triggered important and still unanswered questions. Among them is the possibility that even more exotic collective modes can be detected in superconductors in the presence of distinct, possibly intertwined, electronic orders.

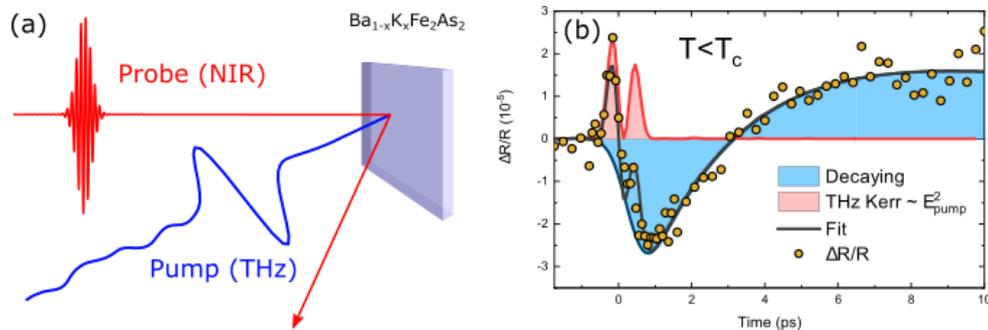


Figure 1 : (a) Sketch of the THz pump NIR probe measurements. (b) Transient reflectivity $\Delta R/R$ following the THz pulse in the nematic superconducting state of $\text{Ba}_{1-x}\text{K}_x\text{Fe}_2\text{As}_2$.

In the present work [3] we report a THz diagnostic of superconducting collective modes in the iron-based superconductor $\text{Ba}_{1-x}\text{K}_x\text{Fe}_2\text{As}_2$ in which superconductivity coexists with an electronic nematic state. Our approach is based on a THz pump-optical probe scheme (See Figure 1.a), where collective modes are detected in the time domain as an instantaneous THz Kerr signal (See Figure 1.b).

We reveal a striking impact of nematic order on the nature of superconducting collective excitation. While the Higgs mode signal is dominant in the non-nematic superconducting state, in the presence of coexisting nematicity a new THz Kerr signal with a striking nematic symmetry is observed which we assign to the emergence of a coupled nematic Bardasis-Schrieffer mode.

[1] R. Shimano and N. Tsuji, *Annu. Rev. Condens. Matter Phys.* 11, 103-124 (2020)

[2] A. Bardasis and J. R. Schrieffer, *Phys. Rev.* 121, 1050 (1961)

[3] R. Grasset et al., *npj Quantum Materials* 7 (1), 1-6 (2022)