Orbital Selective Charge Quadrupole Density Wave in $FeSe_{1-x}S_x$
Charge Fluctuations in Iron Pnictides and Selenides

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Iron based superconductors present a new paradigm of multi-orbital superconductivity in proximity to nematic transition and spin density wave (SDW) order. Most compounds share a common phase diagram which in the underdoped region is marked by a tetragonal to orthorhombic phase structural transition at temperature T_S followed by a SDW transition at T_{SDW}, slightly below T_S. The orthorhombic distortion at T_S breaks C_4 rotational symmetry while the translational symmetry is broken due to doubling of the unit cell either at or above T_{SDW}. The systems provide exceptional setting to study coexistence and/or competition between charge quadrupole fluctuations, superconductivity, and density-wave phases.

We employ polarization-resolved resonant Raman spectroscopy to study phononic, electronic, inter-band and magnetic excitations in numerous families of the oxypnictide compounds. The Raman susceptibility shows critical quadrupole charge fluctuations across the entire phase diagram which we interpreted in terms of inter-orbital quadrupole excitations. We demonstrate that above the structural phase transition the quadrupolar fluctuations with long correlation times are precursor to the discrete four-fold symmetry breaking transition. This is manifested in the XY-symmetry collective fluctuations observed in dynamical Raman susceptibility and enhancement of the static Raman susceptibility. Below superconducting transition, these collective excitations undergo a metamorphosis into a coherent in-gap collective mode of extraordinary strength and at the same time serve as glue for non-conventional superconducting pairing [1-4].

In the most recent studies of $FeSe_{1-x}S_x$, the system which does not show long range magnetic order, we have discovered that a gap reminiscent to a mean-field order parameter opens in the spectra of XY symmetry below T_S. The data is interpreted as formation of the stripe-type quadrupole order. The interpretation provides explanation for the recently reported anisotropic electronic properties in the nematic phase as well as for the puzzling orbital selective superconductivity.

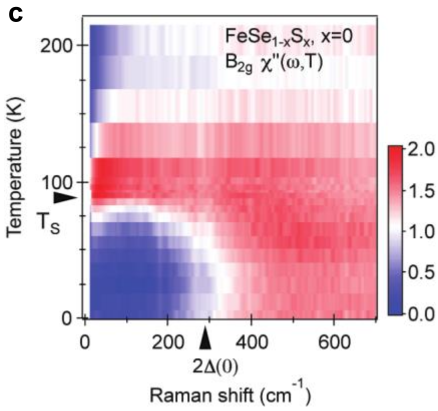

Fig. 1: *T-dependence of Raman response for FeSe [2]. Quadrupolar fluctuations and development of nematic gap are shown.*

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References

[1] V. K. Thorsmølle et al., Phys. Rev. B **93** 054515 (2016).
[2] W.-L. Zhang et al., https://arxiv.org/abs/1710.09892.
[3] S.-F. Wu et al., Phys. Rev. B **95** 085125 (2017).
[4] S.-F. Wu et al., https://arxiv.org/abs/1712.01896; https://arxiv.org/abs/1712.06066.