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Impact of Nematicity in the Optical Response of Iron-based Superconductors

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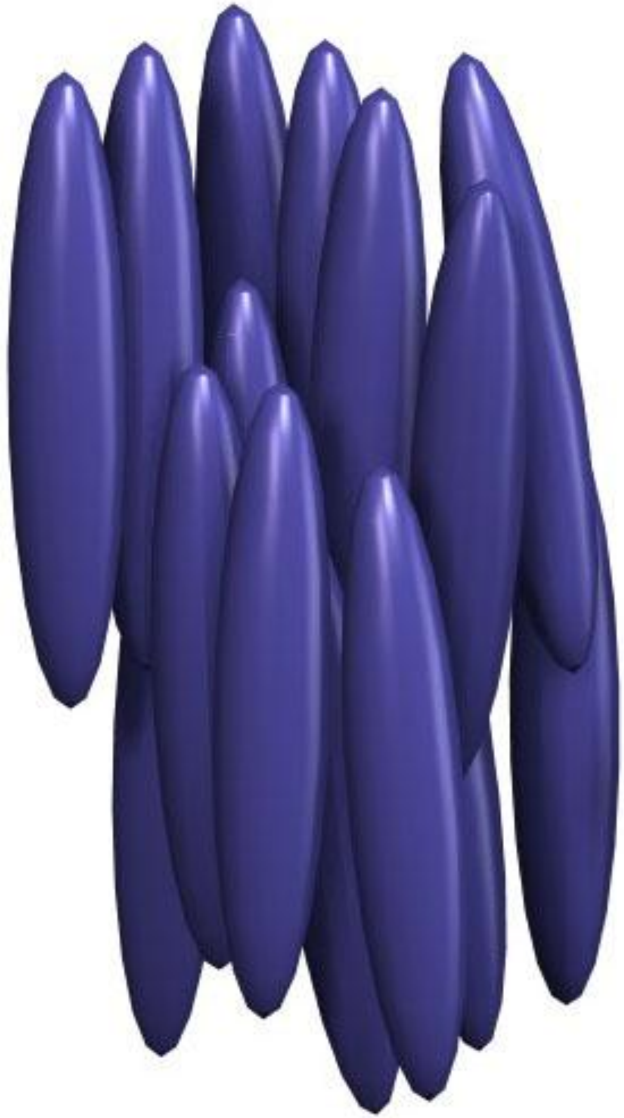
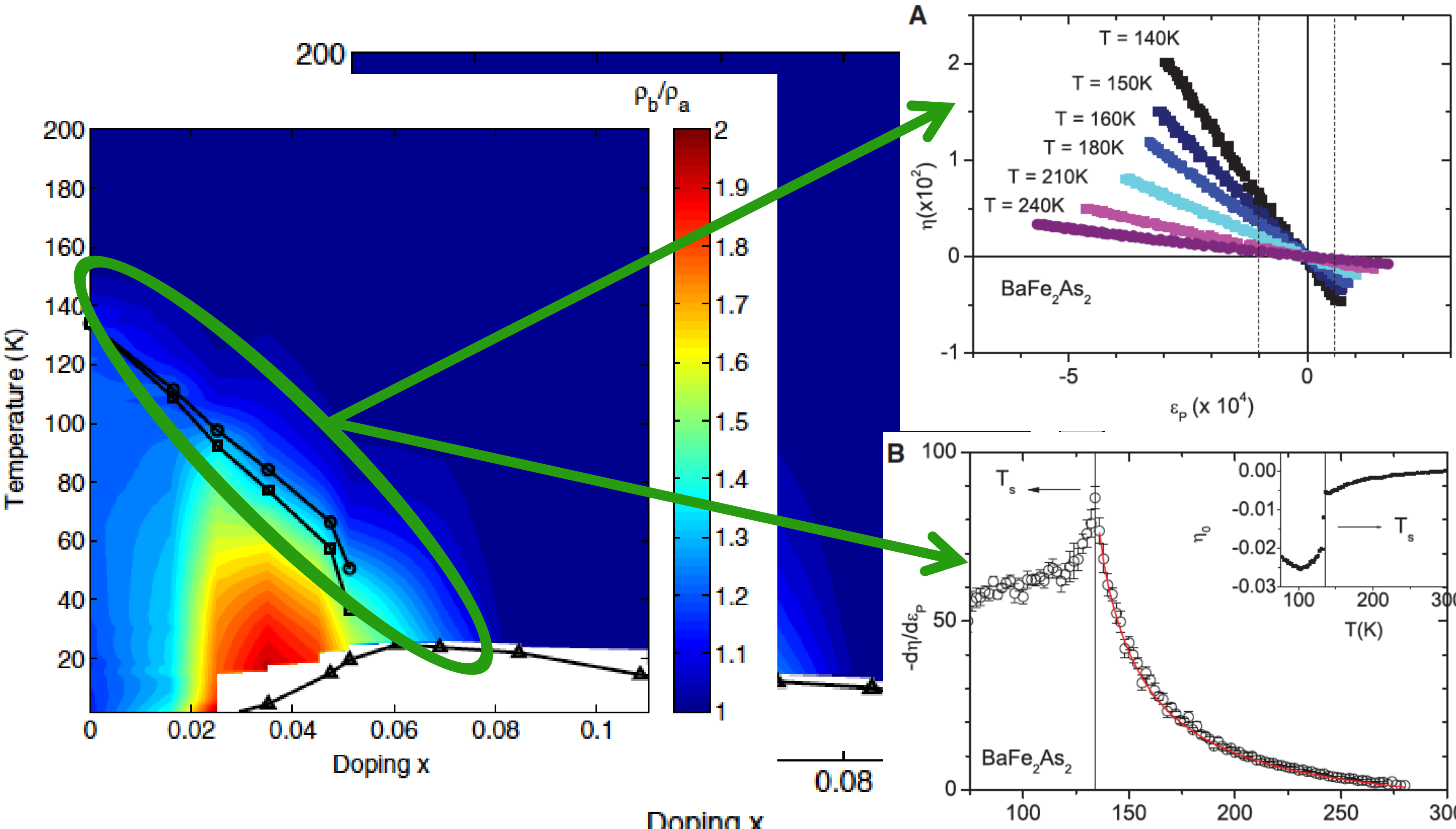
Nematic Phase

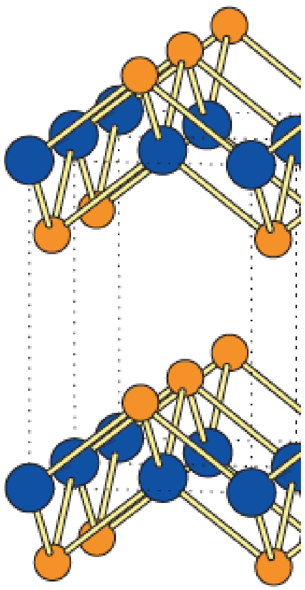


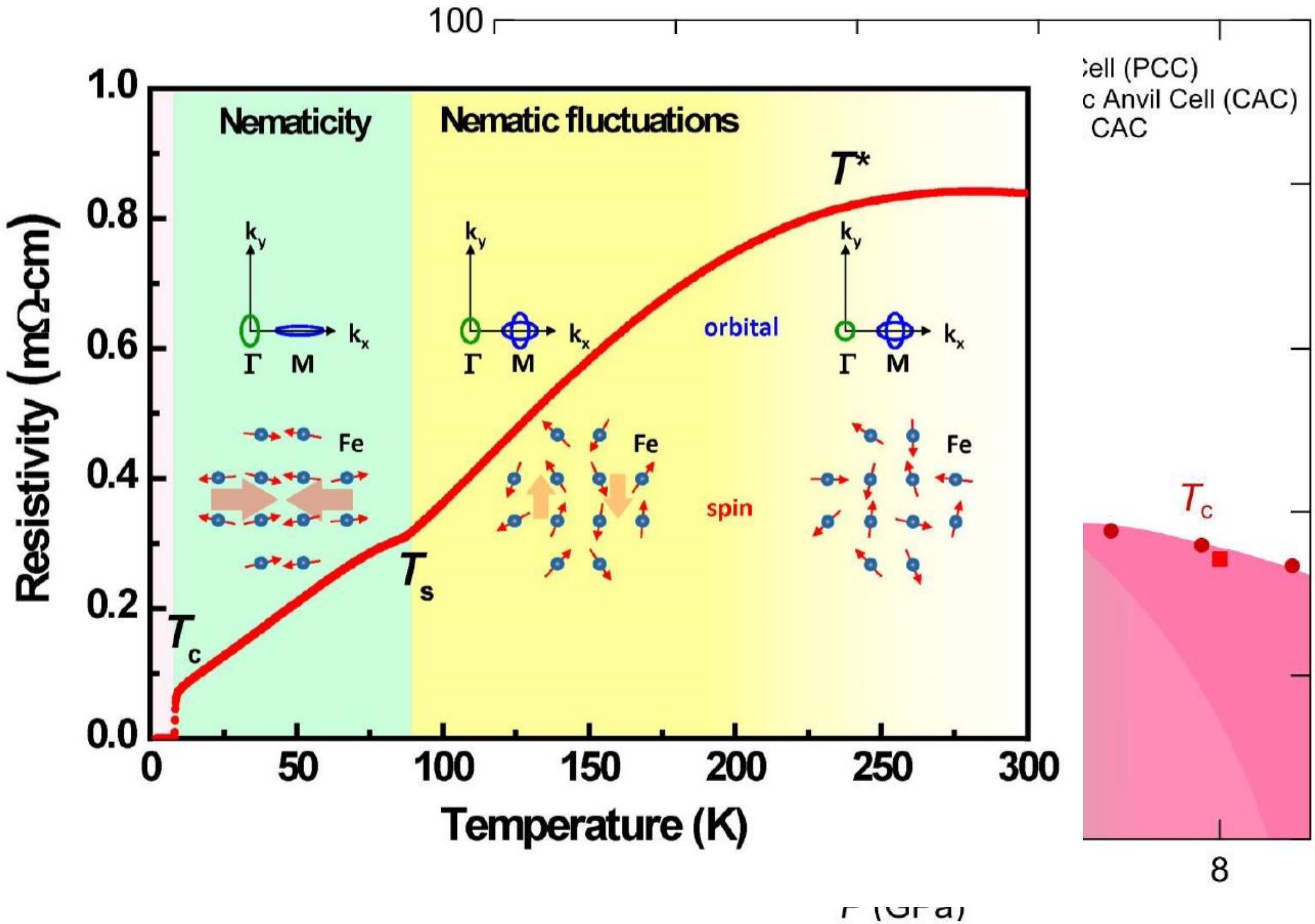
Experimental Evidence of Nematicity in Iron-Pnictides: DC Anisotropy in $Ba(Fe_{1-x}Co_x)_2As_2$



Chu et al., Science **329**, 824 (2010) and Science **337**, 710 (2012)

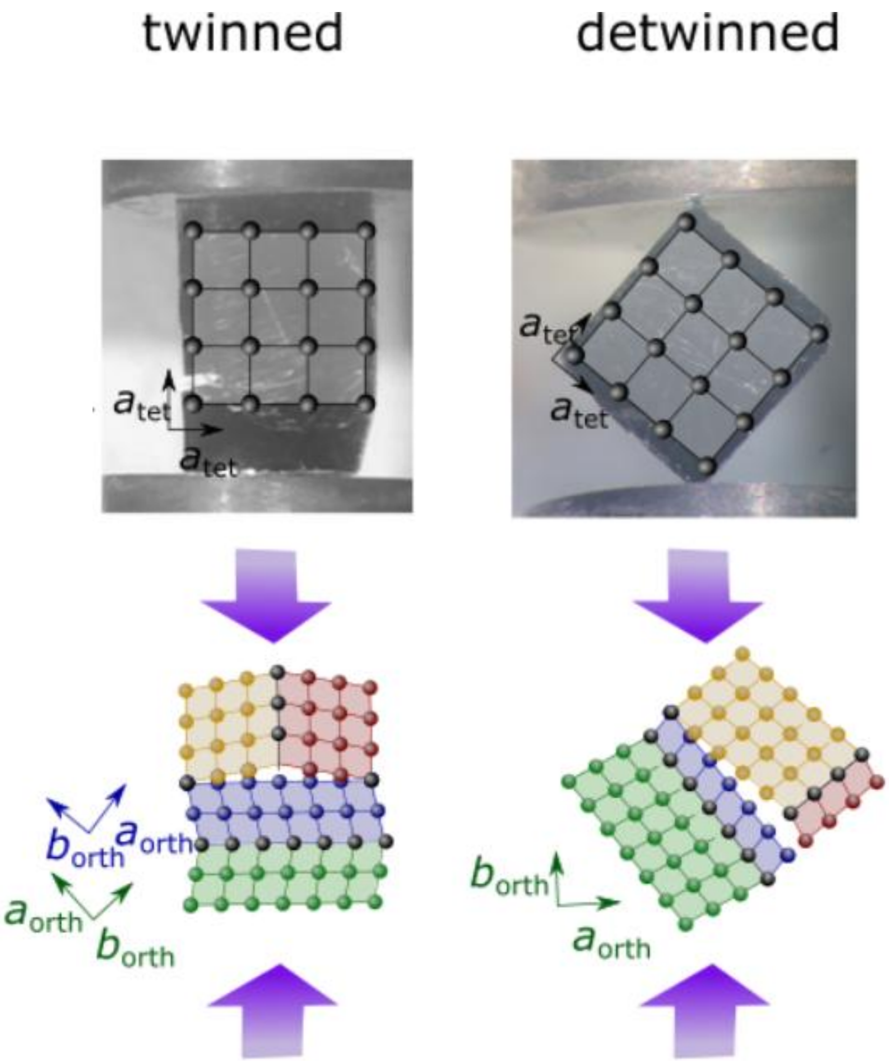
Phase Diagram and DC properties of FeSe

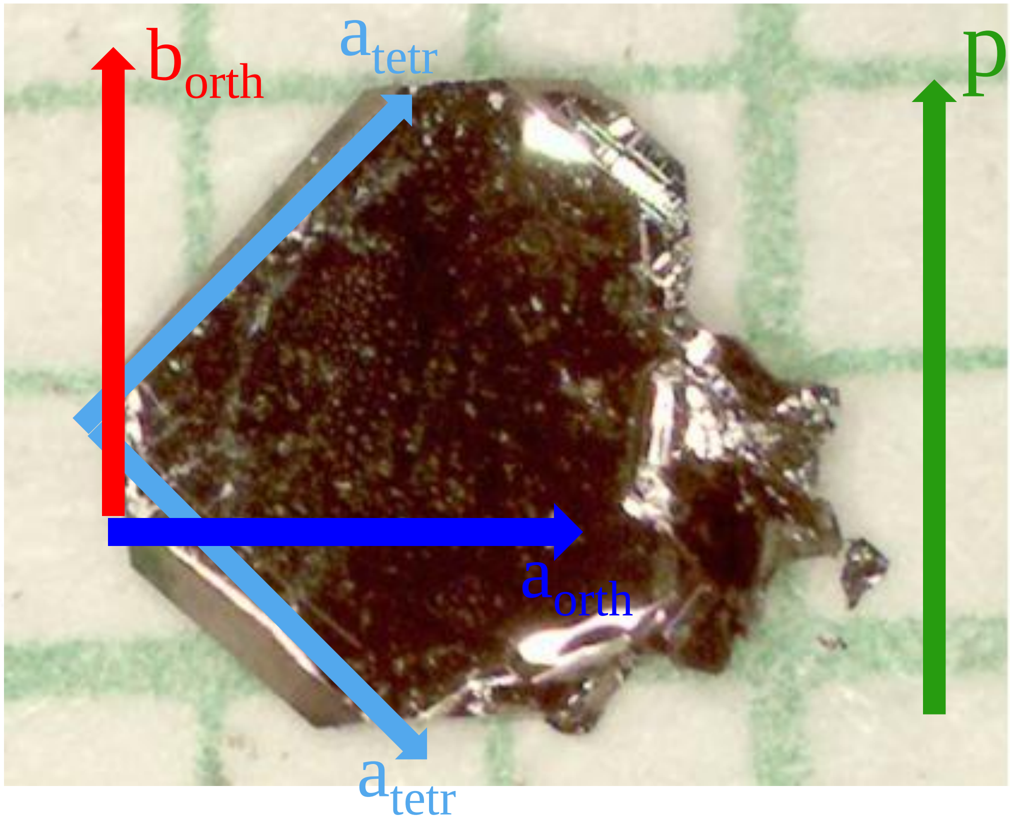




Sun et al., Nat. Commun. **7**, 12146 (2016)
Luo et al., cond-mat/1603.08710 (2016)

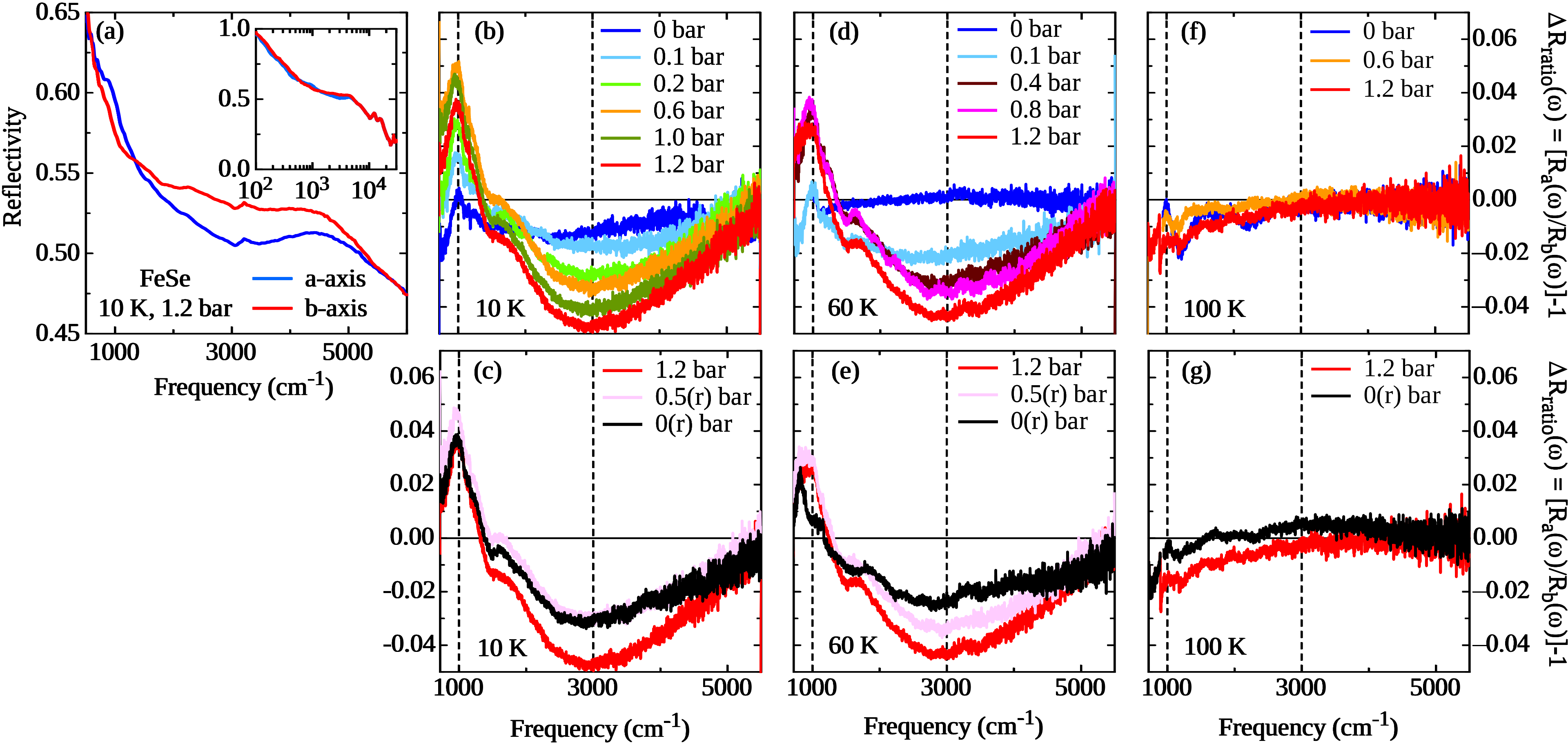
Our Experiment on FeSe Single Crystals



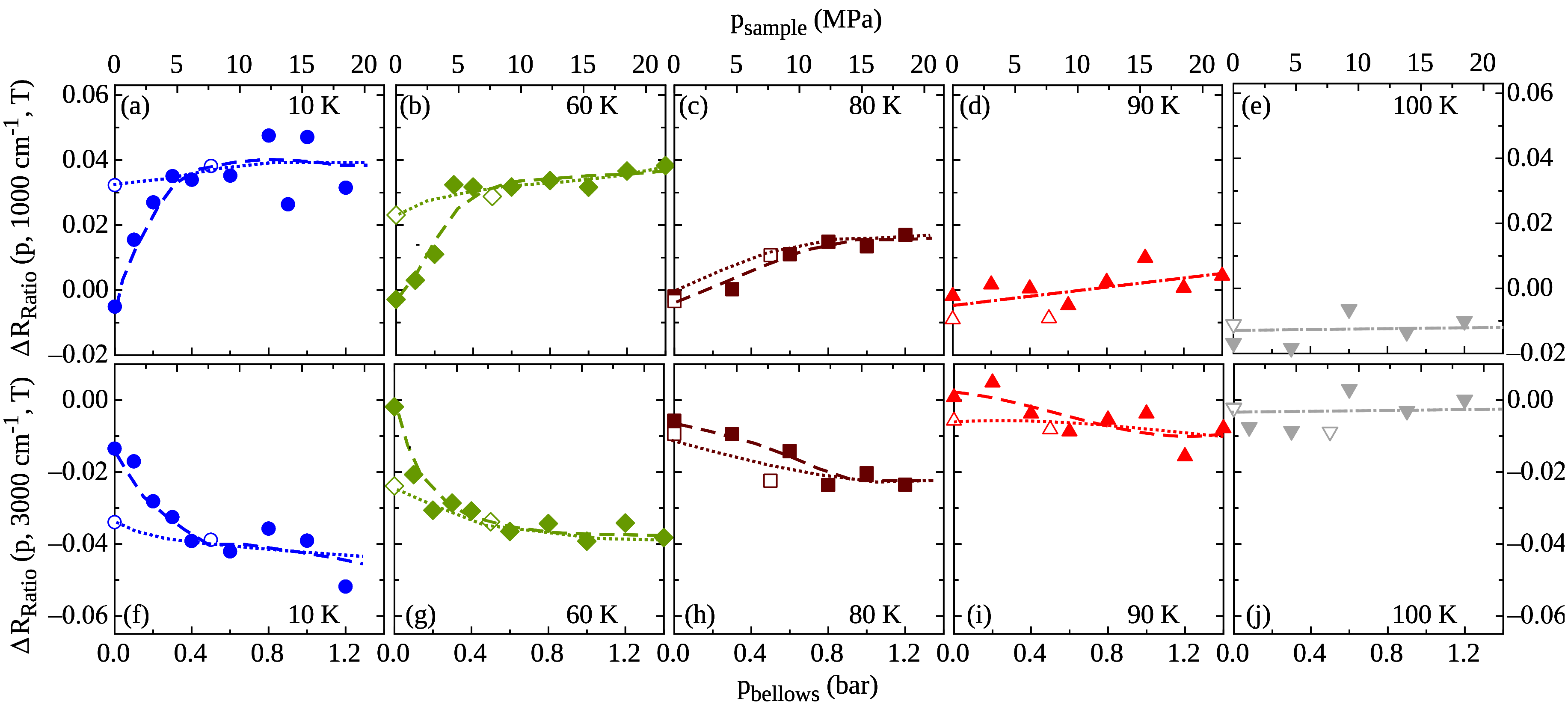


Boehmer et al., private communication (2016)

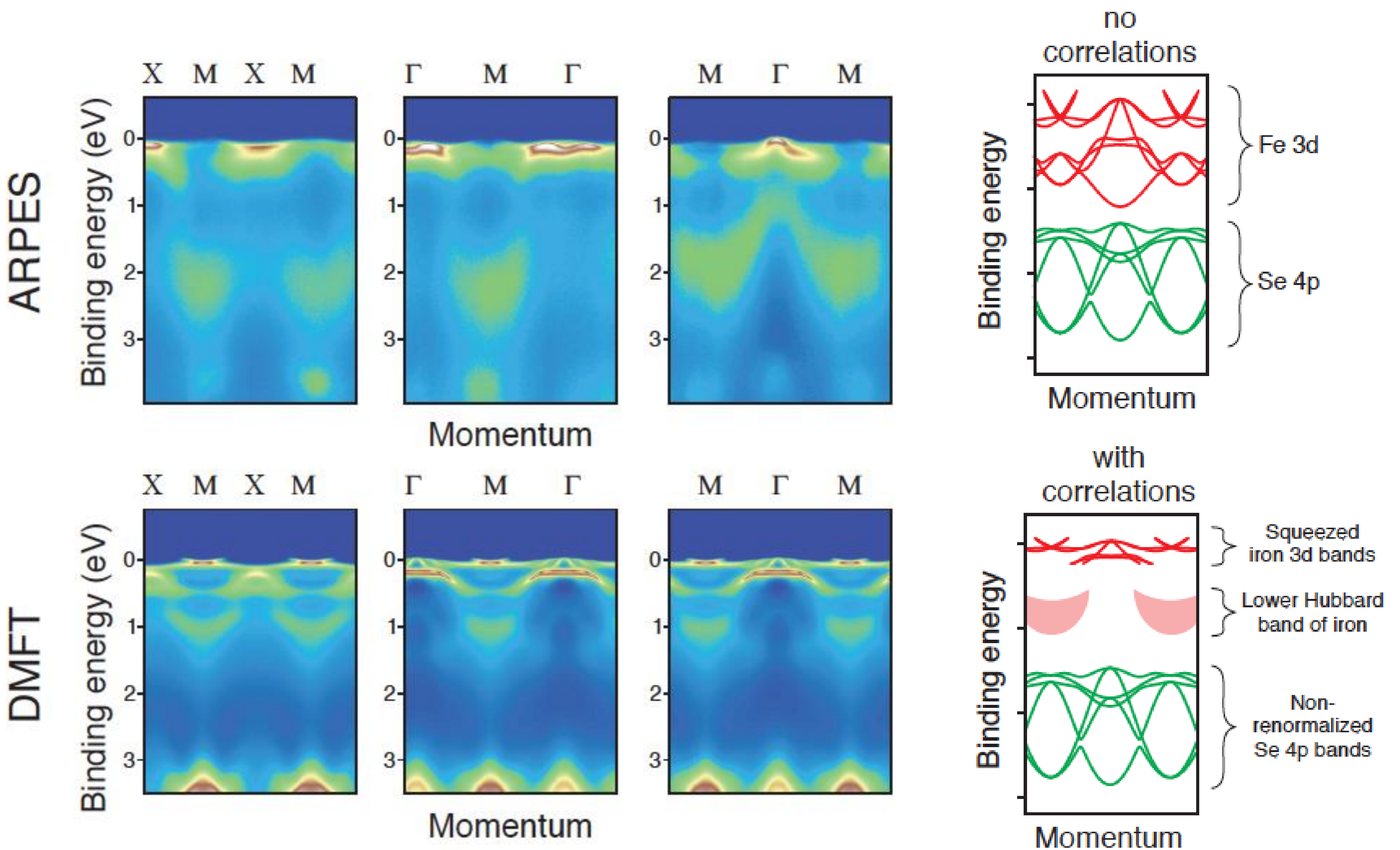
Optical Anisotropy in FeSe after ZPC



Hysteretic Optical Anisotropy in FeSe after ZPC

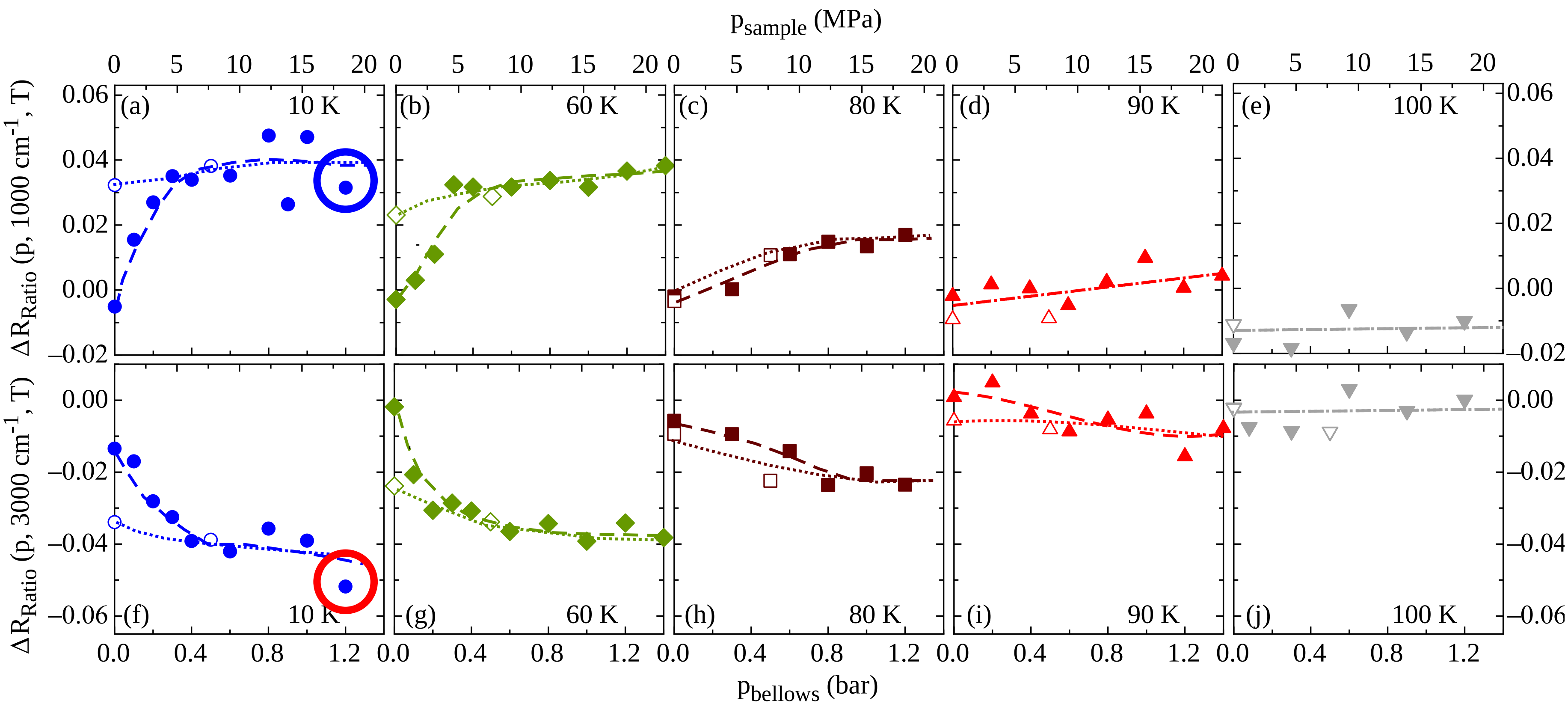


ARPES Evidence for Correlation Effects in FeSe

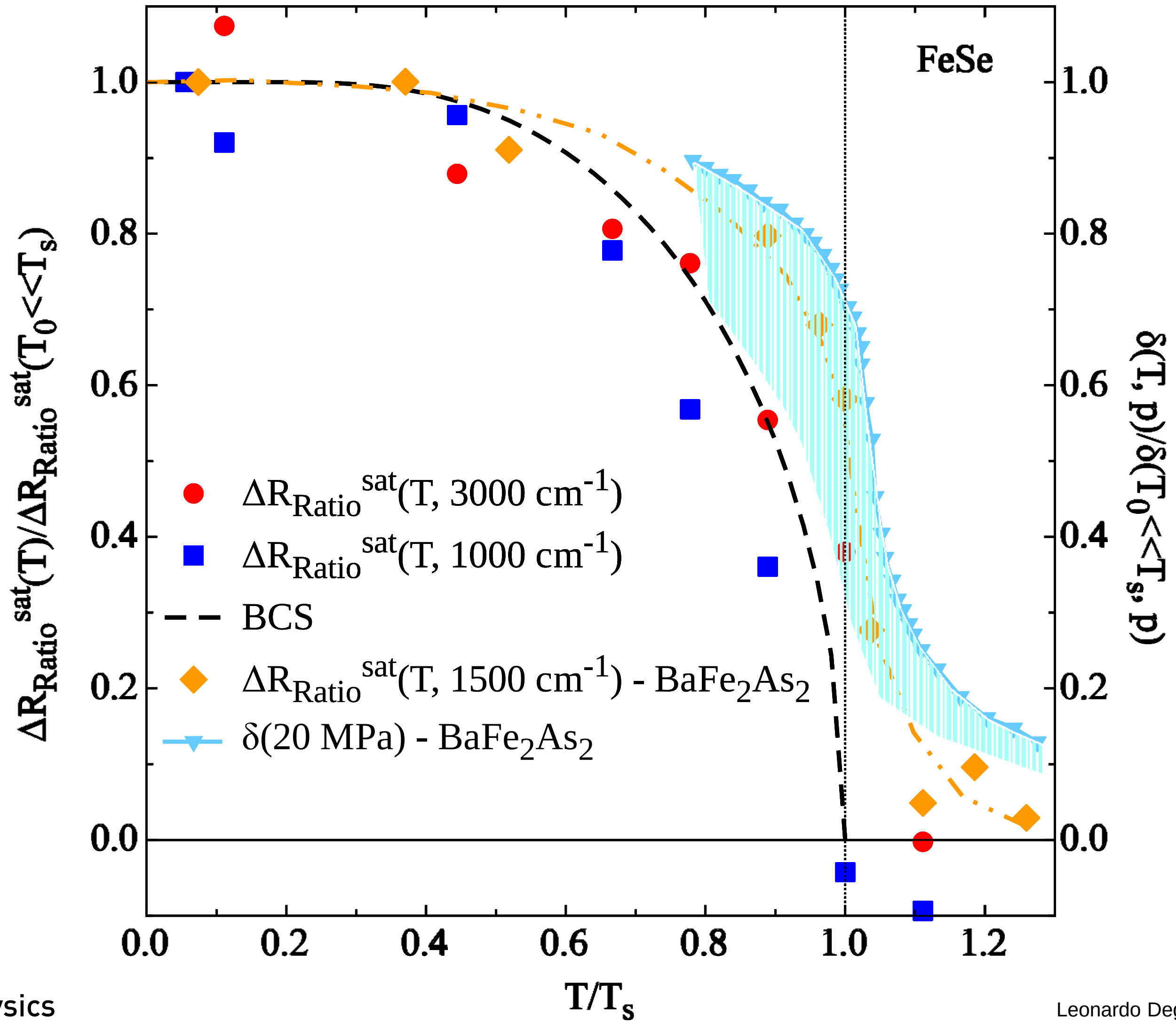


Evtushinsky et al., cond-mat/1612.02313 (2016)

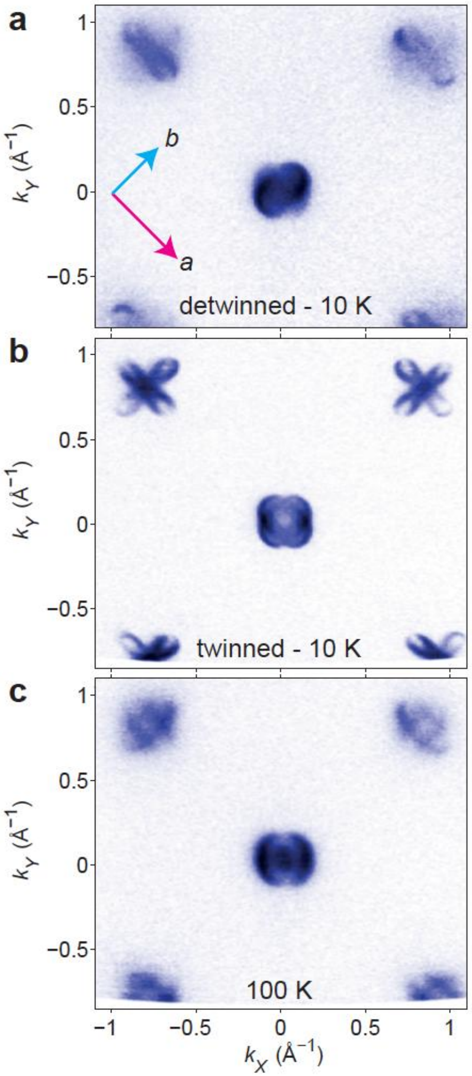
Hysteretic Optical Anisotropy in FeSe after ZPC

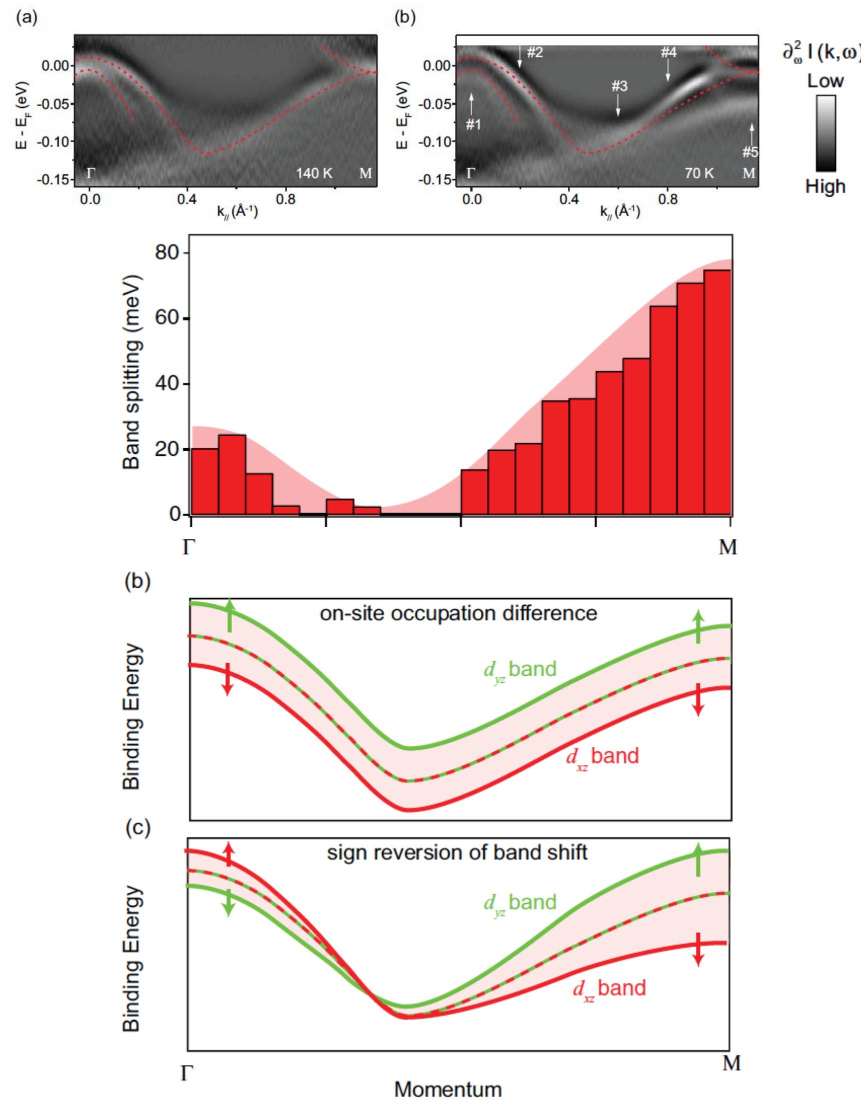


Temperature Dependence of the Optical Anisotropy in FeSe at Saturation after ZPC



Electronic Anisotropy in the Nematic Phase of FeSe

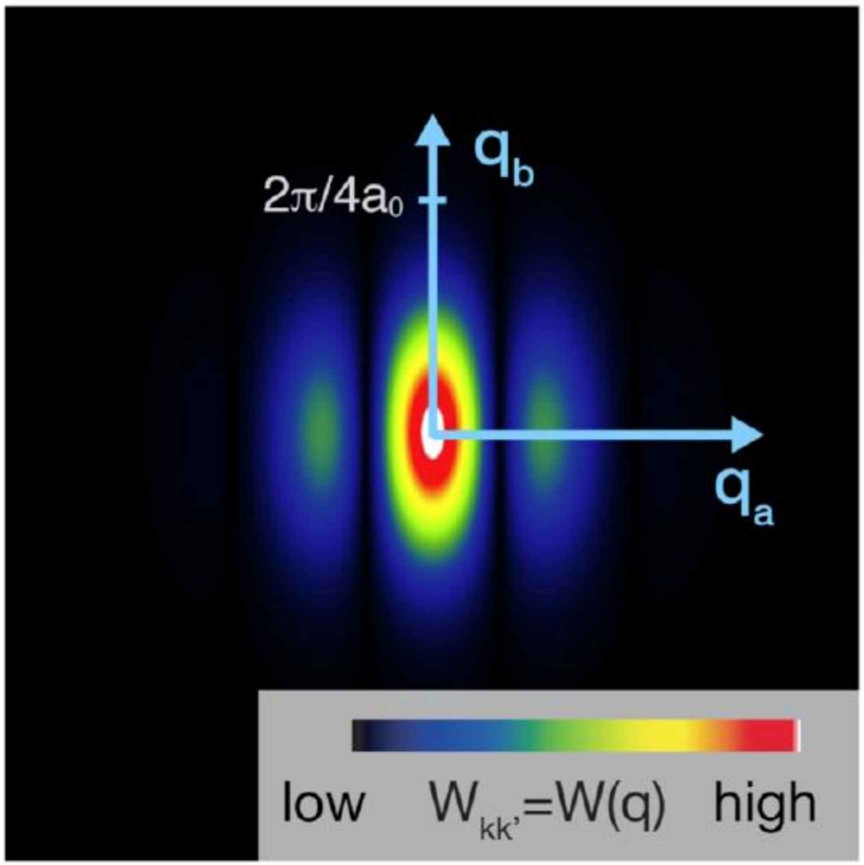


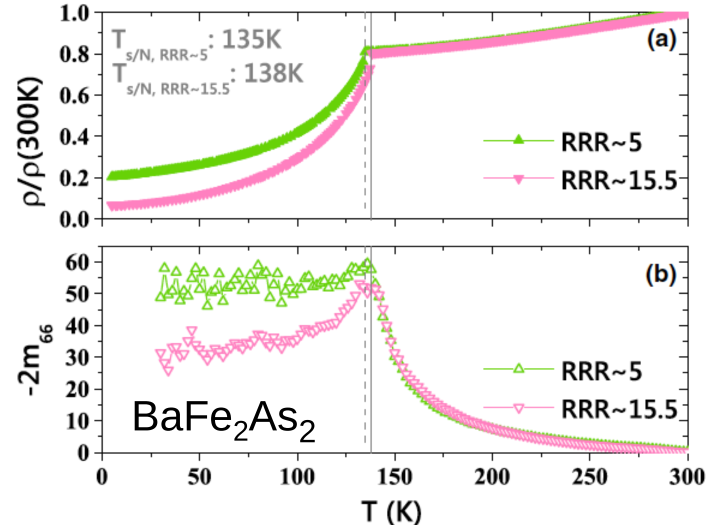


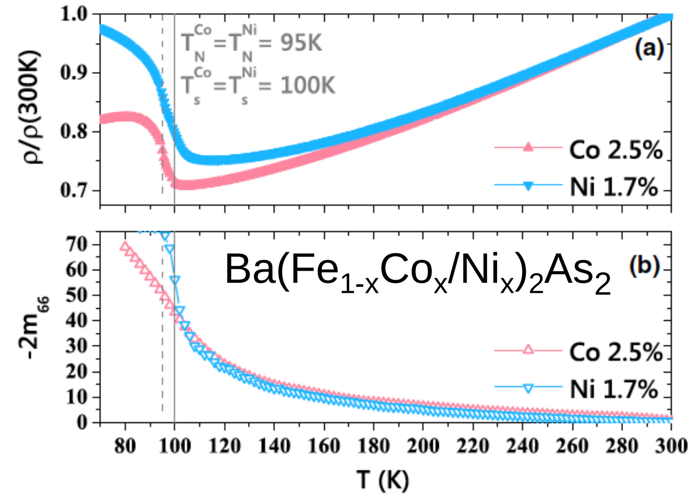
Zhang et al., Phys. Rev. B **94**, 115153 (2016)
Watson et al., cond-mat/1705.02286

Nematic Transport: Anisotropic Impurity States versus Fermi Surface Anisotropy

$Ca(Fe_{1-x}Co_x)_2As_2$

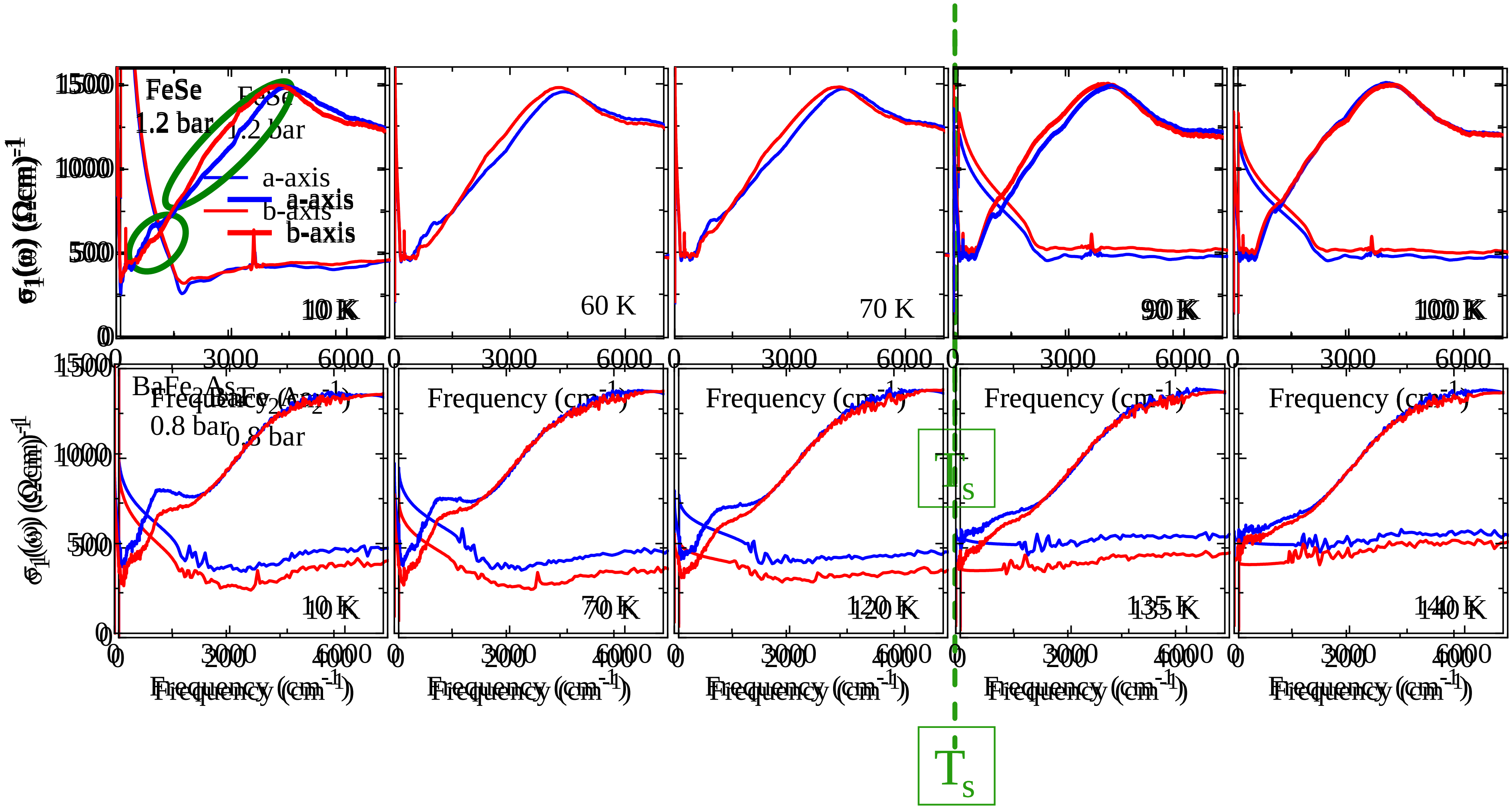






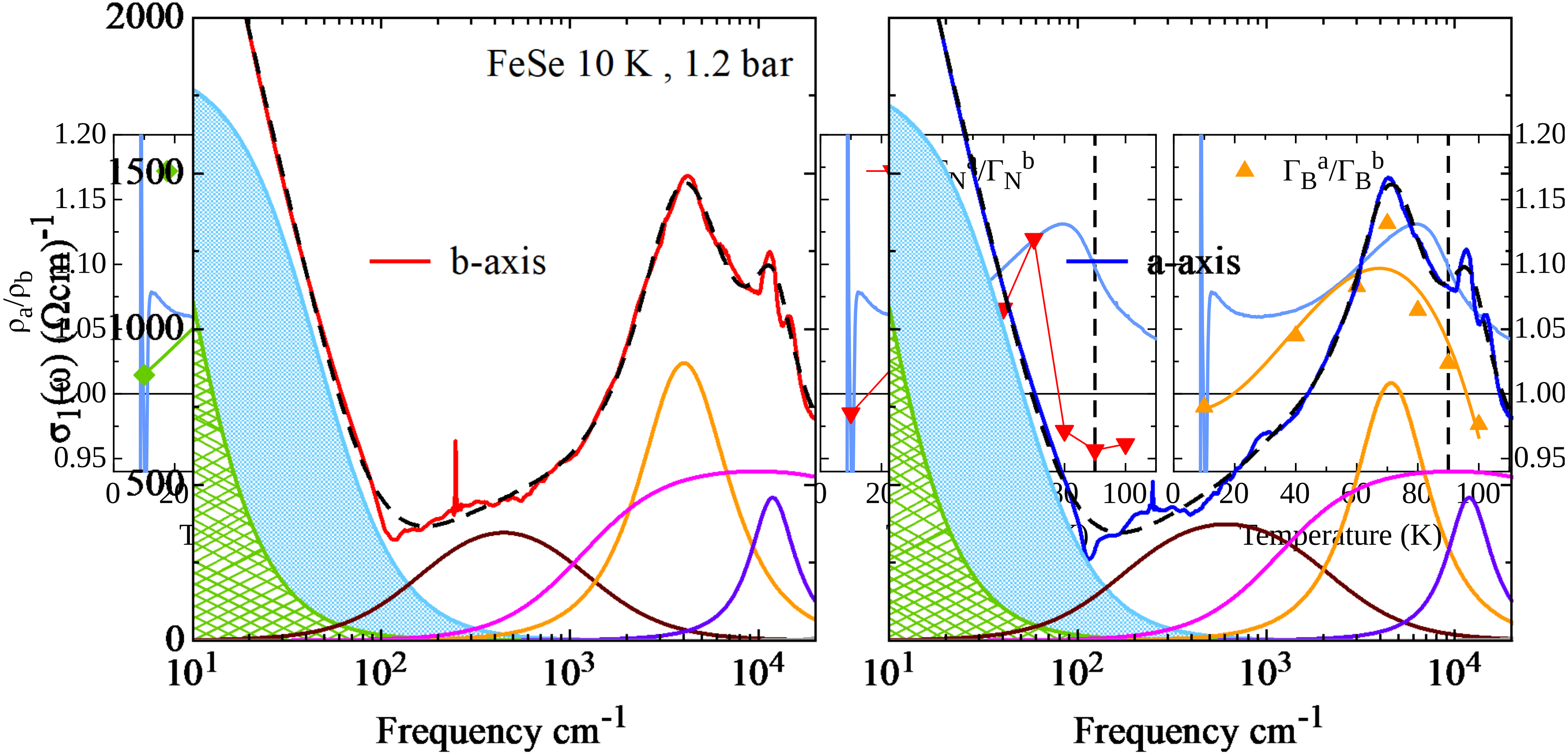
Allan et al., Nature Physics **9,** 220 (2013) and
Kuo et al, Phys. Rev. Lett. **112**, 227001 (2014)

Optical Conductivity in FeSe and $BaFe_2As_2$



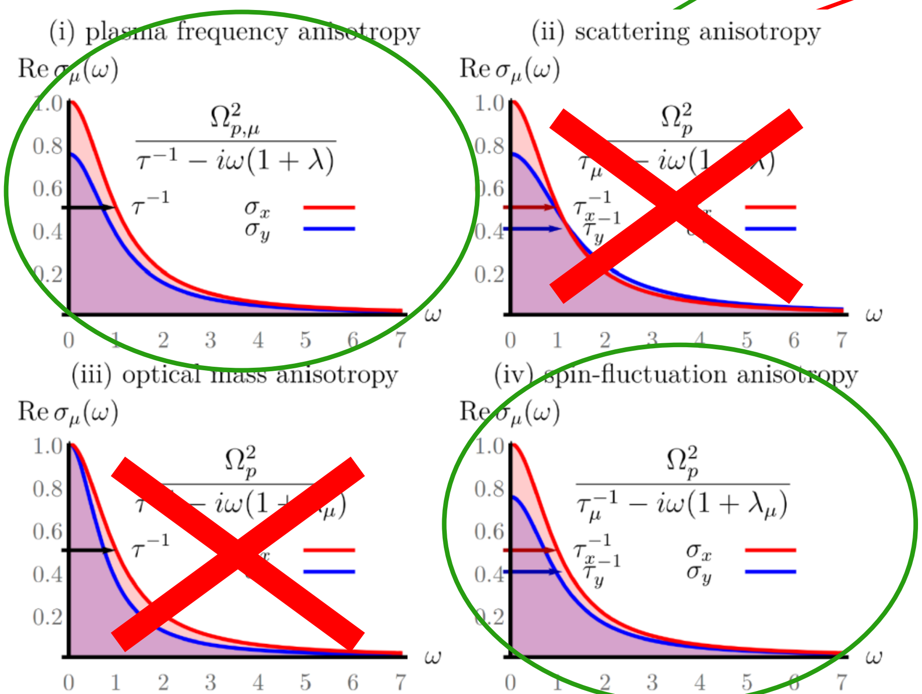
Mirri et al., Phys. Rev. B **93**, 085114 (2016)

Anisotropy of Fit Parameters and DC Transport Properties in FeSe



DC and AC Conductivity Anisotropy: Scattering Rate versus Spectral Weight Effects

$$\sigma(\omega)=\sigma_1(\omega)+i\sigma_2(\omega)=\frac{\Omega_p^2}{4\pi(1+\lambda)}\frac{1}{\frac{\tau^{-1}}{(1+\lambda)}-i\omega}$$



Ω_p and τ^{-1} are unavoidably entangled! $\sigma(\omega)$ depends additionally on the optical mass enhancement λ.

Attention: $\sigma_{dc} = \sigma(\omega\rightarrow 0)$ does not depend on λ!

From the optical experiment we extract the *effective* scattering rate and plasma frequency (Drude weight, DW):

$$\Gamma=\frac{\tau^{-1}}{(1+\lambda)},\ DW=\frac{\Omega_p^2}{(1+\lambda)}$$

not allowed due to causality

both consistent with experiment

Schütt et al., Phys. Rev. B **94**, 075111 (2016)

Origin of Transport Anisotropy due to Collision of Electrons and Spin Fluctuations

Model: three band model in which electrons interact with spin fluctuations (anisotropic in the nematic phase). This interaction causes anisotropy in both τ^{-1} and λ. λ is imaging the electronic Fermi velocity renormalization induced by spin fluctuations.

0

T

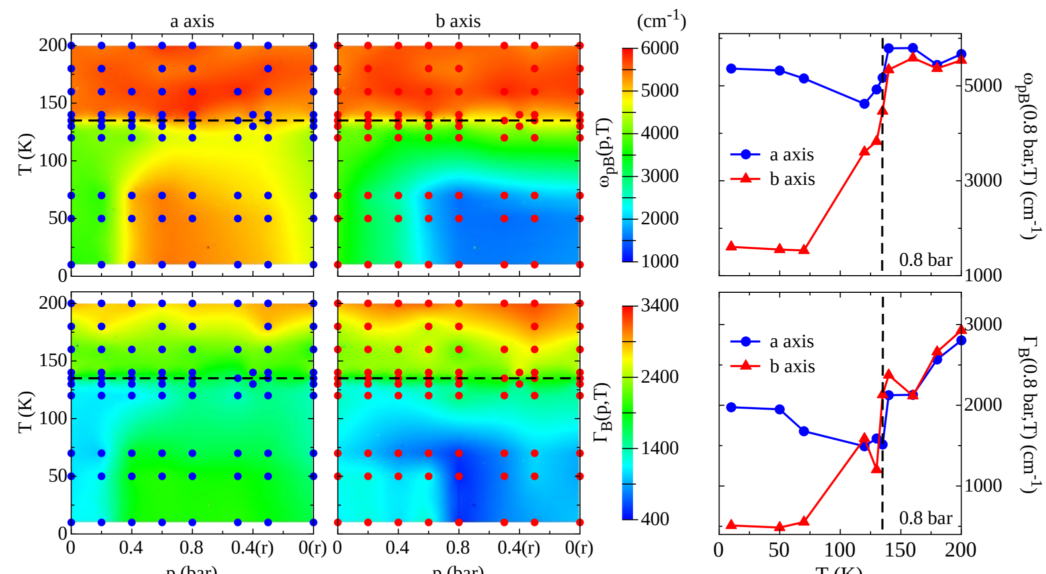
$$\sigma(\omega) = \sigma_1(\omega) + i\sigma_2(\omega) = \frac{\Omega_p^2}{4\pi(1+\lambda)} \frac{1}{\frac{\tau^{-1}}{(1+\lambda)} - i\omega}$$

The anisotropy of σ_{dc} is solely determined by the anisotropy of τ^{-1}, since the induced anisotropy in the e

$$\Delta\Gamma = \Delta\tau^{-1} - \tau_0^{-1}\Delta\lambda, \quad \Delta(\Delta W) = -\Omega_{p0}^2\Delta\lambda$$

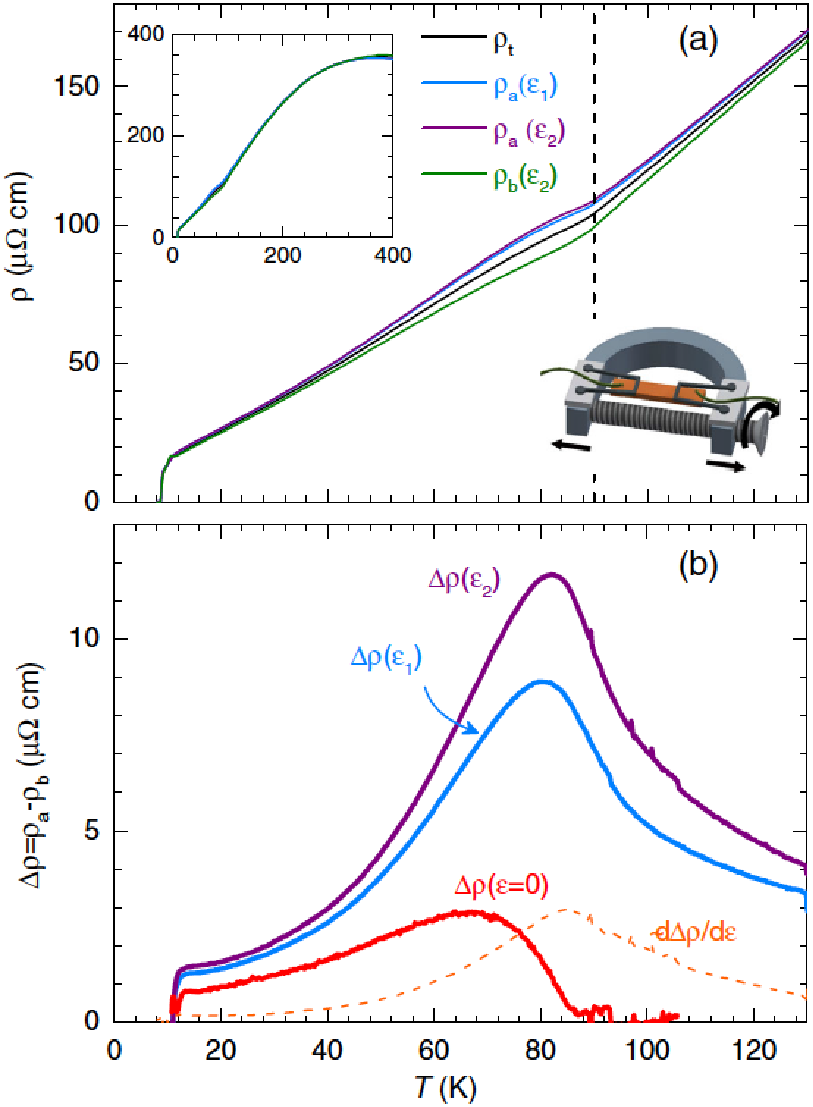
ency exactly compensate each other in the dc limit.

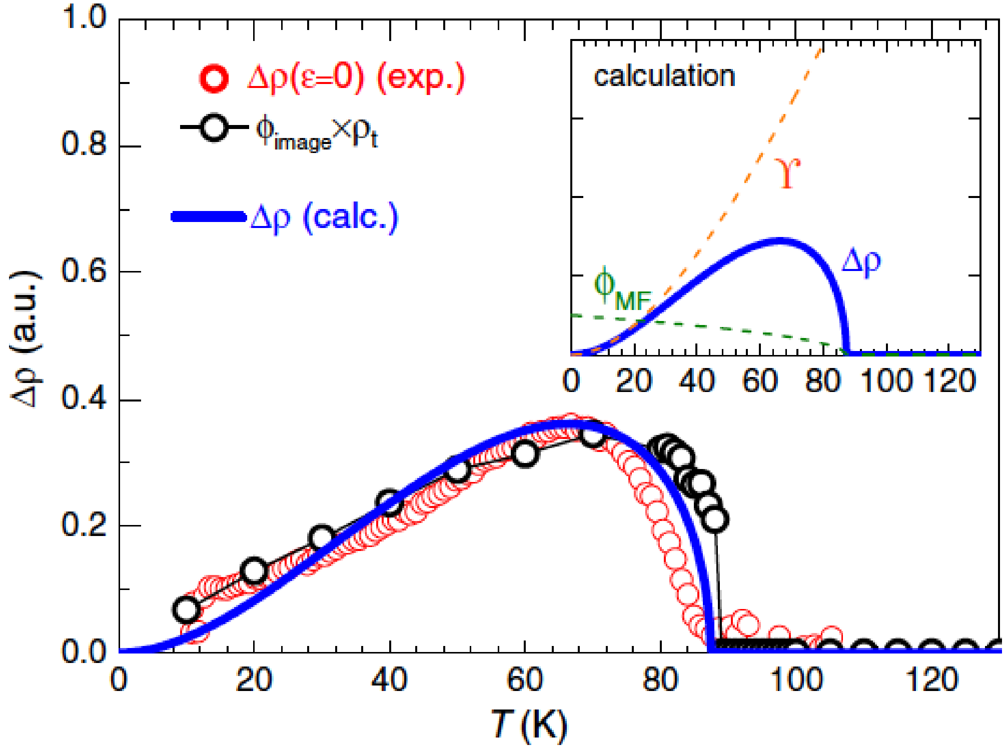
Within the scenario of interactions between magnetic fluctuations and electrons, the effective scattering rate anisotropy changes sign, whereas the effective spectral weight anisotropy increases as temperature is lowered (being τ_0^{-1} and Ω_{p0} the bare isotropic scattering rate and plasma frequency, respectively).



Schütt et al., Phys. Rev. B **94**, 075111 (2016)

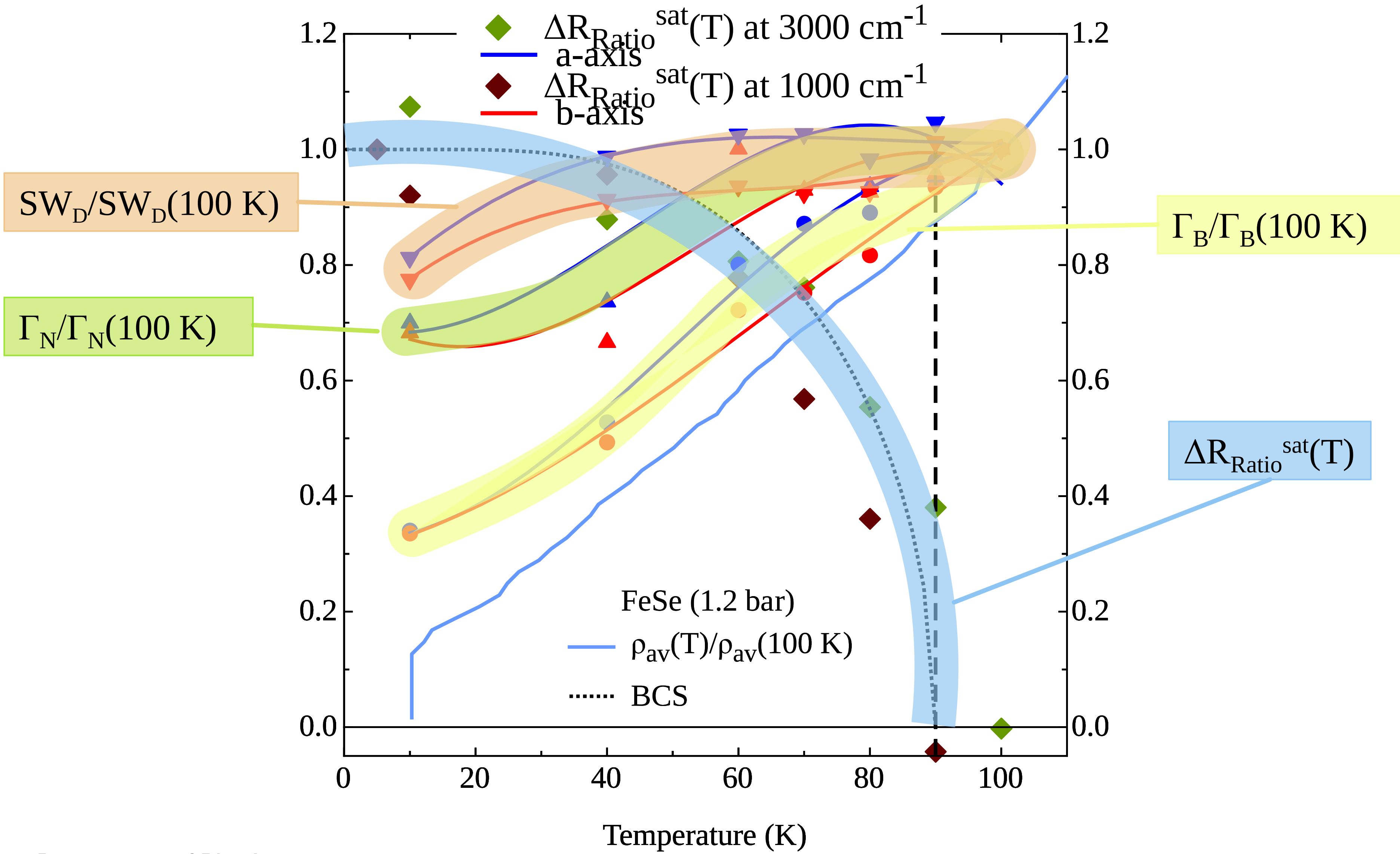
Inelastic Scattering by Spin Fluctuations





Tanatar et al., Phys. Rev. Lett. **117**, 127001 (2016)

Conclusion from Optical Response in FeSe



Acknowledgements

Anirban Pal

Manuel Chinotti

Chiara Mirri

Adam Dusza

Samples

A. Böhmer
P.C. Canfield
(Ames Laboratory)

I.R. Fisher
J.G. Analytis
J.-H. Chu
H.-H. Kuo
(Stanford University)

Theory

M. Schütt
R.M. Fernandes
A.V. Chubukov
(University of Minnesota)

J. Schmalian
(University of Karlsruhe)

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