1. Physikalisches Institut
Universität Stuttgart

INSTITUT ZA FIZIKU

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Recent optical studies in several 1T-transition metal dichalcogenides

Kristijan Velebit

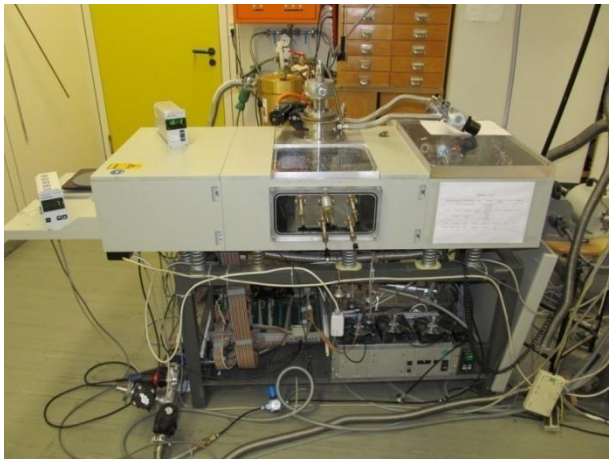
UNITY THROUGH KNOWLEDGE FUND

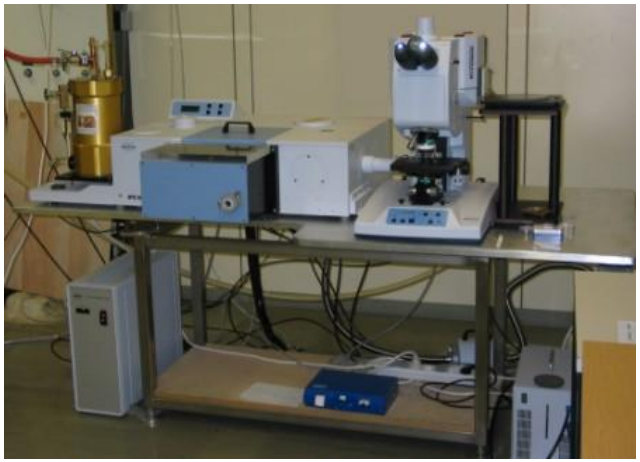
UKF 65/10
http://frustrated-electrons.ifs.hr/

DAAD
Deutscher Akademischer Austausch Dienst
German Academic Exchange Service

Measurements...

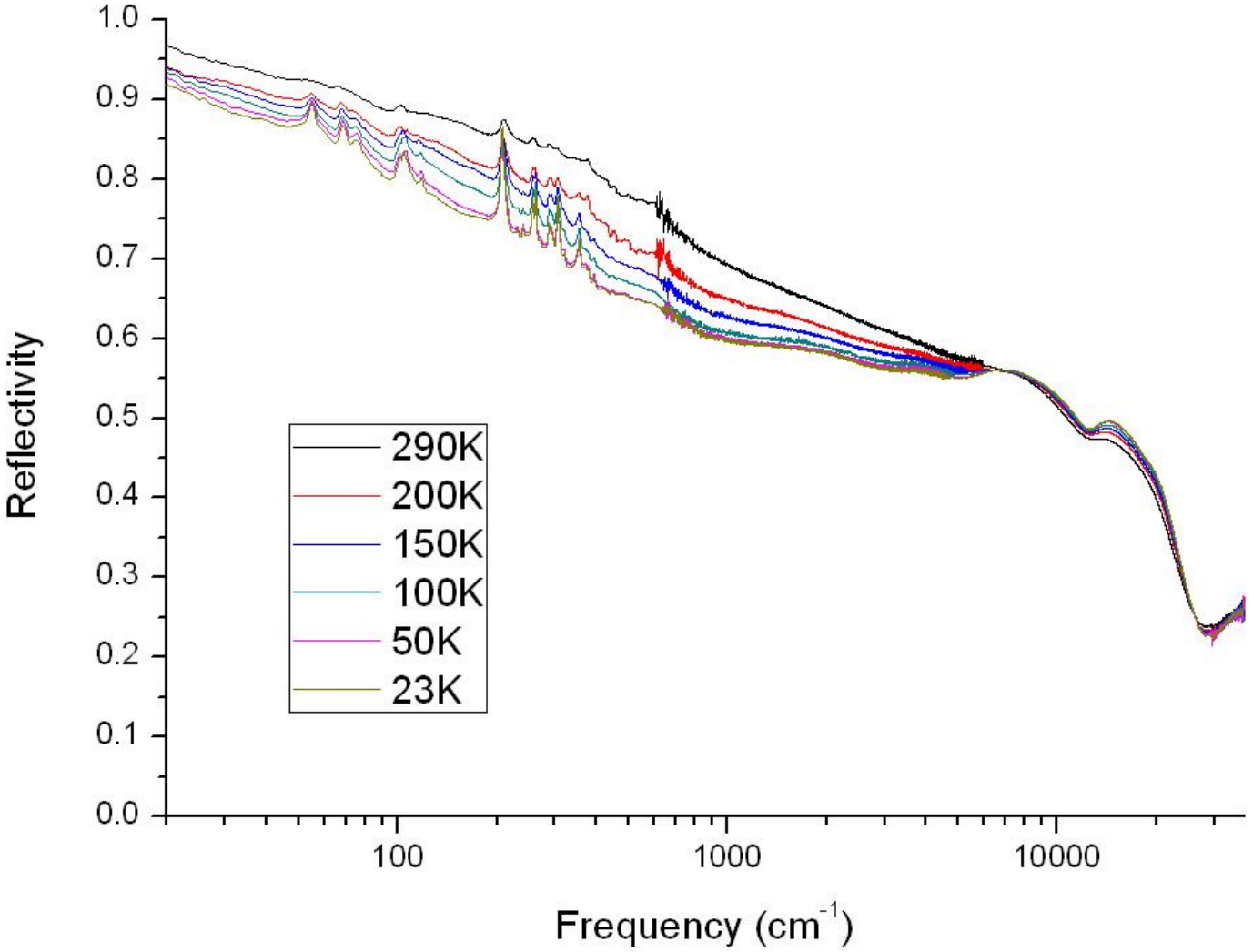
Fourier Transform Infrared Spectroscopy





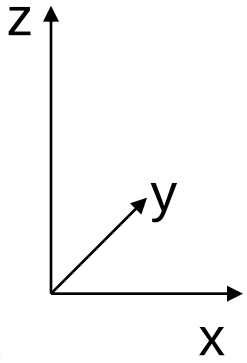
Spectroscopic ellipsometry

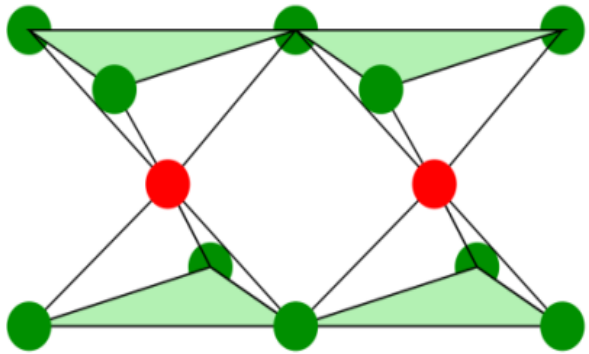
An example of output spectra

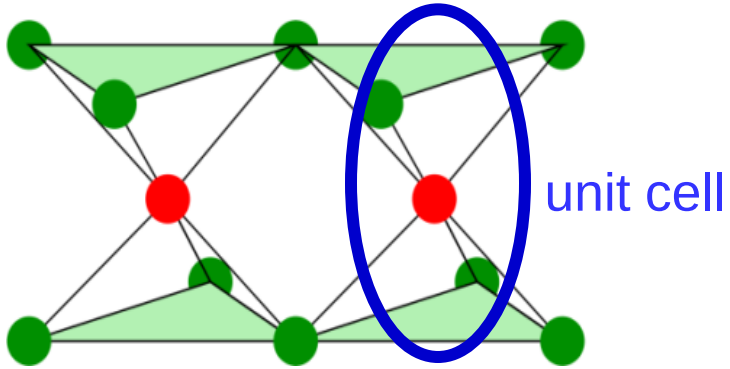


Materials and crystal structure

- Pure 1T-TaS_2
- Intercalated 1T-TaS_2
- Pure 1T-$TiSe_2$
- Doped 1T-$TiSe_2$





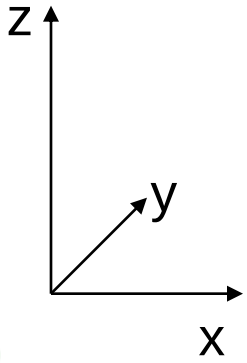


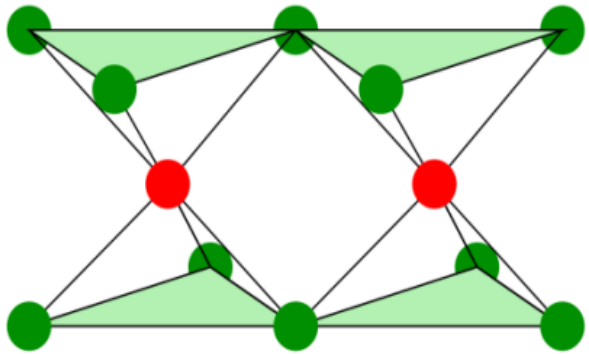
Ta, Ti

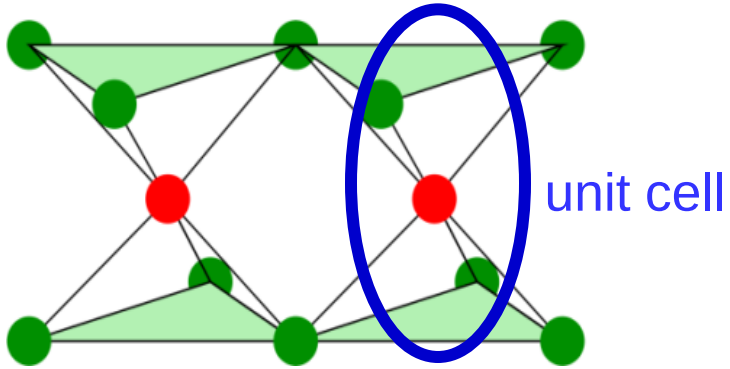
S, Se

Materials and crystal structure

- Pure 1T-TaS_2
- Intercalated 1T-TaS_2
- Pure 1T-$TiSe_2$
- Doped 1T-$TiSe_2$



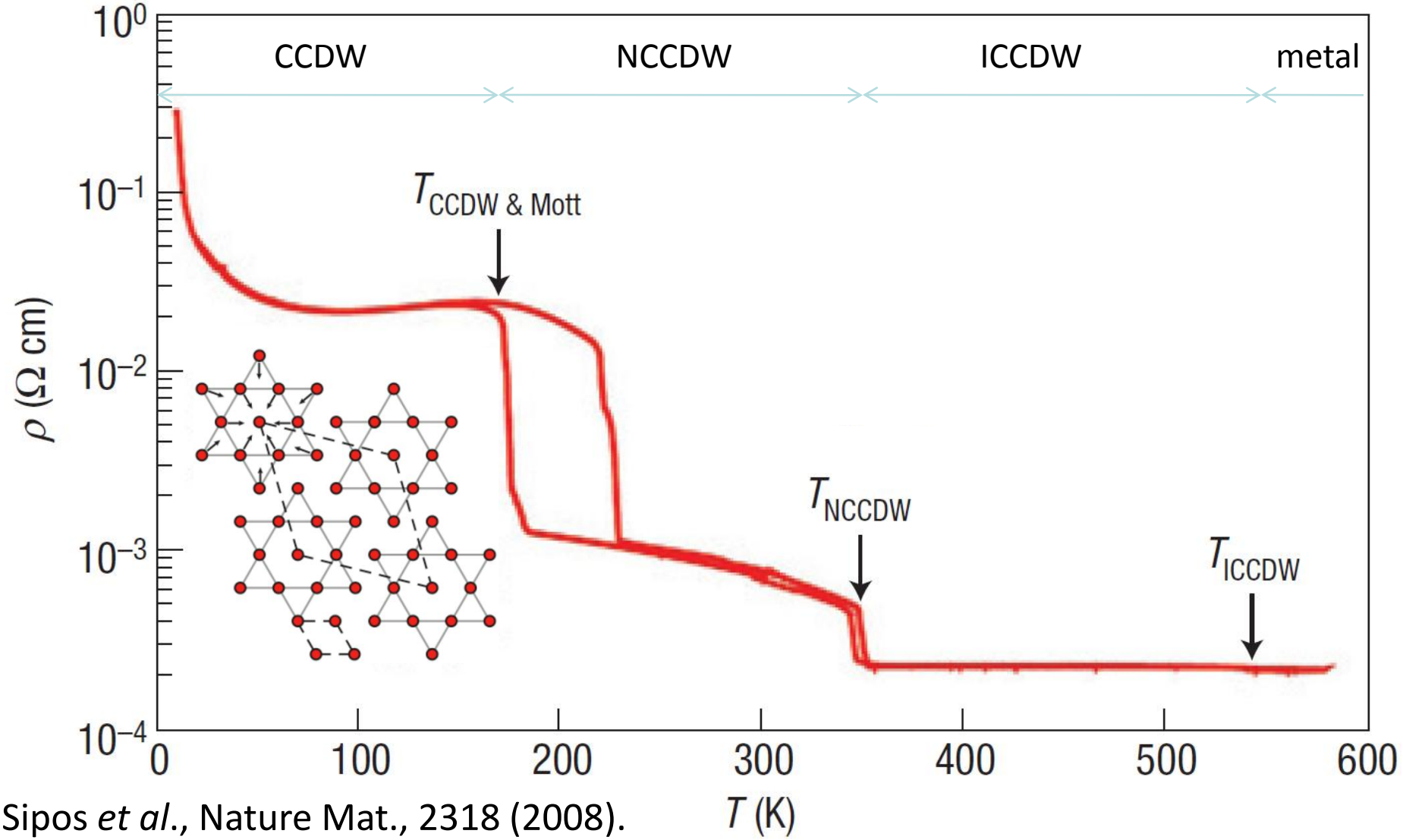




Ta, Ti

S, Se

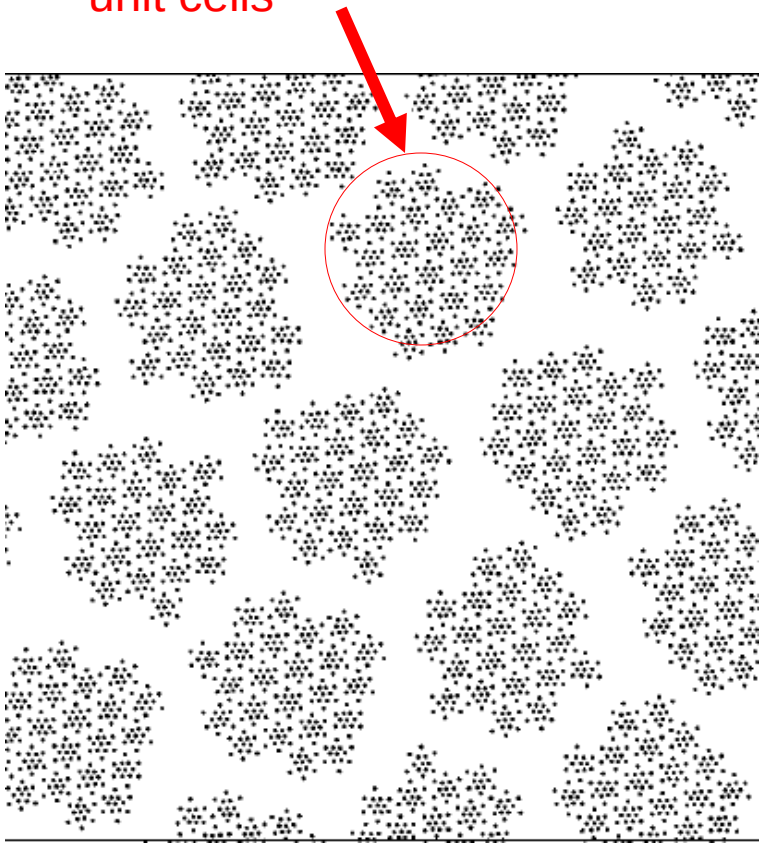
Pure 1T-TaS_2



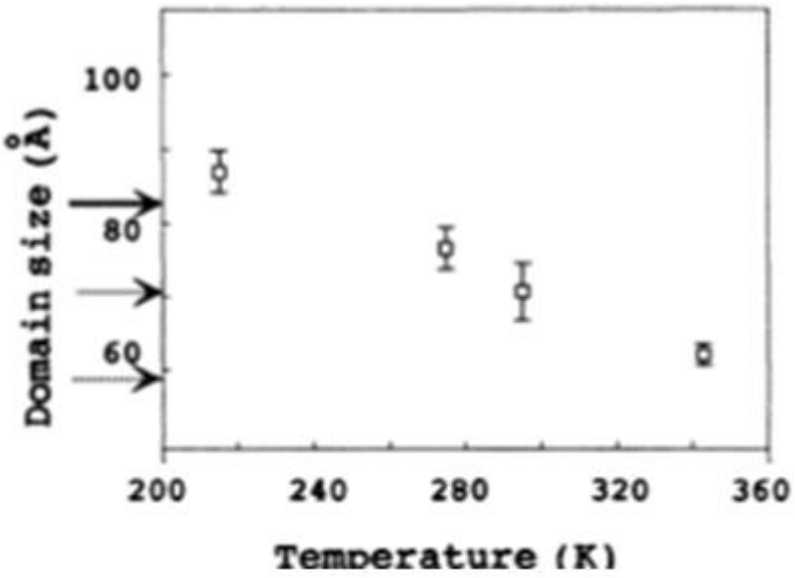
Sipos *et al*., Nature Mat., 2318 (2008).

NC-CDW state

~200 TaS_2 unit cells



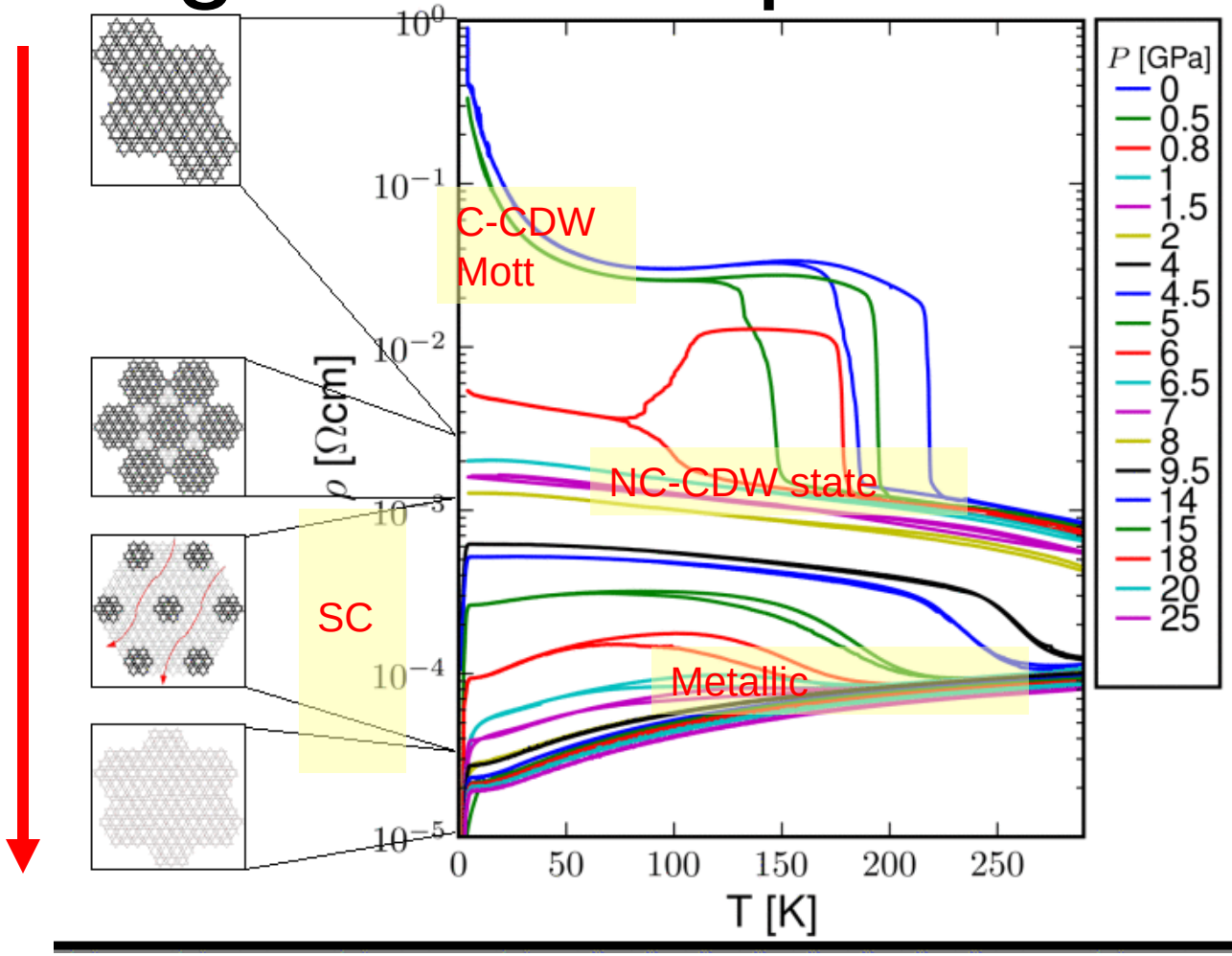
Spijkerman 1997 PRB
X ray



Thompson, Phys. Rev. B (1994)

1T-TaS_2

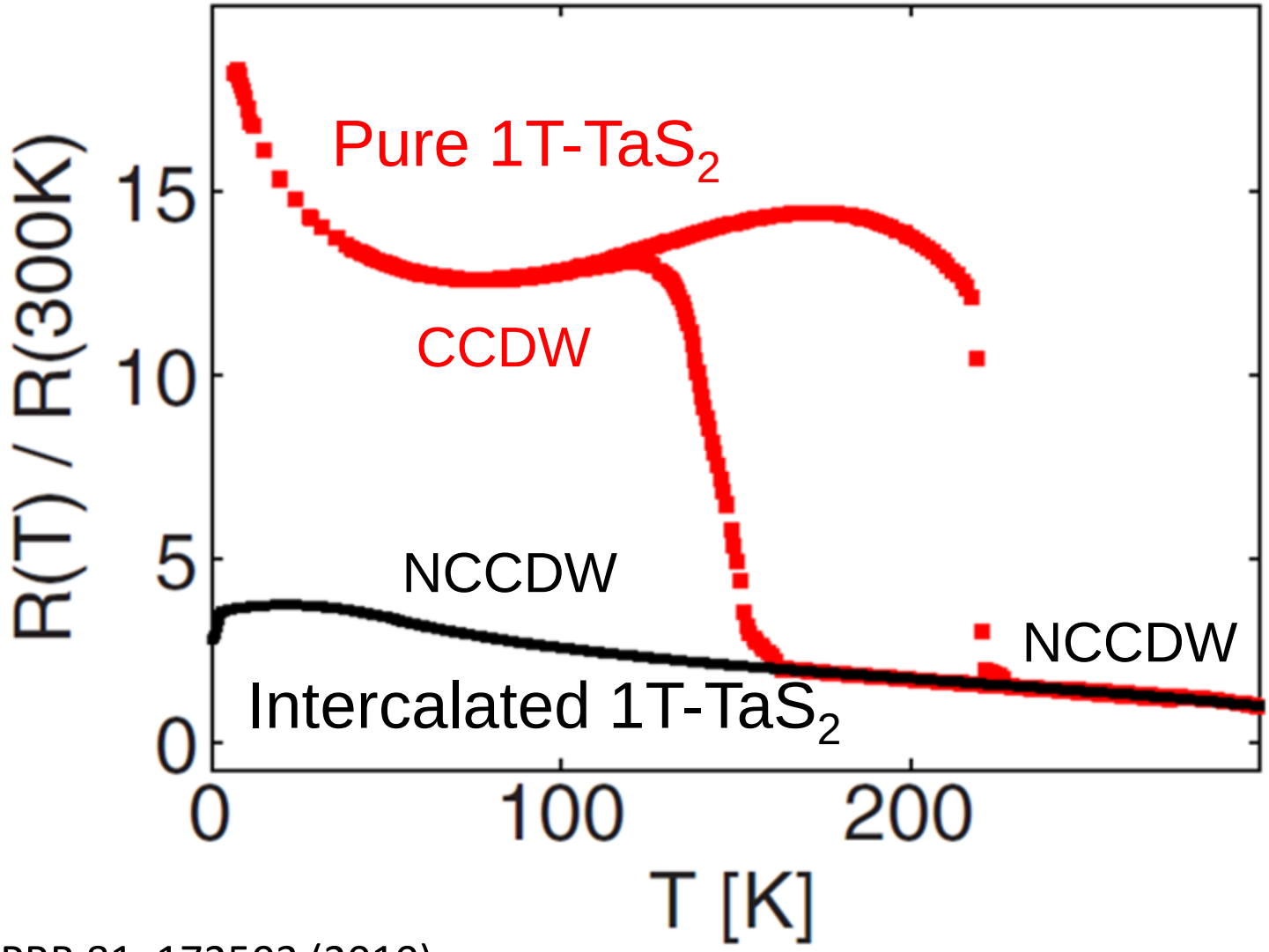
Suppression of Mott state and emergence of superconductivity



1T-TaS_2

Sipos *et al*., Nature Mat., 2318 (2008).

1T-TaS_2 – intercalated vs. pure



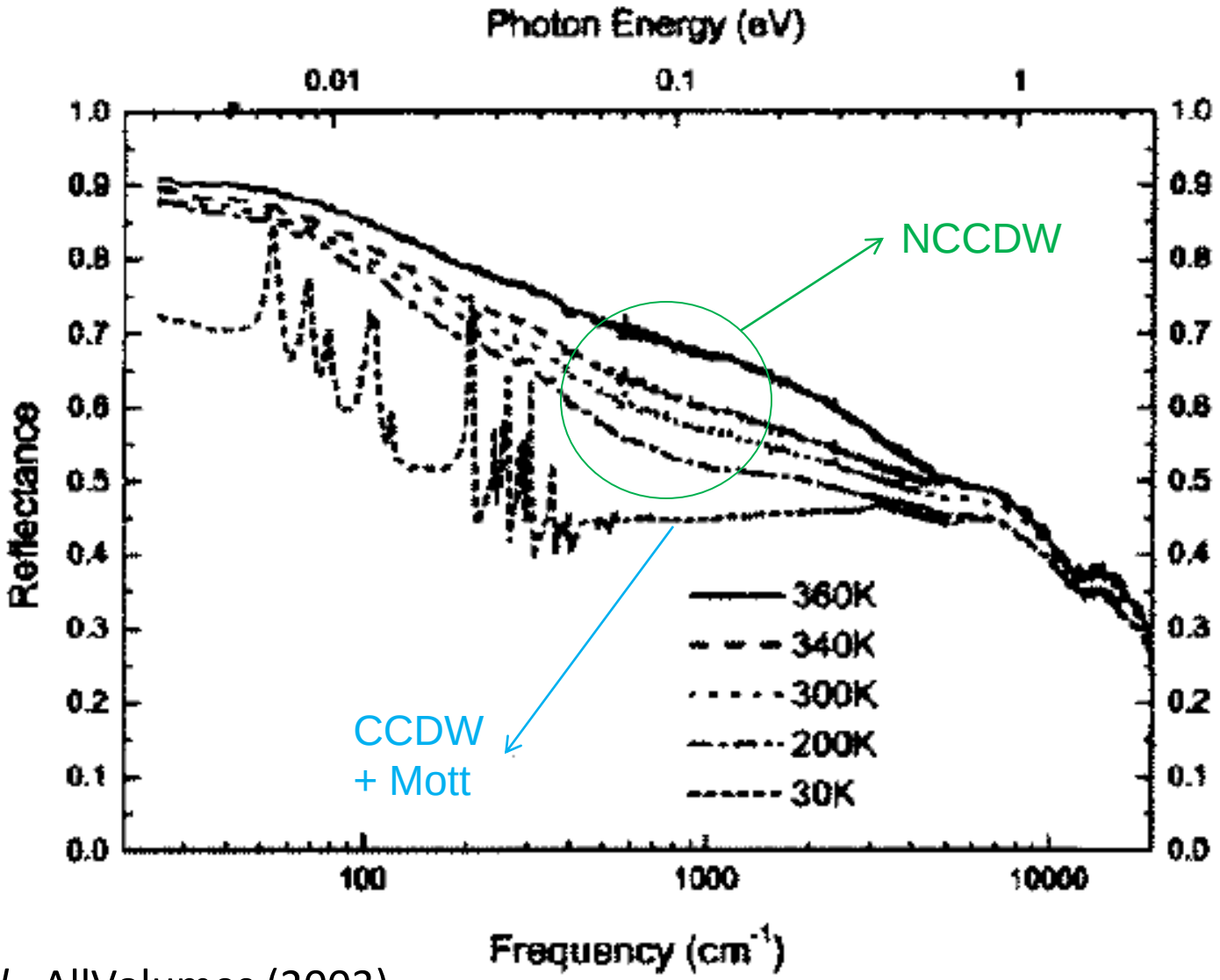
Xu *et al.*, PRB 81, 172503 (2010).

Motivation for optical measurements

- Intercalated 1T-TaS_2 allows us to study the NCCDW phase down to very low temperatures at ambient pressure
- dc resistivity measurements unable to distinguish the contribution of different domains in the “mixed” (NCCDW) phase
- Optical measurements might enable us to separate the contributions of different domains

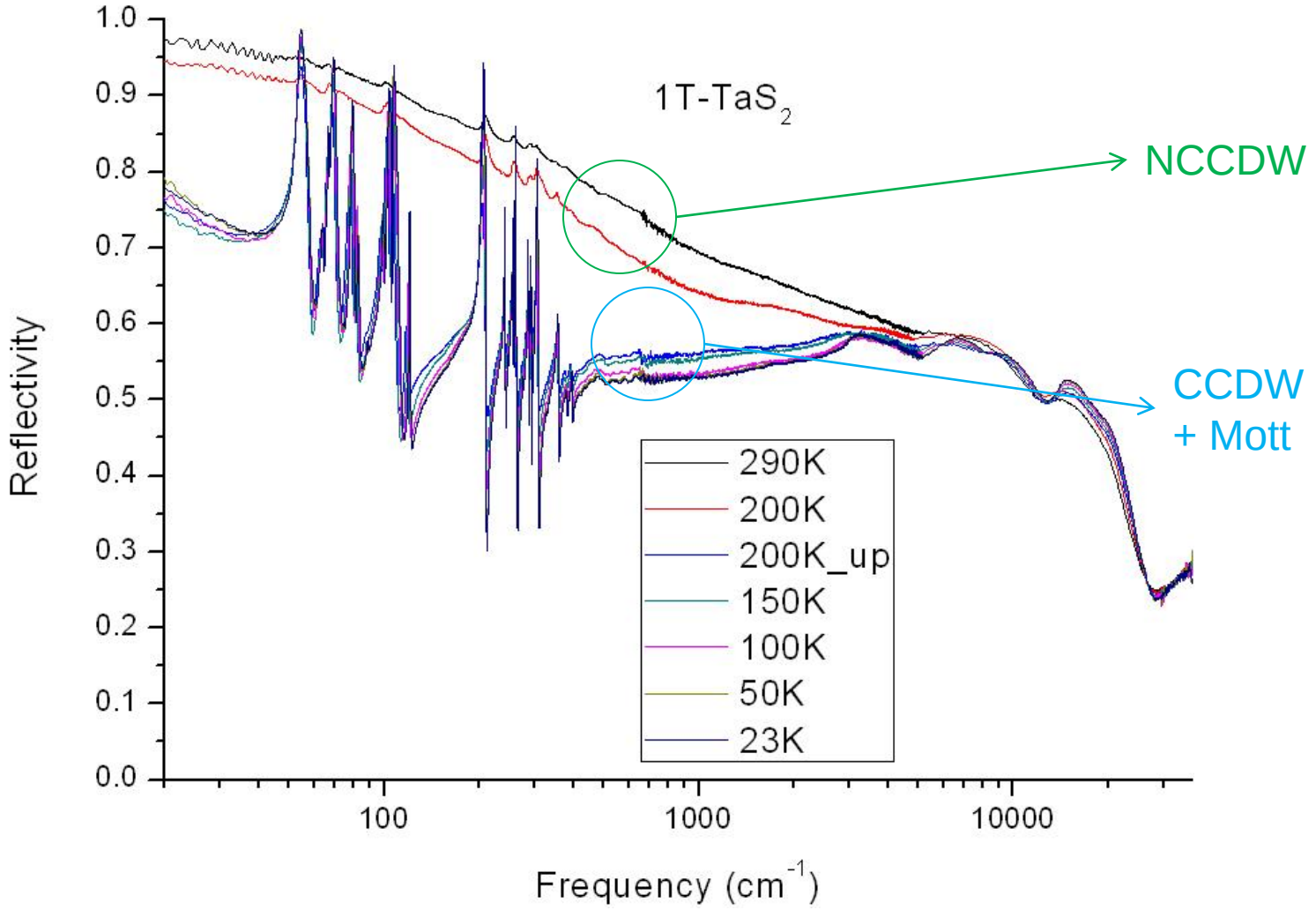
dc resistivity - “metal pieces connected by wires”

Optics in pure 1T-TaS_2

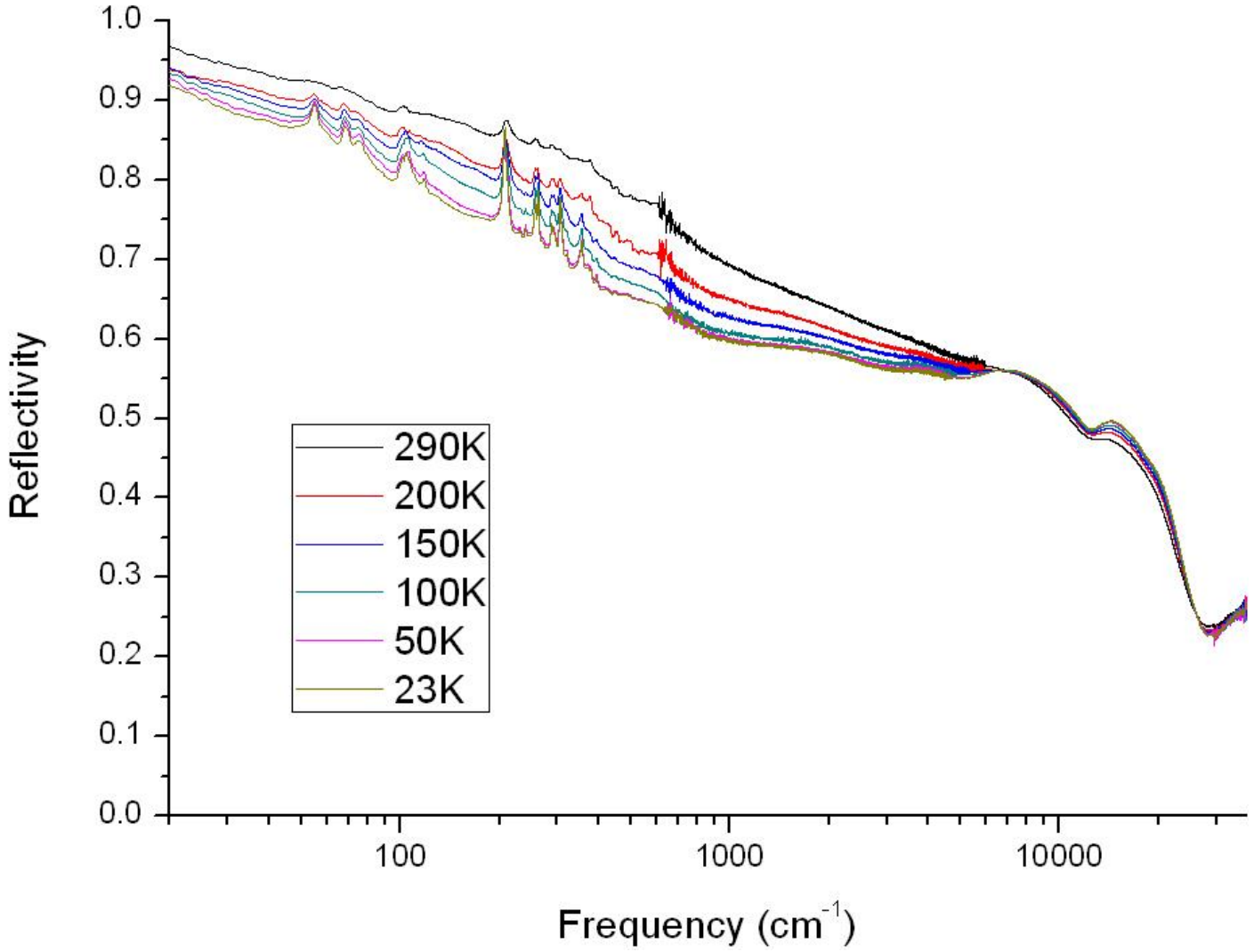


Brown *et al.*, AllVolumes (2003).

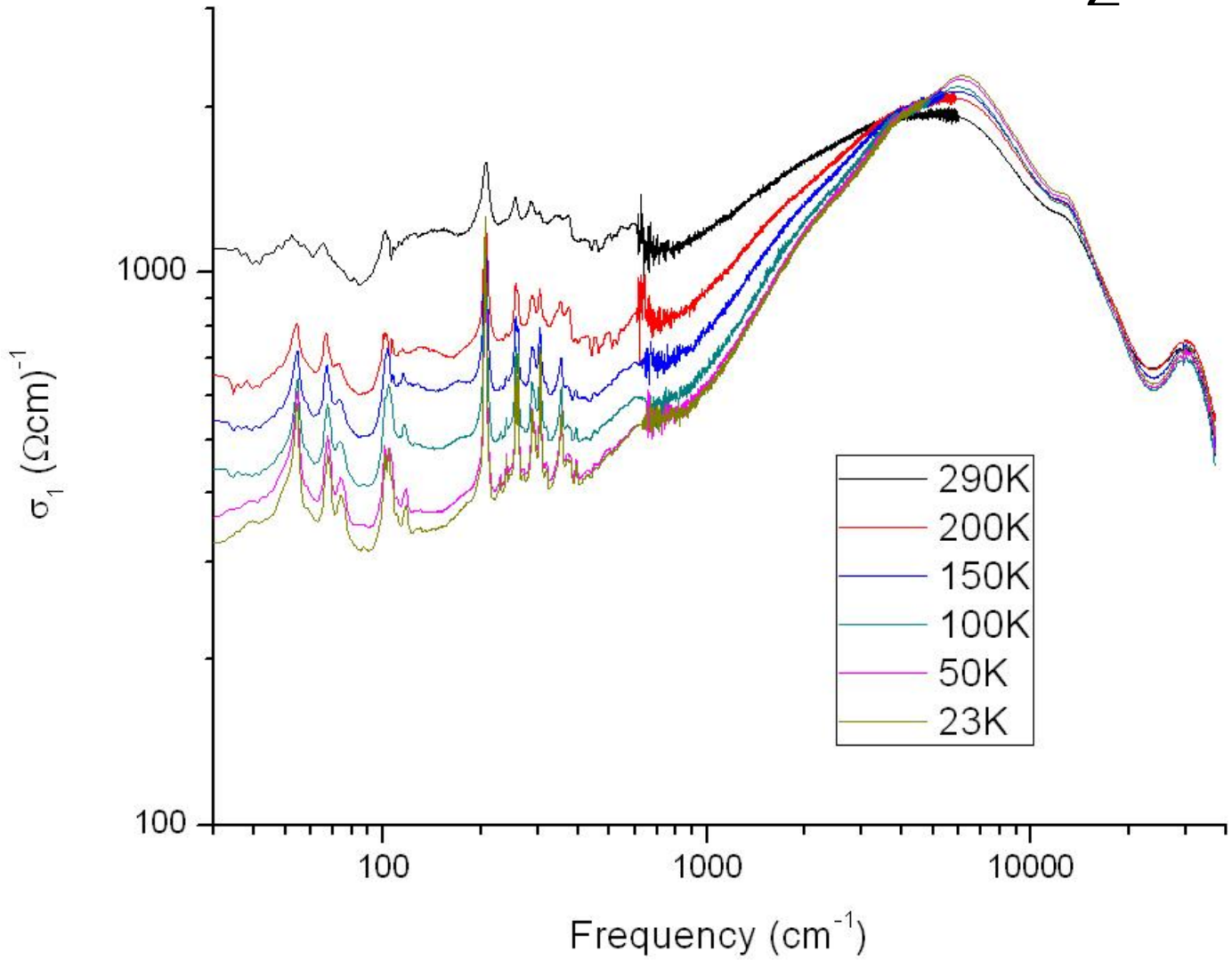
Our measurements on pure $1T\text{-}TaS_2$



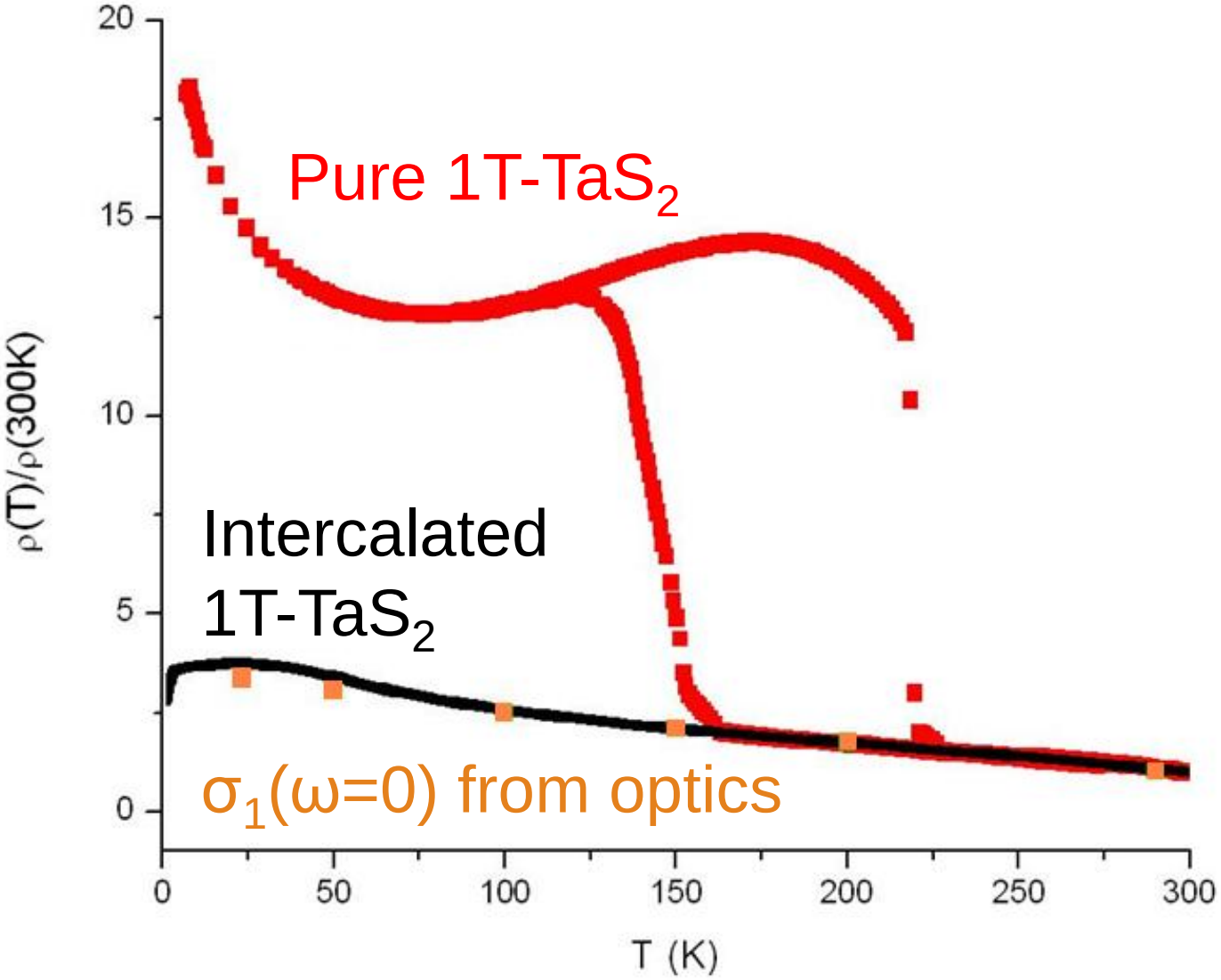
Reflectivity of intercalated 1T-TaS_2



Optical conductivity $\sigma_1(\omega)$ of intercalated 1T-TaS_2



σ_{dc} vs $\sigma_1(\omega=0)$ extrapolated from optics

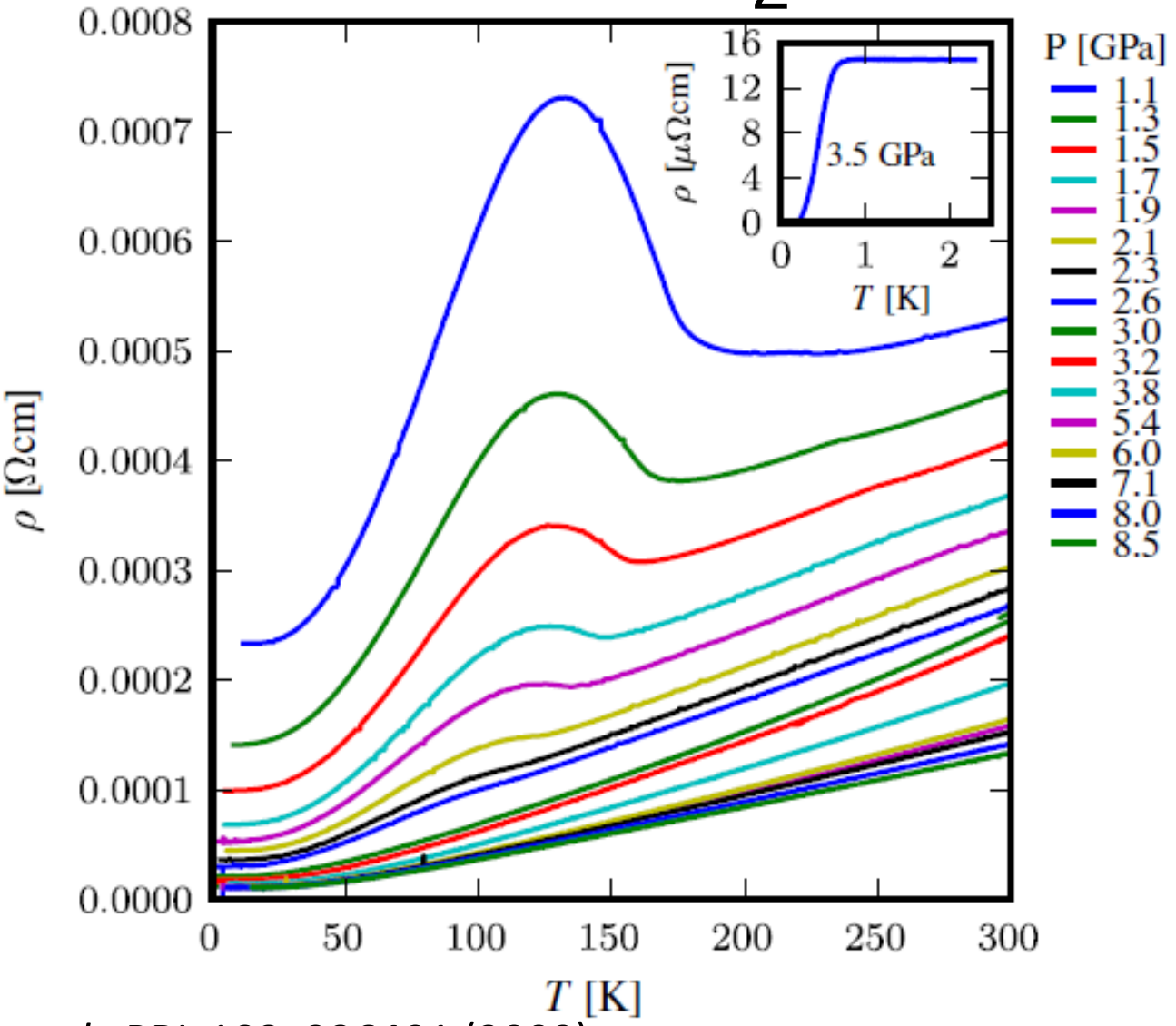


1T-TaS_2 conclusions

- NCCDW phase in intercalated 1T-TaS_2 measured optically to low temperatures
- Observed phonon modes offer a way to analyse the nature of CDW domains vs. Mott phase
- We are unable at the moment to separate the contributions of the metallic and insulating domains
- Analysis in progress…

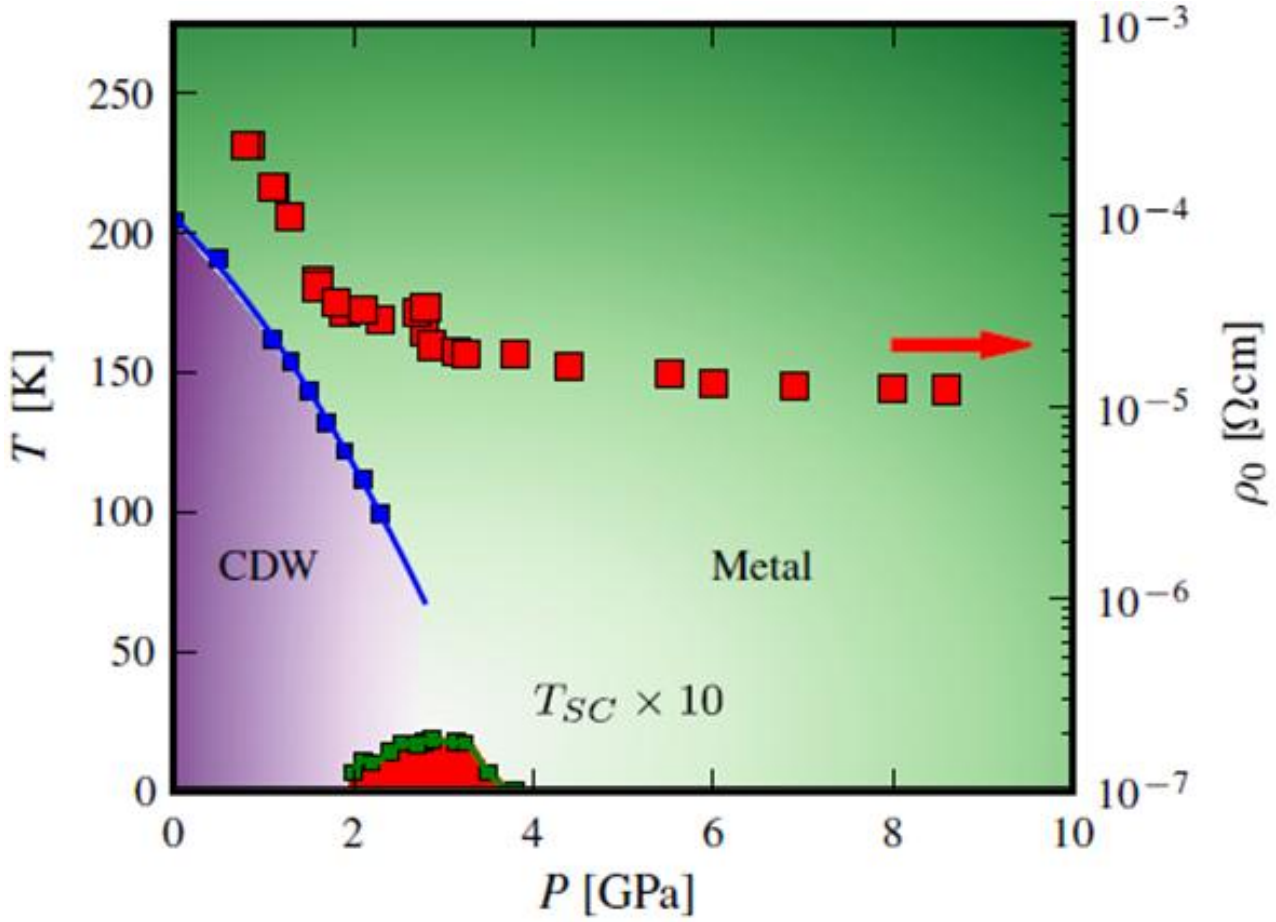
1T-$TiSe_2$
pure and doped

1T-$TiSe_2$



Kusmartseva *et al*., PRL 103, 236401 (2009).

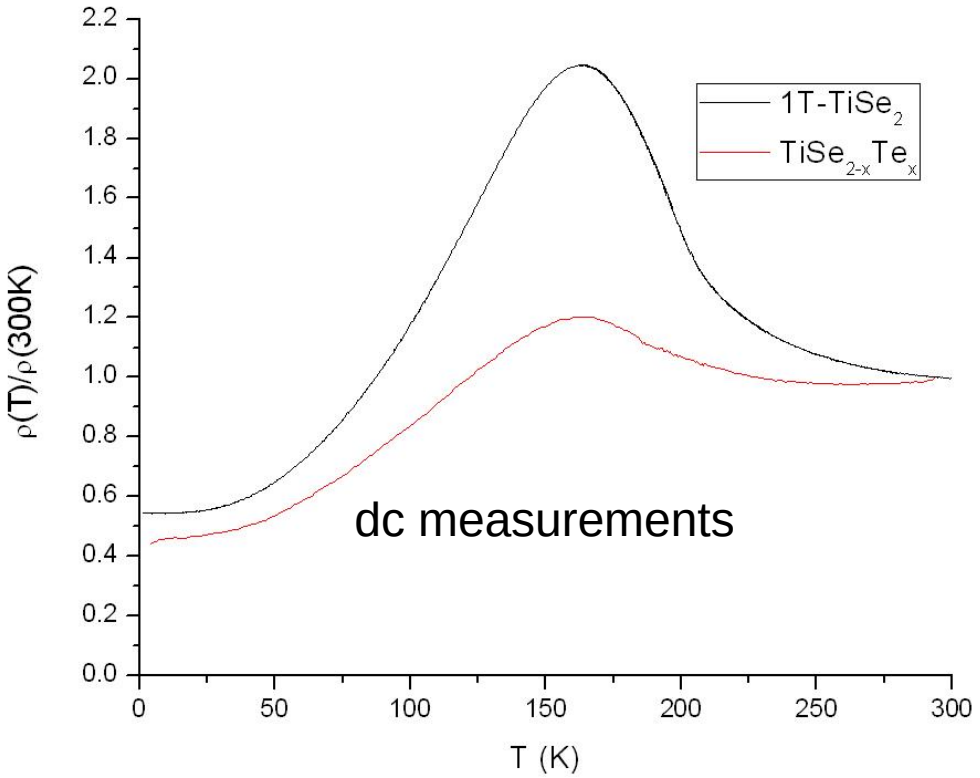
CDW + SC in 1T-$TiSe_2$



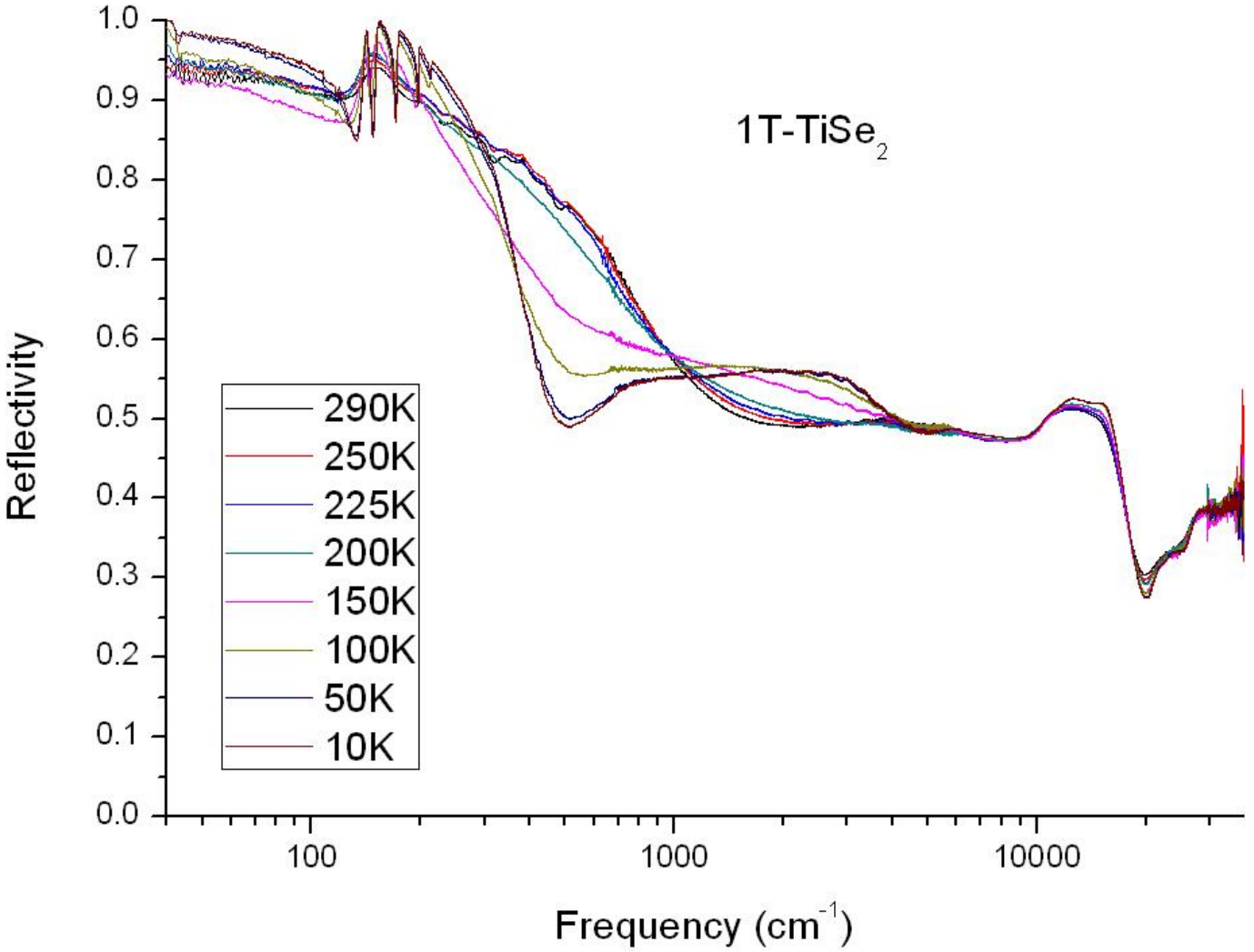
Kusmartseva *et al*., PRL 103, 236401 (2009).

Motivation for optical measurements

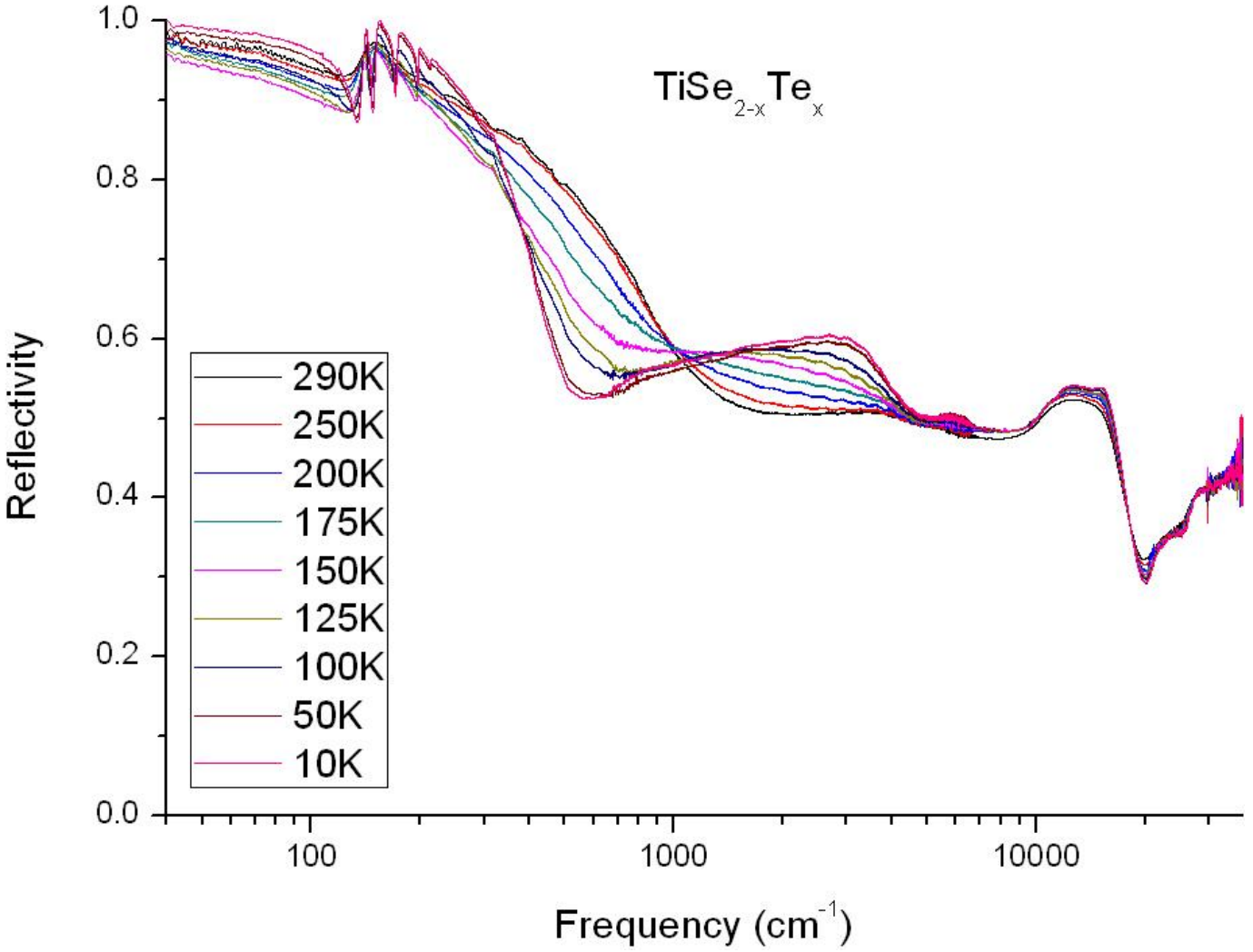
- Te doping produces a noticeable effect in the dc dana
- Similar effect expected in the optical measurements
- Better insight into the nature of the CDW phase



Measurements on 1T-$TiSe_2$



Measurements on $TiSe_{2-x}Te_x$



More to follow…