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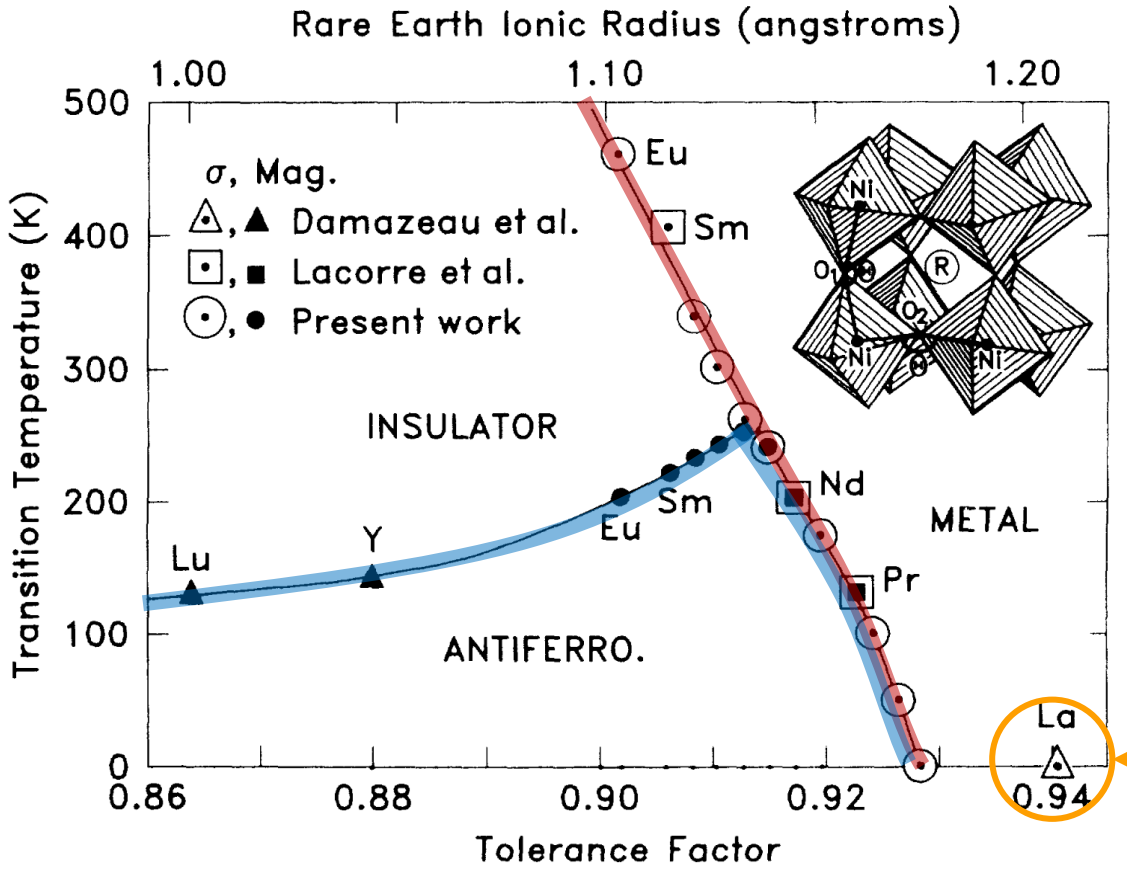
Studying $LaNiO_3$ and $LaNiO_3/LaAlO_3$ superlattices using ^{8}Li β-detected NMR

Victoria Louise Karner

The metal-insulator transition in rare-earth nickelates ($RNiO_3$)

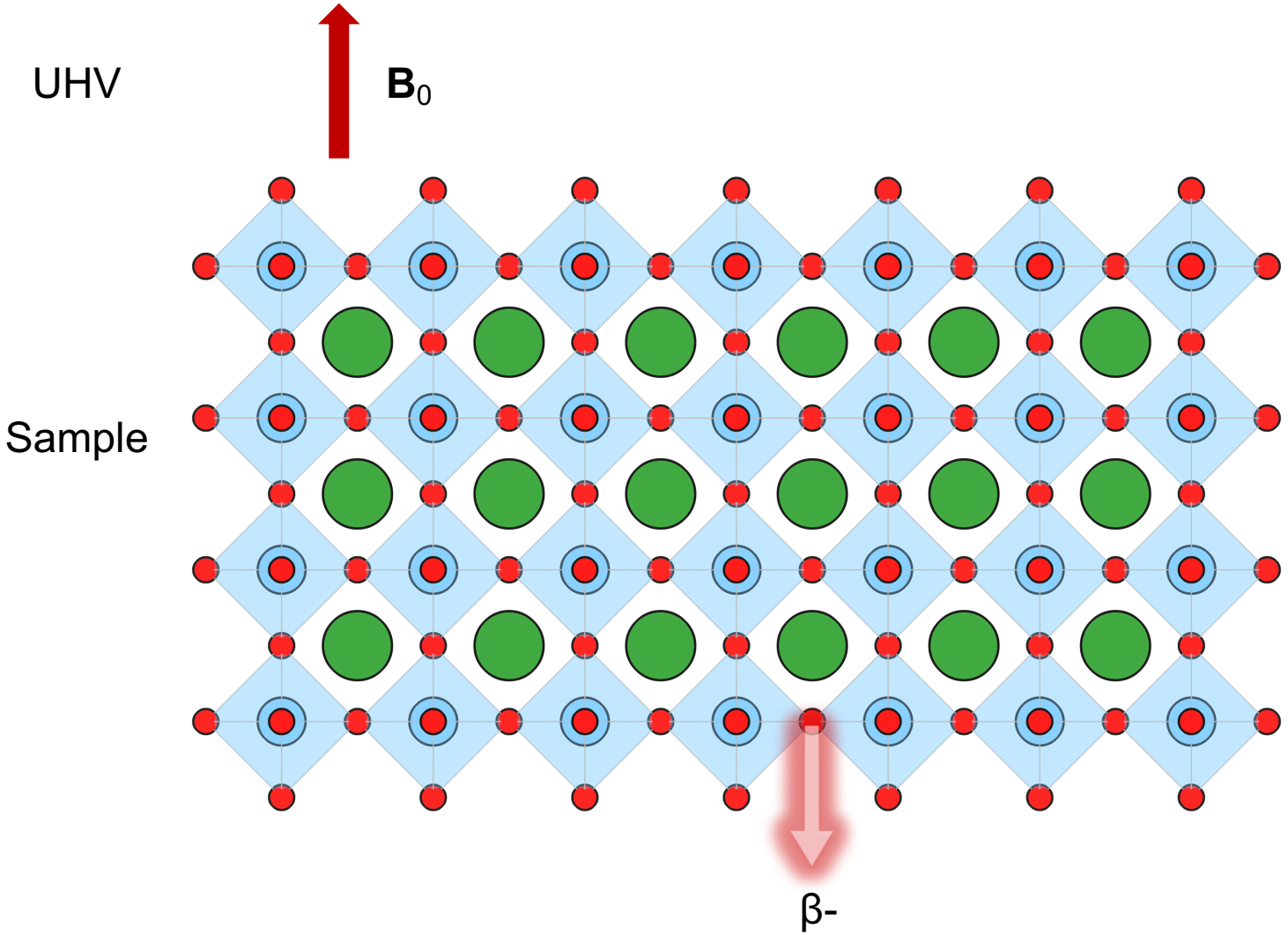


only metal!

J.B. Torrance, *et al*. Phys. Rev. B **45**, 8209 (1992)

Goal: Study the change in the metallic state of $LaNiO_3$ between the bulk and ultrathin layers in superlattices

What is β-detected NMR?



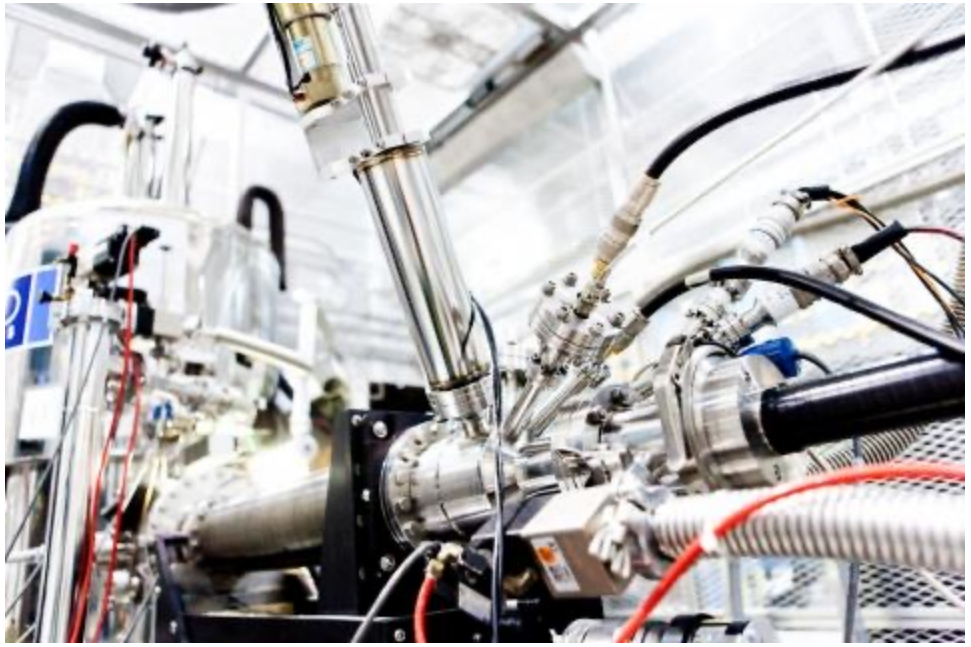
$$^{8}_{3}\mathrm{Li} \rightarrow {}^{8}_{4}\mathrm{Be} + \mathrm{e}^{-} + \bar{\nu}_{\mathrm{e}}$$

$$t_{1/2} = 848\ ms$$

$$I = 2$$

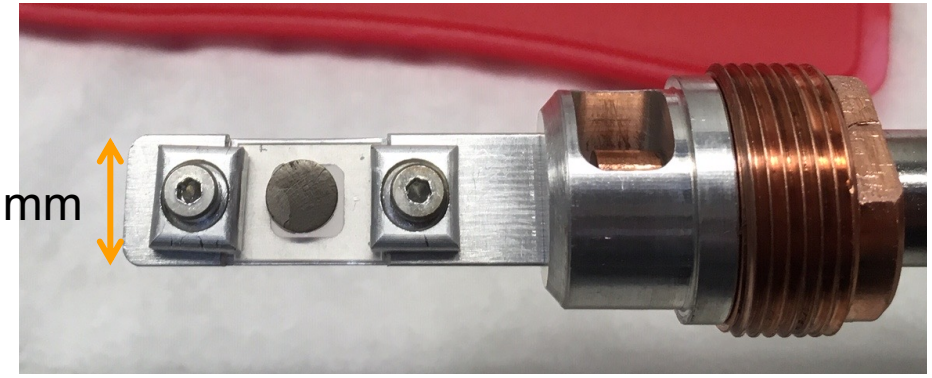
What is β-detected NMR?

- Uses implanted β-decaying radioisotopes
- The ions are spin polarized (magnetized) prior to implantation in sample
- Detection is possible due to the anisotropy of β-decay



$LaNiO_3$ Samples

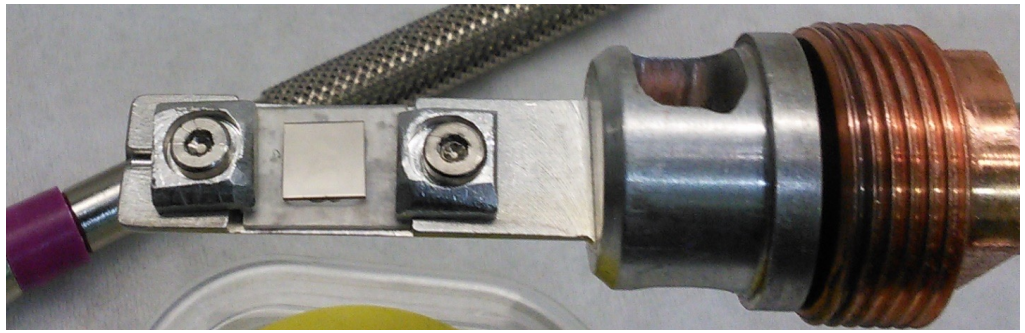
Single Crystal



J. Mitchell (ANL)

J. Zhang, *et al.* Cryst. Growth Des. **17**, 2730 (2017)

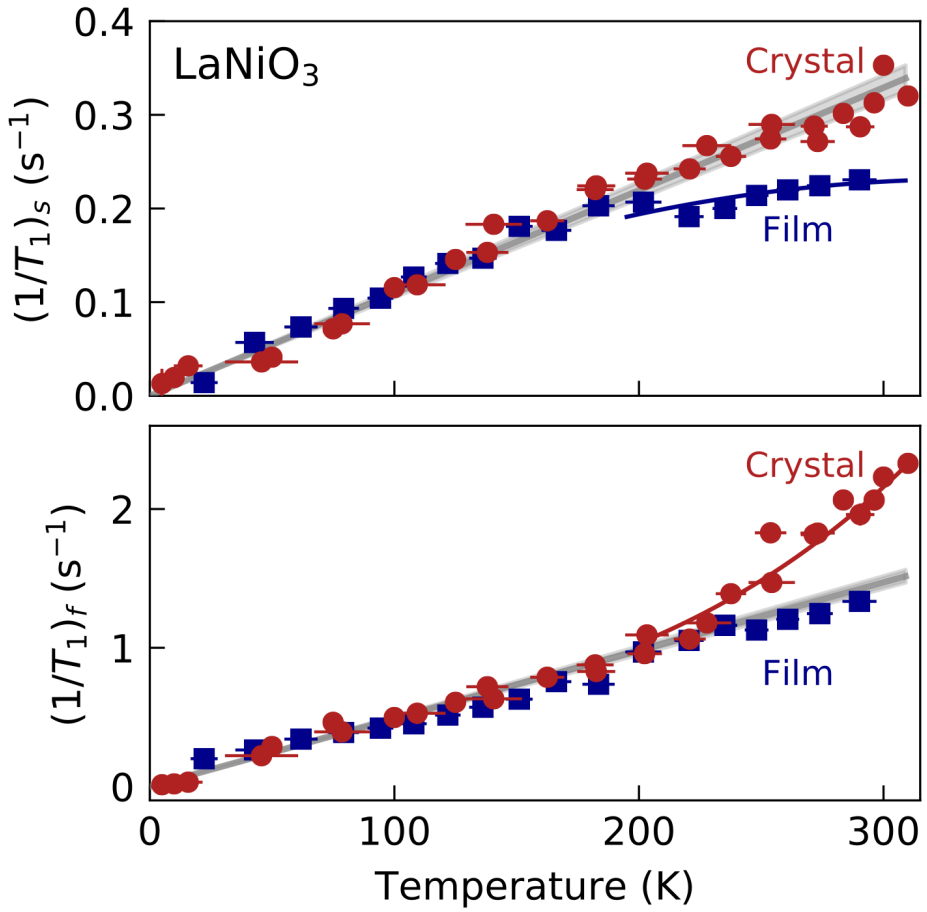
38 nm PLD Film on LSAT



G. Cristiani (MPI-FKF)

A.V. Boris, *et al.* Science **332**, 937 (2011)

Excellent agreement between single crystal and film

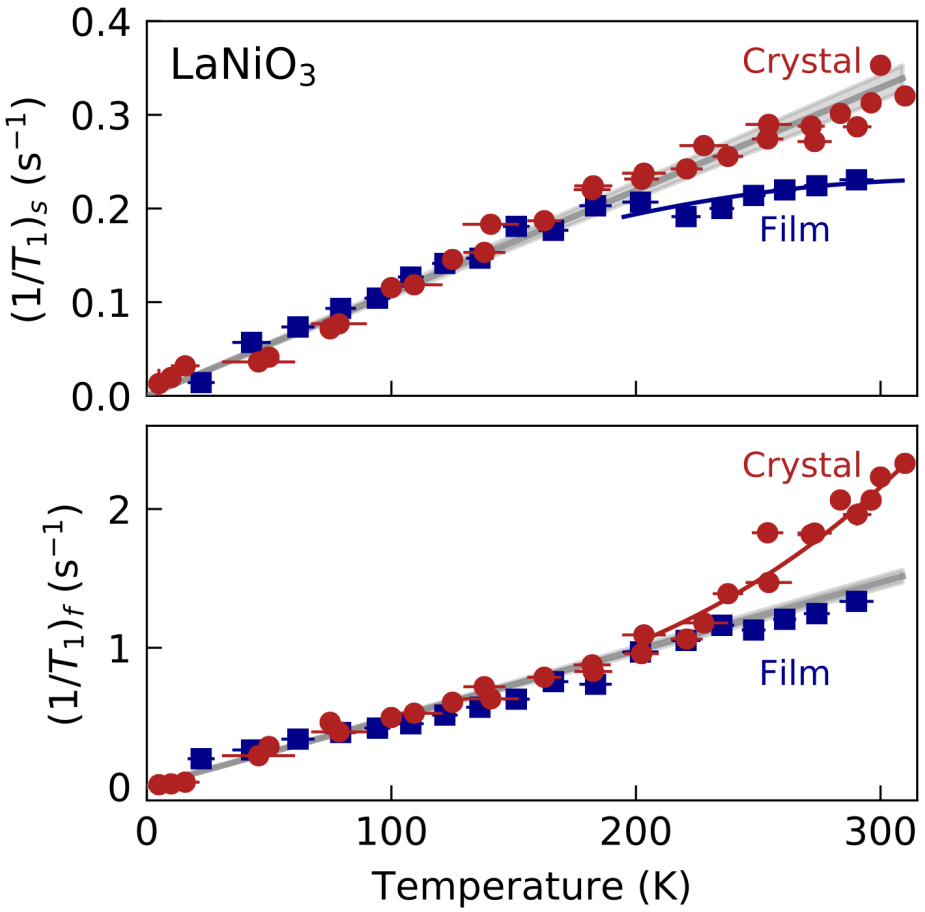


Biexponential relaxation is surprising!

V. L. Karner, *et al.* Phys. Rev. B **100**, 165109 (2019)

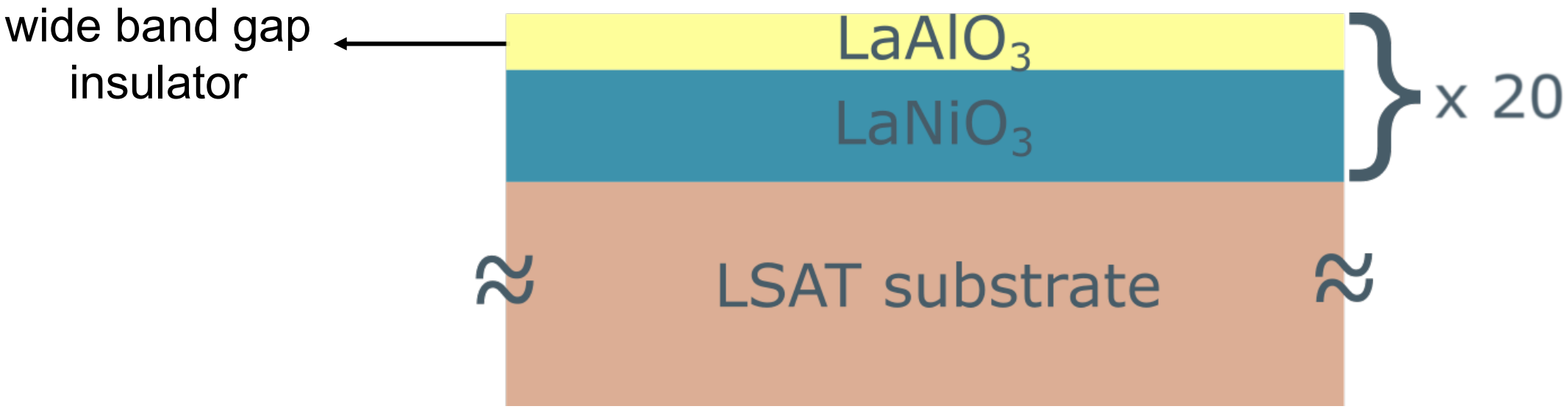
Summary of bulk $LaNiO_3$

1. Biexponential relaxation:
   - intrinsic to $LaNiO_3$
   - two different hyperfine couplings to ^8Li
2. Linear SLR:
   - conventional metallic state



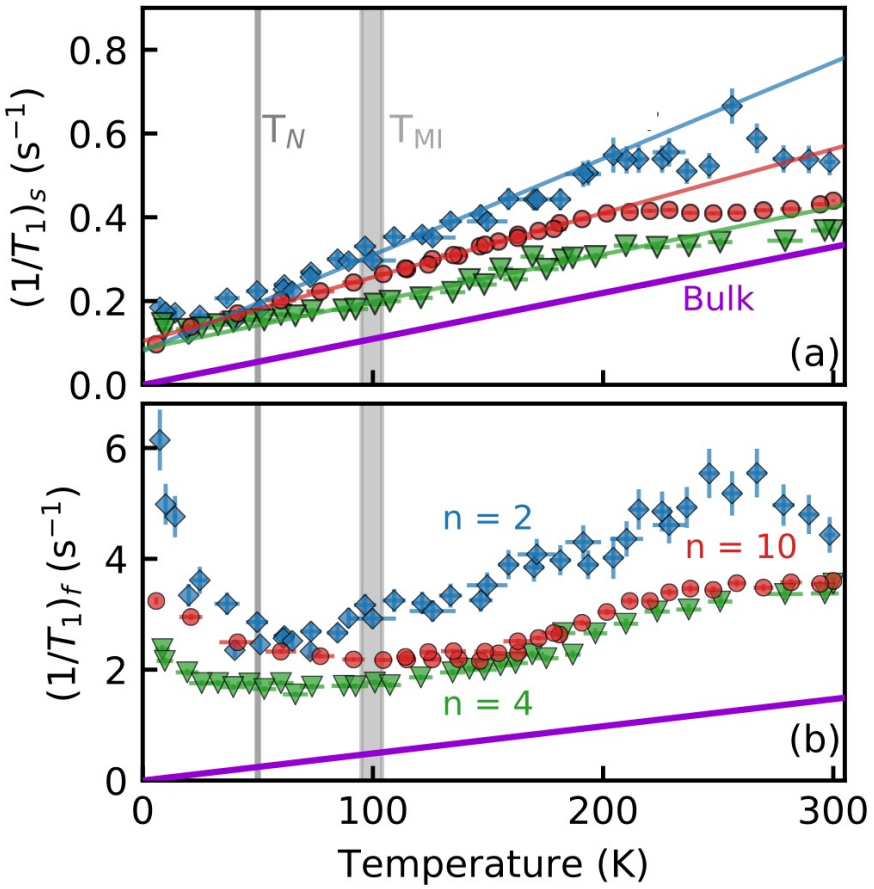
V. L. Karner, *et al.* Phys. Rev. B **100**, 165109 (2019)

Structure of the $LaNiO_3/LaAlO_3$ superlattices



LNO lattice constant ≈ 3.75 Å

Where is the metal-insulator transition?

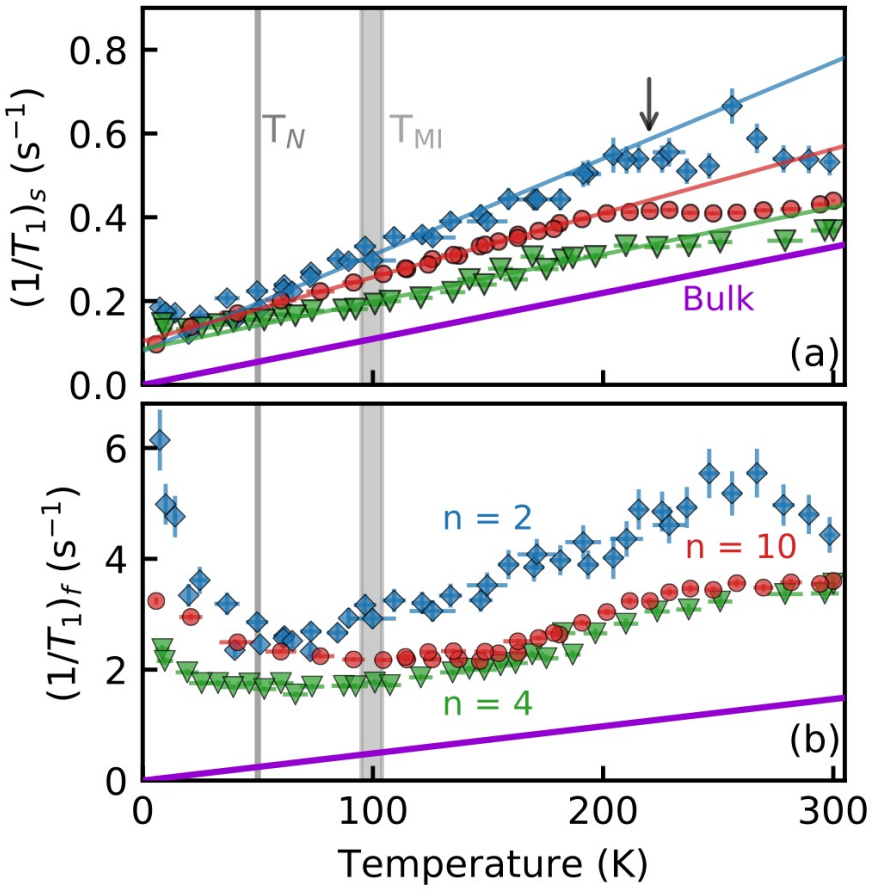


Different Temperature Dependences!

Suggests **microscopic electronic phase separation**

V. L. Karner, *et al.* Phys. Rev. B **104**, 205114 (2021)

Biexponential relaxation suggests phase separation



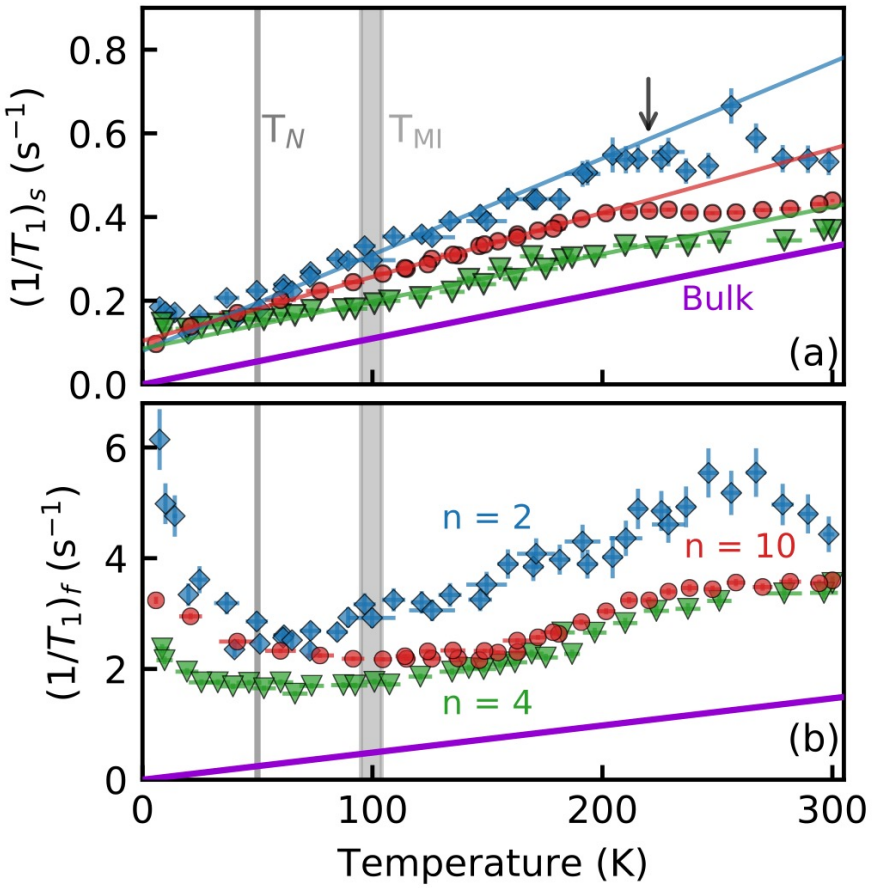
Phase separation is unique:

- Static on our timescale
- Persists to 300 K
- Observed in all samples, even bulk

V. L. Karner, *et al.* Phys. Rev. B **104**, 205114 (2021)

Summary

1. In the bulk:
   - linear SLR indicates conventional metallic state
2. In the SLs:
   - slow component is linear even in the n = 2 SL
   - fast component is more complex
3. Biexponential relaxation:
   - intrinsic to $LaNiO_3$
   - suggests microscopic phase separation



V. L. Karner, *et al.* Phys. Rev. B **100**, 165109 (2019); V. L. Karner, *et al.* Phys. Rev. B **104**, 205114 (2021)

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Thank you!

Discovery, accelerated