

# Vortex-like excitation above $T_c$ in 2D superconductor

## $\text{PrO}_{0.5}\text{F}_{0.5}\text{BiS}_2$

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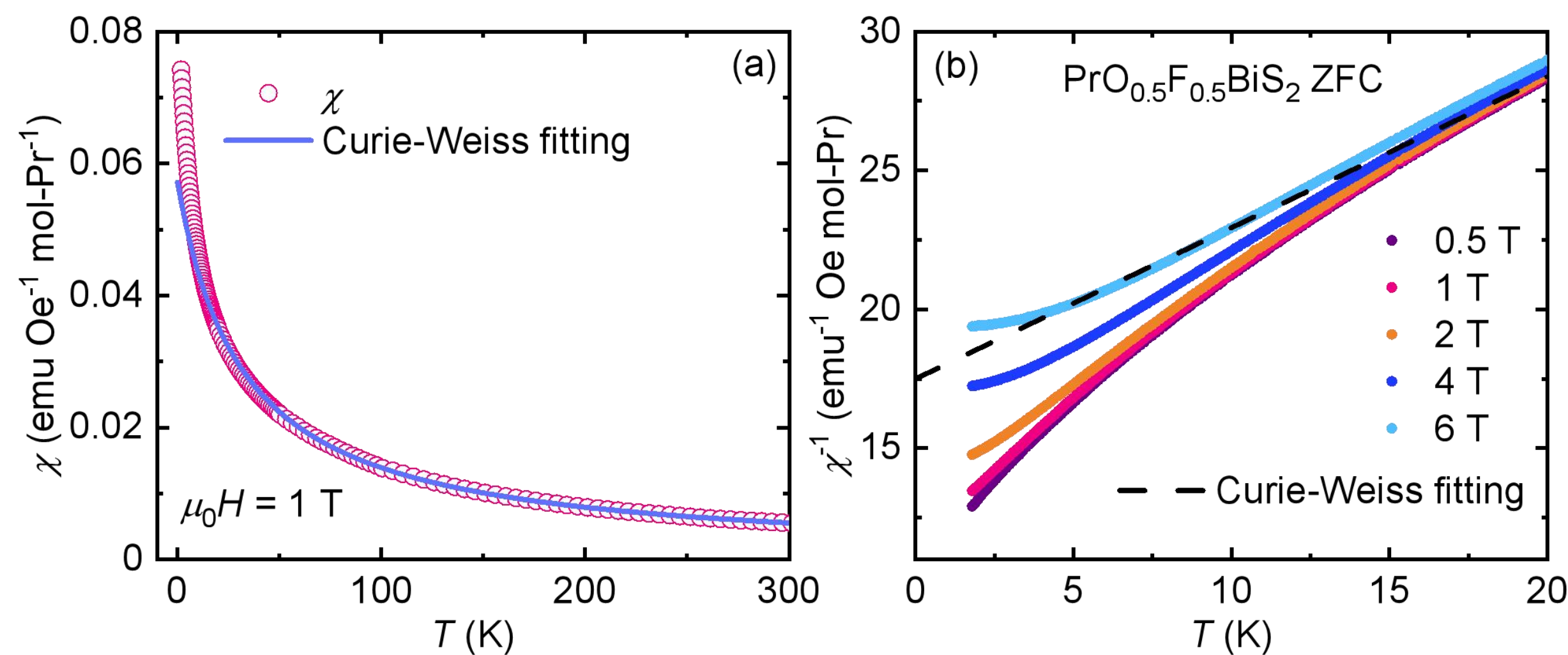
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### Motivations

- $\text{PrO}_{0.5}\text{F}_{0.5}\text{BiS}_2$ : 2D, layered structure, with  $T_c = 3.5$  K[1].
- Superconductivity arises from  $\text{BiS}_2$  layers, analogous to  $\text{CuO}_2$  layers in cuprates and  $\text{FeAs}/\text{FeSe}$  layers in iron-based SC.
- No study on the potential phase fluctuation and pseudogap regime due to the two-dimensionality of the system[2][3].
- Explore the coexistence of superconductivity and magnetism.

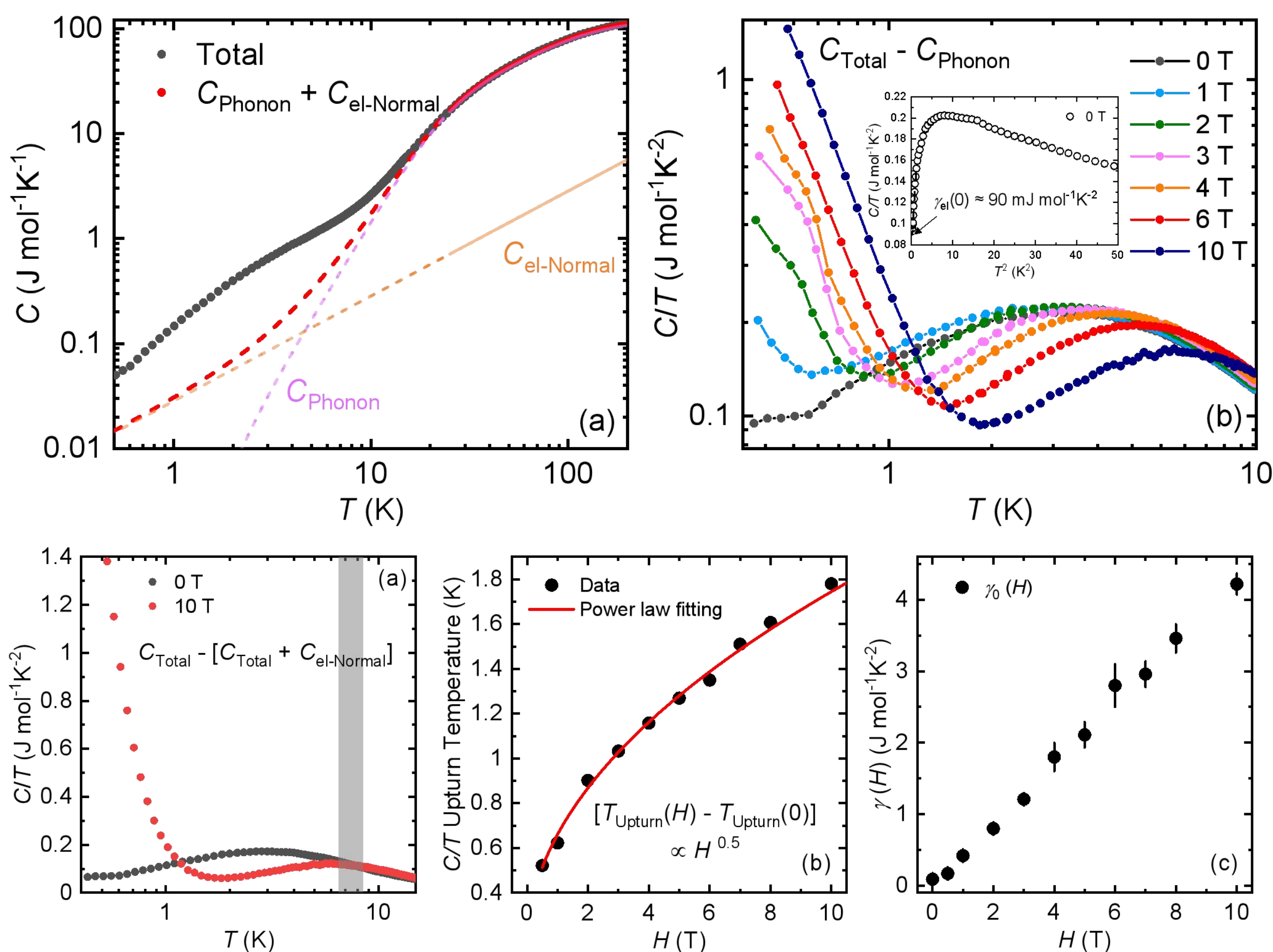
### Magnetic Susceptibility

- The system becomes itinerant below 20 K.
- External field suppresses the itineration and makes the 4f electrons in Pr more localized.



### Specific Heat

- $C_{\text{total}} = C_{\text{Phonon}} + C_{\text{el-Normal}}$  above 20 K
- Non-Fermi liquid behaviour: nonlinear electron specific heat.
- Kondo scattering at low temperature: a low- $T$  rise in  $C/T$ .
- External fields enhance such Kondo scattering.
- Potential superconducting fluctuation above  $T_c$  at zero field.



### Conclusions

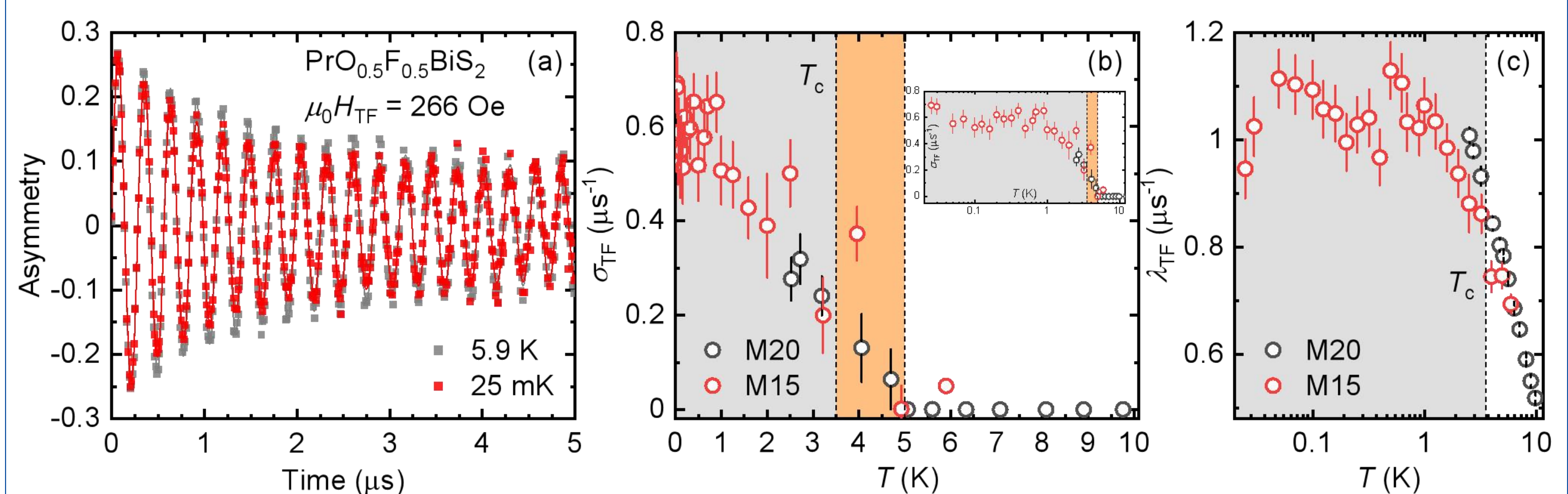
- 4f electrons of Pr ions change from itinerant to localized with the increase of external magnetic field.
- Kondo effect at low temperature.
- Vortex-like excitation and phase fluctuation above  $T_c$ .
- Slow magnetic fluctuation above  $T_c$  in the pseudogap-like regime.

### Transverse field $\mu\text{SR}$

Fitting function:

$$A_s(t) = A_s \exp\left(-\frac{1}{2} \sigma_{\text{TF}}^2 t^2 - \lambda_{\text{TF}} t\right) \cos(\omega_s t + \phi)$$

- Gaussian relaxation rate  $\sigma_{\text{TF}}$  is enhanced by FLL field inhomogeneity.
- $\sigma_{\text{TF}}$  appears above  $T_c$  indicating vortex-like excitation in the normal state.

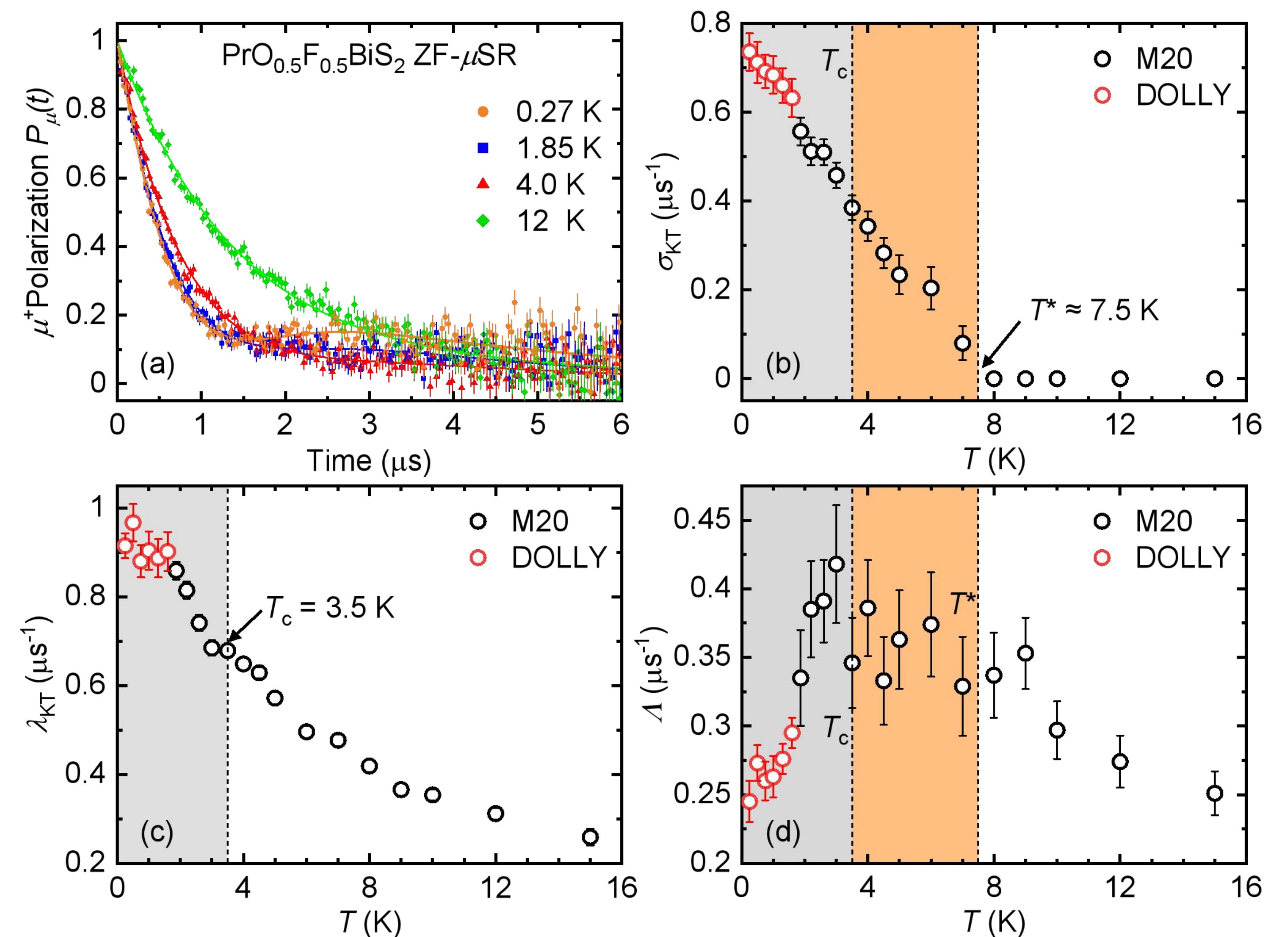


### Zero field $\mu\text{SR}$

Fitting function:

$$P_\mu(t) = A_s G_{\text{ZF}}^{\text{LGKT}}(\sigma_{\text{KT}}, \lambda_{\text{KT}}, t) \exp(-\Lambda t)$$

- Static fields with both Gaussian and Lorentzian distribution are obtained.
- $\sigma_{\text{KT}}$  appears below  $T^*$  indicating the spontaneous vortex-like excitation in the pseudogap-like regime above  $T_c$ .



### References

- [1] D. Yazici, *et al.*, Philosophical Magazine 2013, 93, 6673.
- [2] M. Franz, Nature Physics 2007, 3, 10 686.
- [3] M. Hashimoto, Nature Physics 2014, 10, 7 483.

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