

PS-B4

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Effective Hamiltonian for $Tb_2Ti_2O_7$

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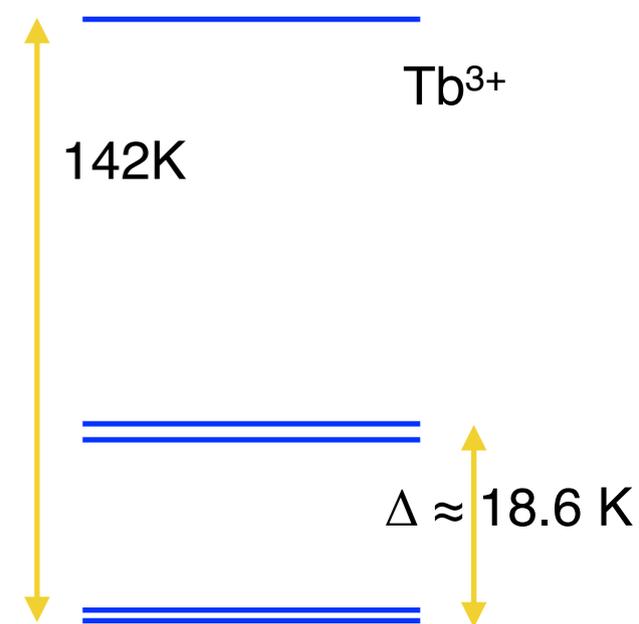
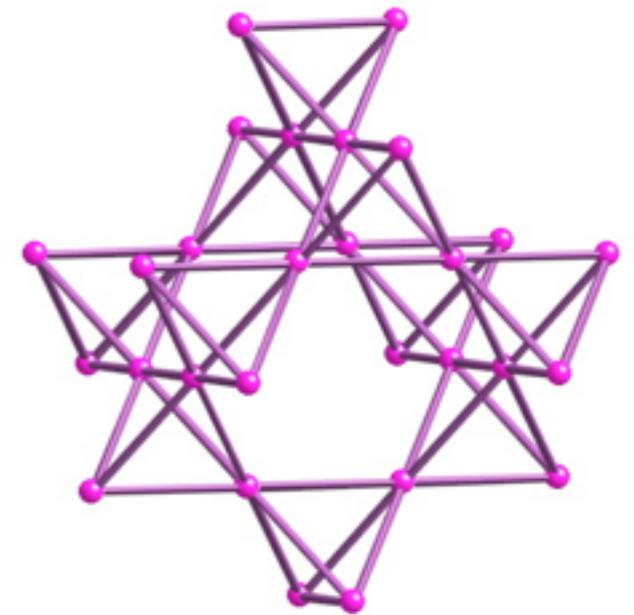
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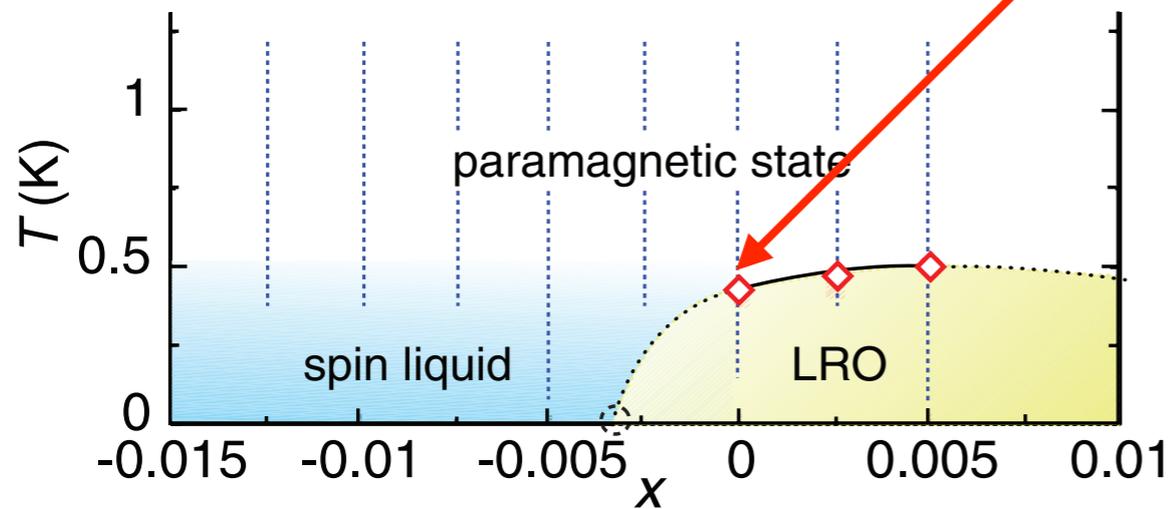
Key features of $\text{Tb}_2\text{Ti}_2\text{O}_7$

- Pyrochlore material
- Two low-lying crystal field doublets with small energy gap $\Delta \approx 18.6$ K.
- shows **no long-range order** down to 50 mK.
- A $q=(1/2, 1/2, 1/2)$ **short-range order** and **specific heat anomaly** are reported recently.
- Quantum spin ice.



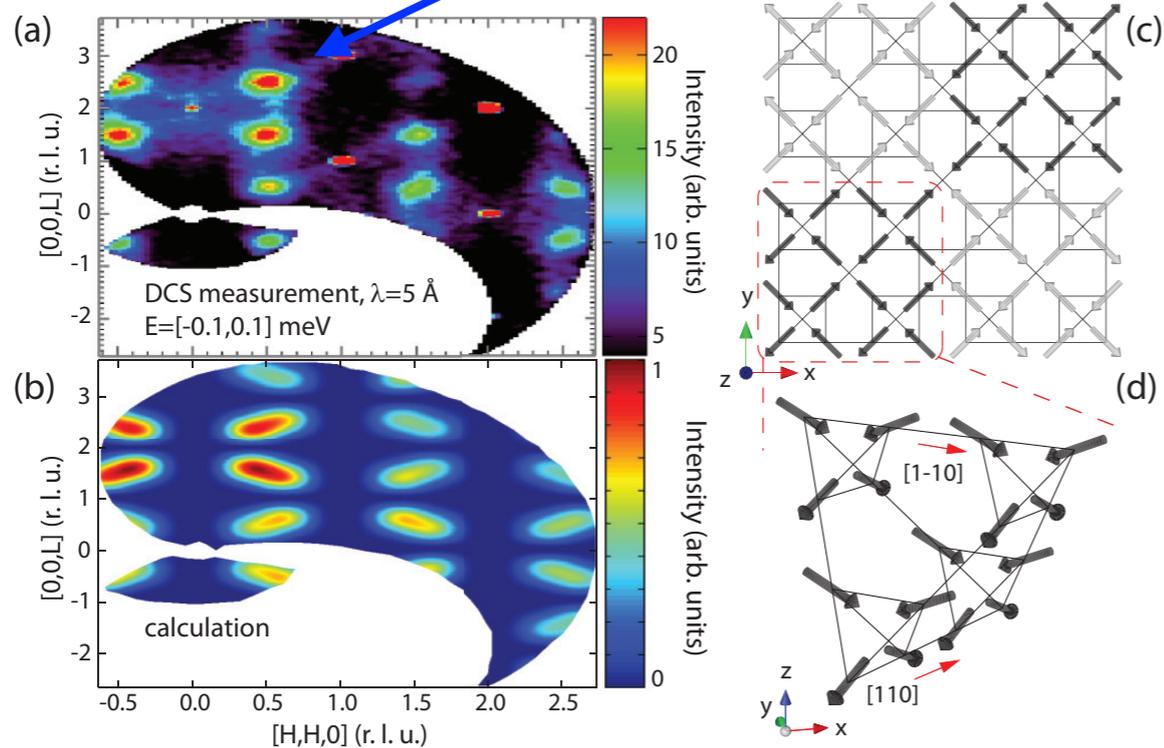
Experiments

no magnetic Bragg peak, specific heat anomaly

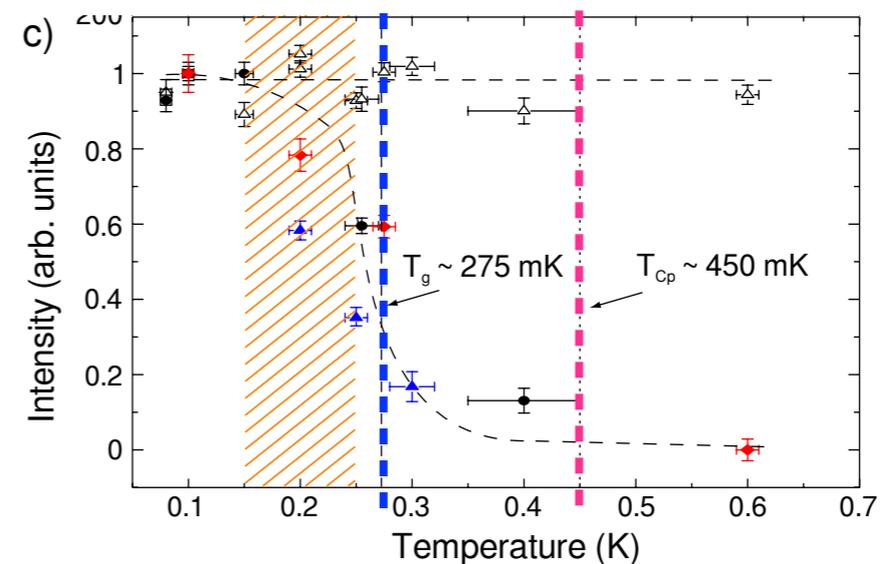
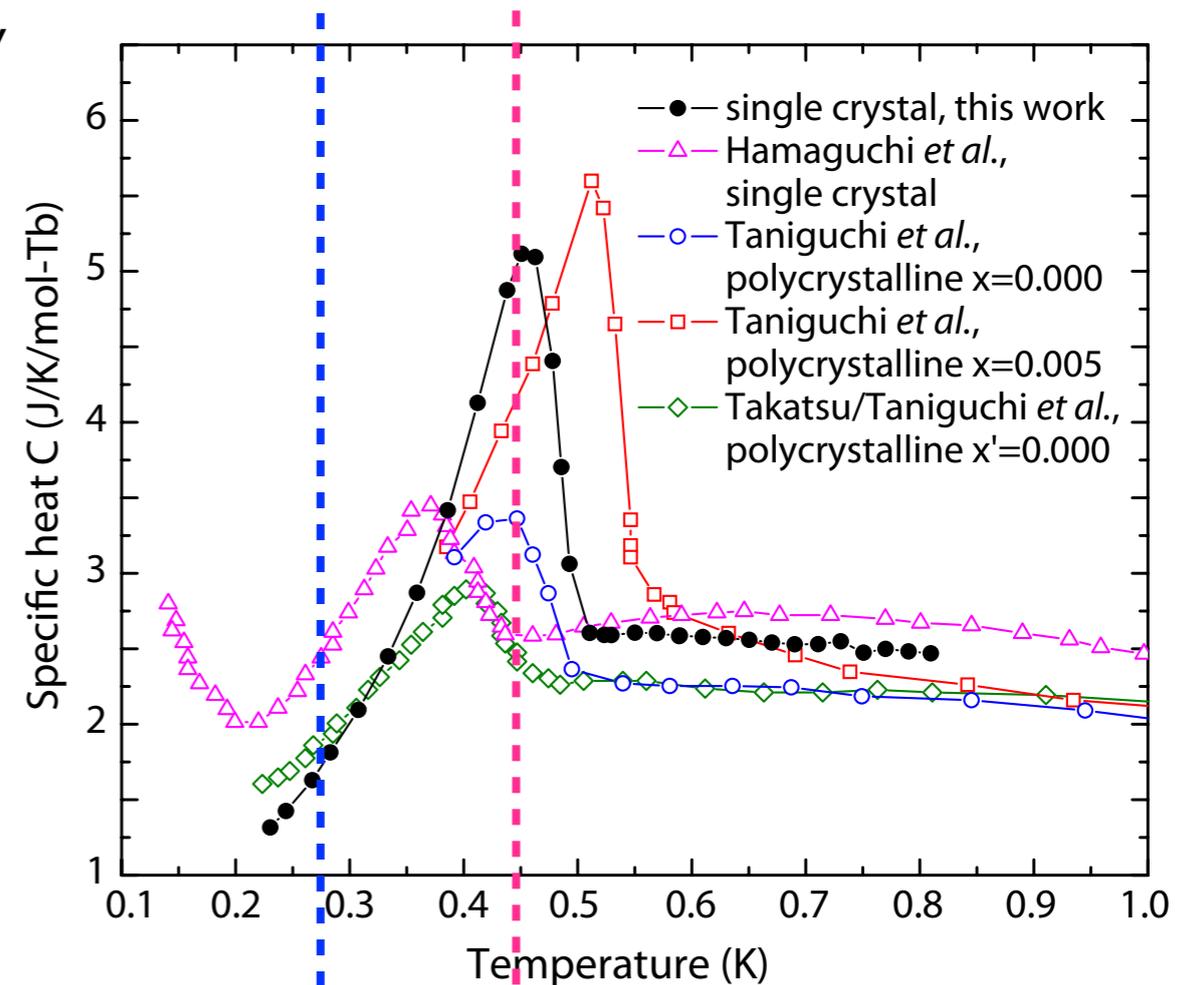


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$(1/2, 1/2, 1/2)$ short-range order



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Effective Hamiltonian

$$\hat{\mathcal{H}}_{\text{eff}} = -J_{nn} \sum_{\langle ia;jb \rangle} \left[\hat{\sigma}_i^{a,z} \hat{\sigma}_j^{b,z} + \frac{\delta}{2} (\hat{\sigma}_i^{a,+} \hat{\sigma}_j^{b,-} + \hat{\sigma}_i^{a,-} \hat{\sigma}_j^{b,+}) + \frac{q}{2} (\hat{\sigma}_i^{a,+} \hat{\sigma}_j^{b,+} e^{2i\phi_{a,b}} + H.c.) \right]$$

$$- J_{2nn} \sum_{\langle ia;jb \rangle_2} \hat{\sigma}_i^{a,z} \hat{\sigma}_j^{b,z} - J_{3nn} \sum_{\langle ia;jb \rangle_3} \hat{\sigma}_i^{a,z} \hat{\sigma}_j^{b,z} + \hat{\mathcal{H}}_{b_3}$$

$$\hat{\mathcal{H}}_{b_3} = -b_3 \sum_{\langle ia;kc;jb \rangle} \hat{\sigma}_i^{a,z} \hat{\sigma}_j^{b,z} [(\cos \phi_{ac} + \cos \phi_{bc}) \hat{\sigma}_k^{c,x} - (\sin \phi_{ac} + \sin \phi_{bc}) \hat{\sigma}_k^{c,y}]$$

