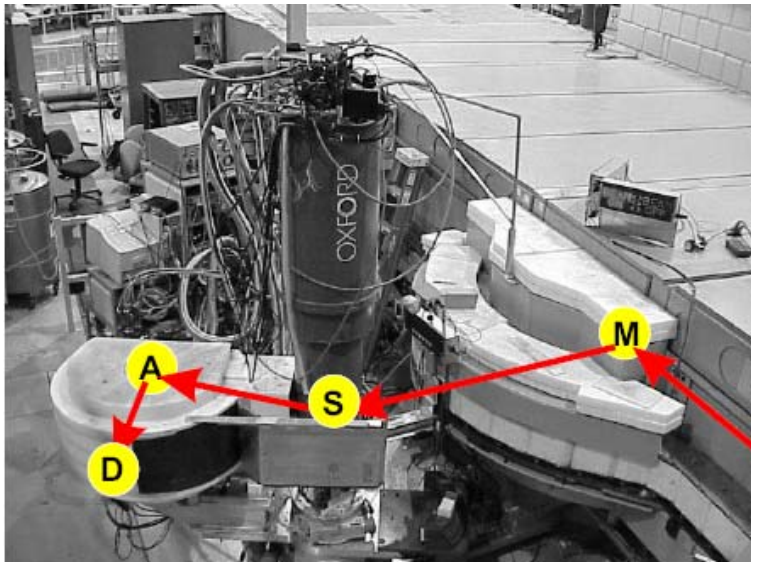
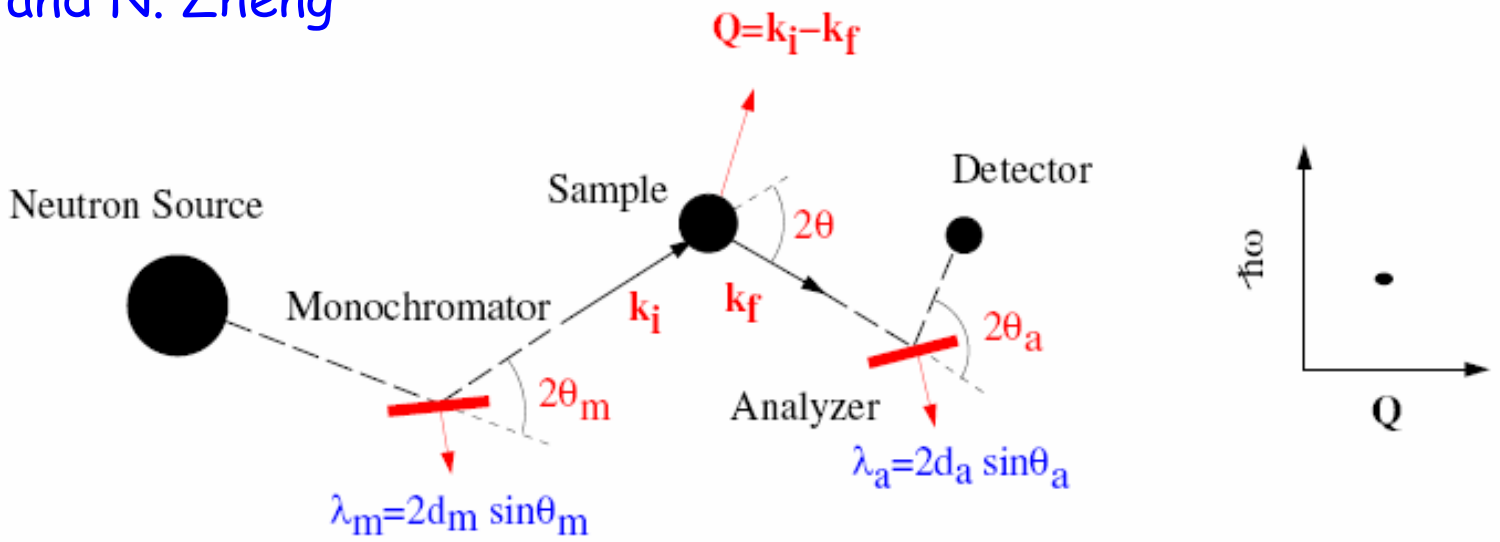
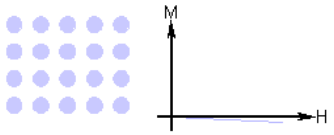
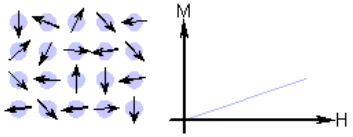
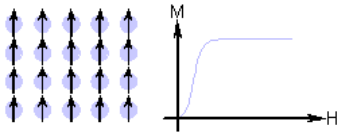
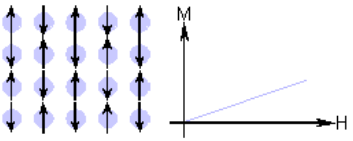
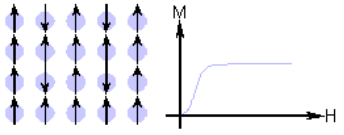
Spins fluctuations and geometrical frustration in anti-ferromagnetic $CdCr_2O_4$

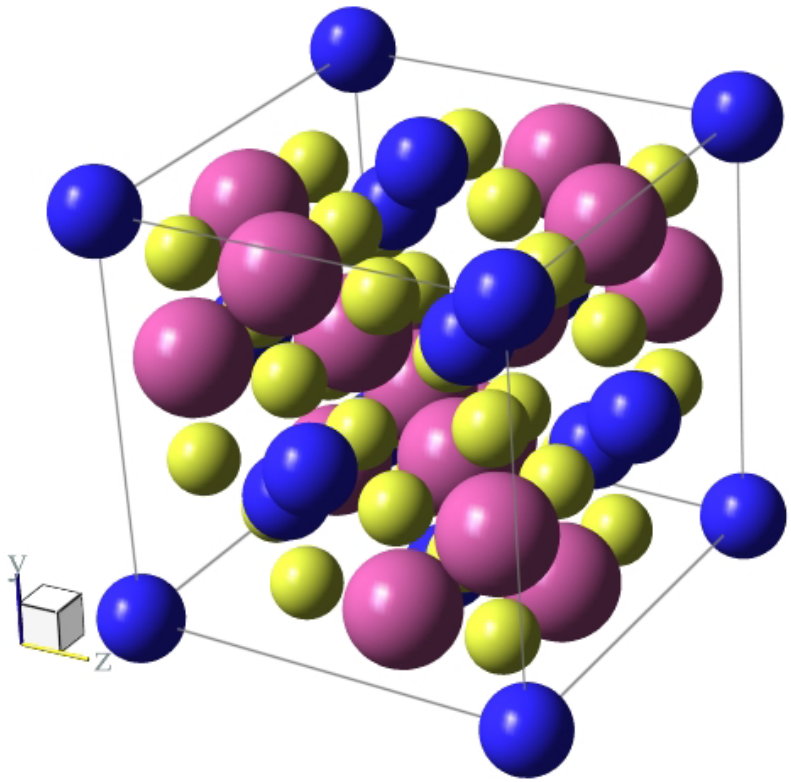


M. Castro-Colin, C. Capan, K. Holman, I. M. Cabrera, K. Johnson, S. Park, J. Yu and N. Zheng



type	susceptibility	atomic /magnetic behaviour		example	susceptibility
Diamagnetism	Small & negative	Atoms have no magnetic moment		Au Cu	-2.74×10^{-6} -0.77×10^{-6}
Paramagnetism	Small & positive	Atoms have randomly oriented magnetic moments		B-Sn Pt Mn	0.19×10^{-6} 21.04×10^{-6} 66.10×10^{-6}
Ferromagnetism	Large & positive, function of applied field, microstructure dependent	Atoms have parallel aligned magnetic moments		Fe	$\cong$100 000
Antiferromagnetism	Small & positive	Atoms have mixed parallel and anti-parallel aligned magnetic moments		Cr	3.6×10^{-6}
Ferrimagnetism	Large & positive, function of applied field, microstructure dependent	Atoms have anti-parallel aligned magnetic moments		Ba Ferrite	$\cong$3

The structure



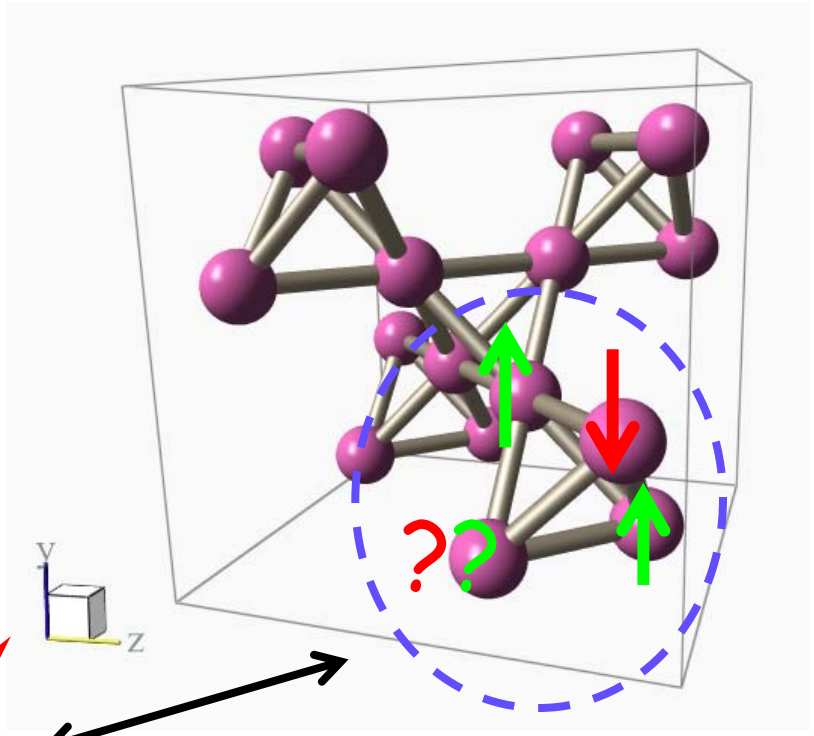
$CdCr_2O_4$

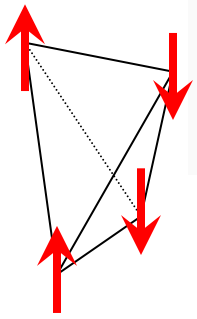
$Fd\bar{3}m$

Cd

Cr

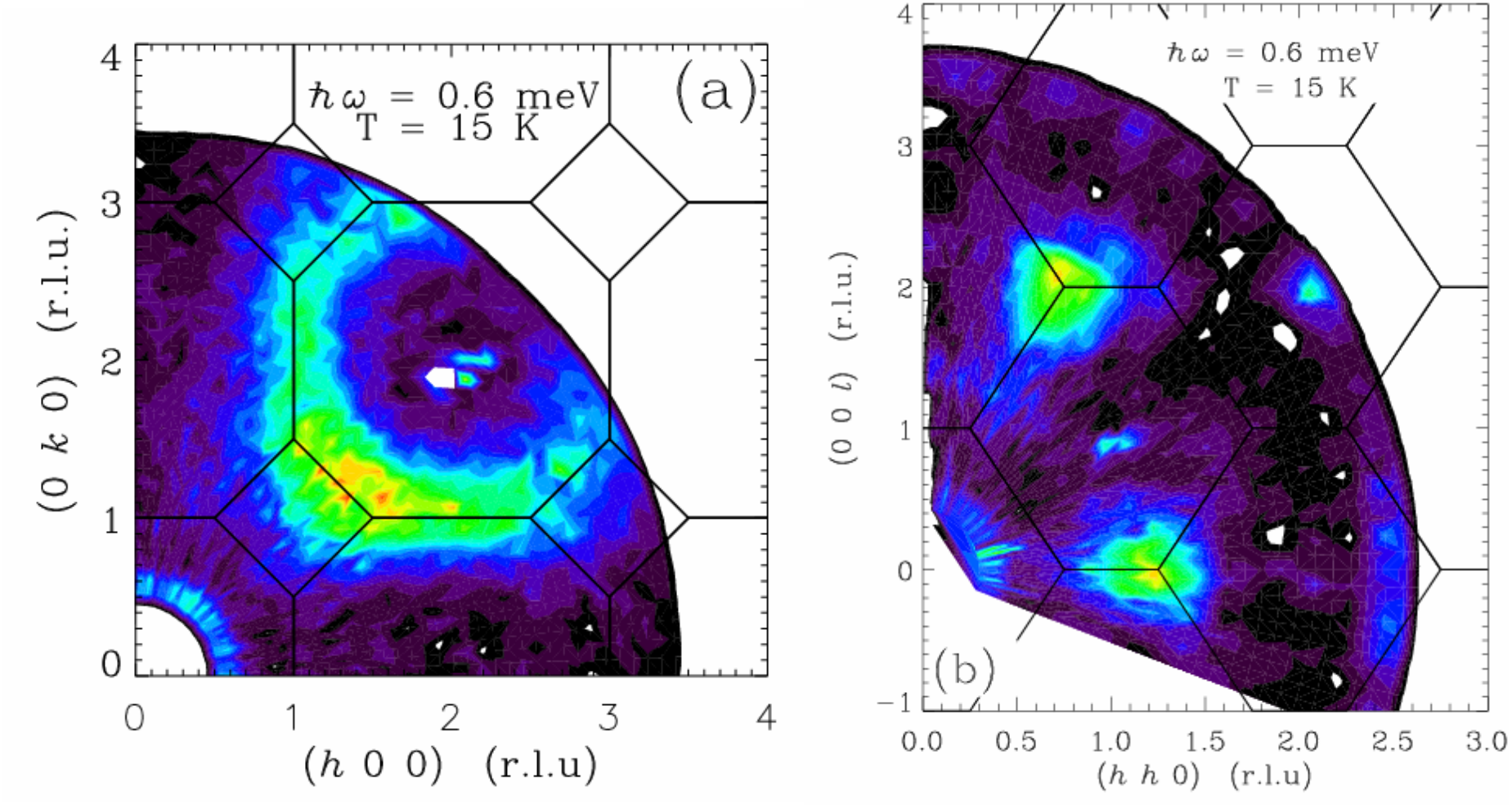
Cr^{3+} tetrahedra and frustration



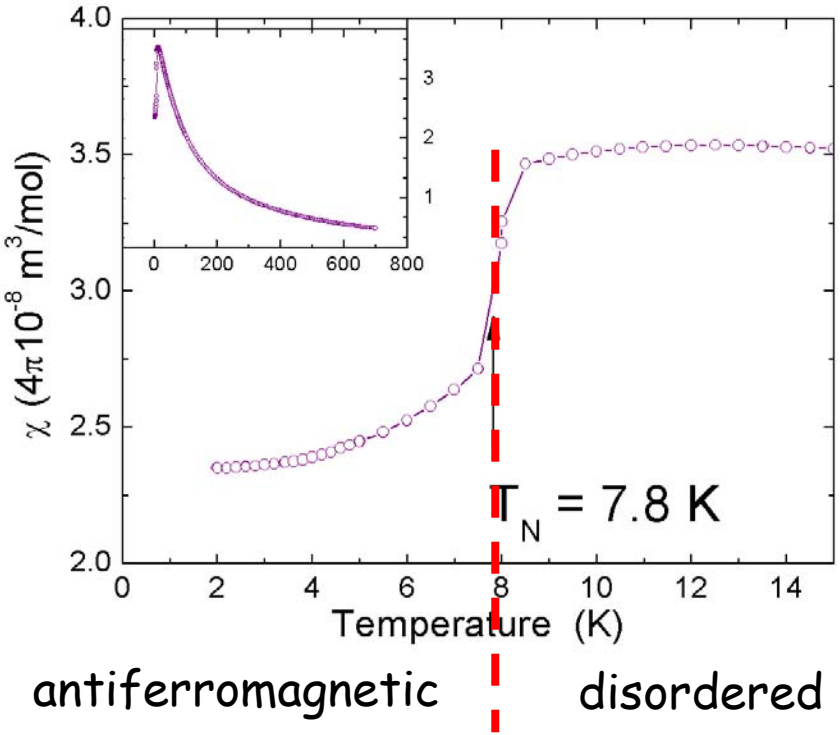


$CdCr_2O_4$

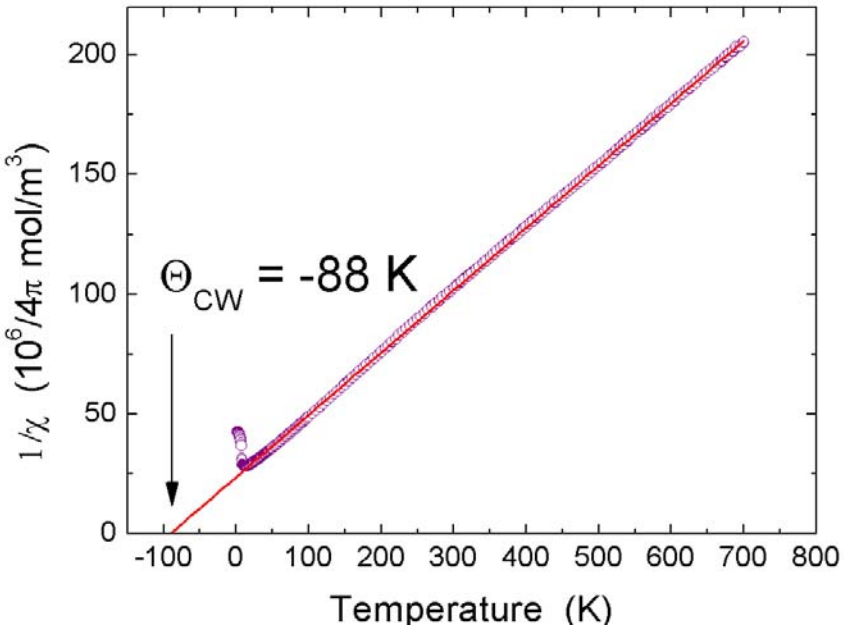
Prior work


ħω = 0.6 meV
T = 15 K
(a)
(0 k 0) (r.l.u.)
(h 0 0) (r.l.u)
0
1
2
3
4
ħω = 0.6 meV
T = 15 K
(b)
(0 0 l) (r.l.u.)
(h h 0) (r.l.u)
−1
0.0
0.5
1.0
1.5
2.0
2.5
3.0

Prior work



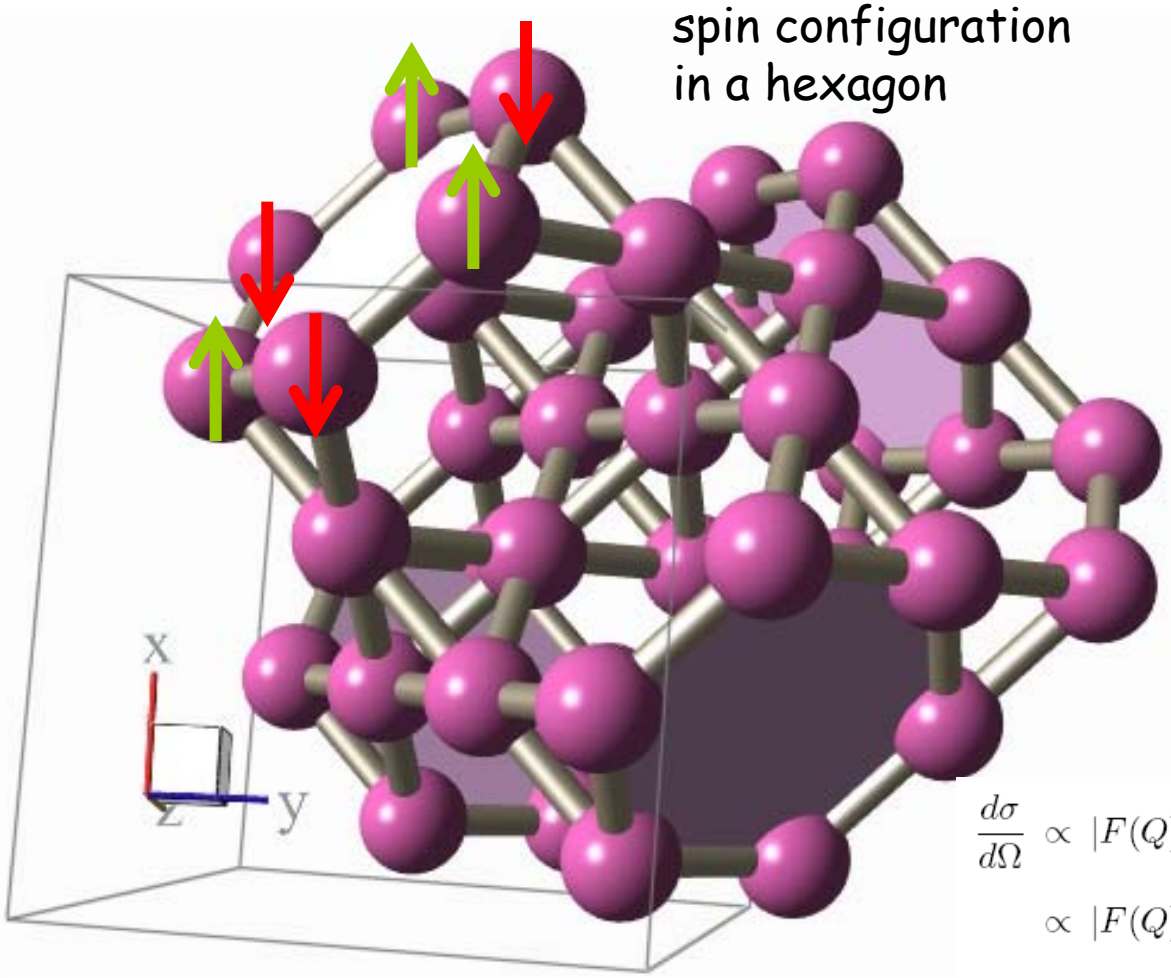
antiferromagnetic | disordered

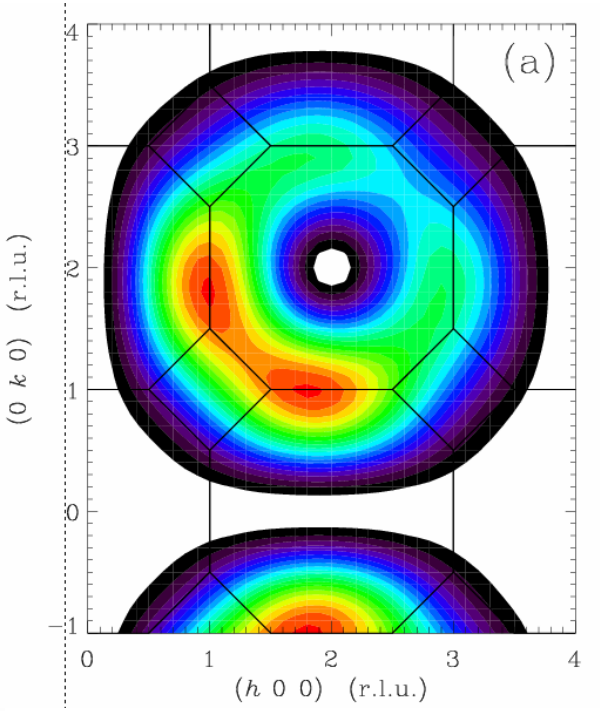


$$\frac{\Theta_{CW}}{T_N} >> 1$$; strong frustration

The model

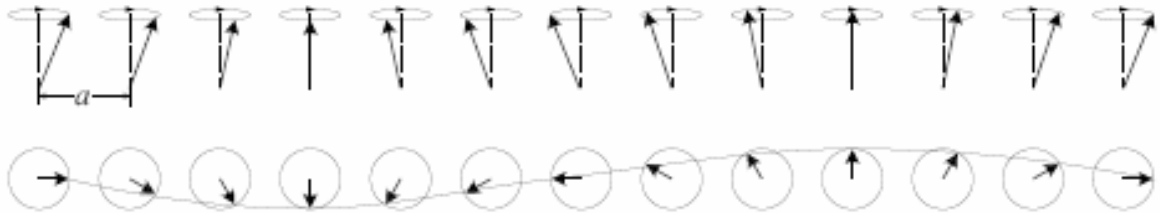
Antiferromagnetic spin configuration in a hexagon





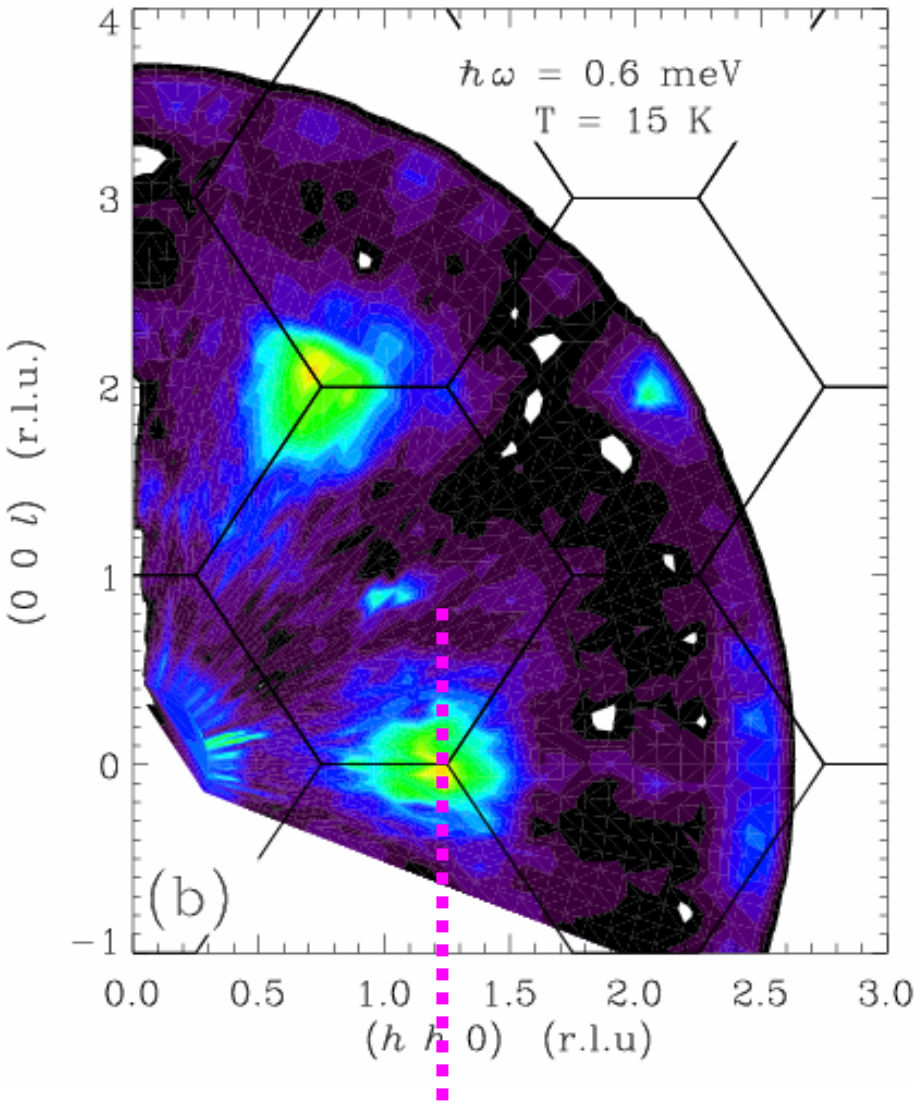
$$\frac{d\sigma}{d\Omega} \propto |F(Q)|^2 \sum_{\alpha\beta}(\delta_{\alpha\beta} - \hat{Q}_\alpha \hat{Q}_\beta) \sum_{\mathbf{R}\mathbf{R}'} S^\alpha_{\mathbf{R}} S^\beta_{\mathbf{R}'} e^{-i\mathbf{Q}\cdot(\mathbf{R}-\mathbf{R}')}$$

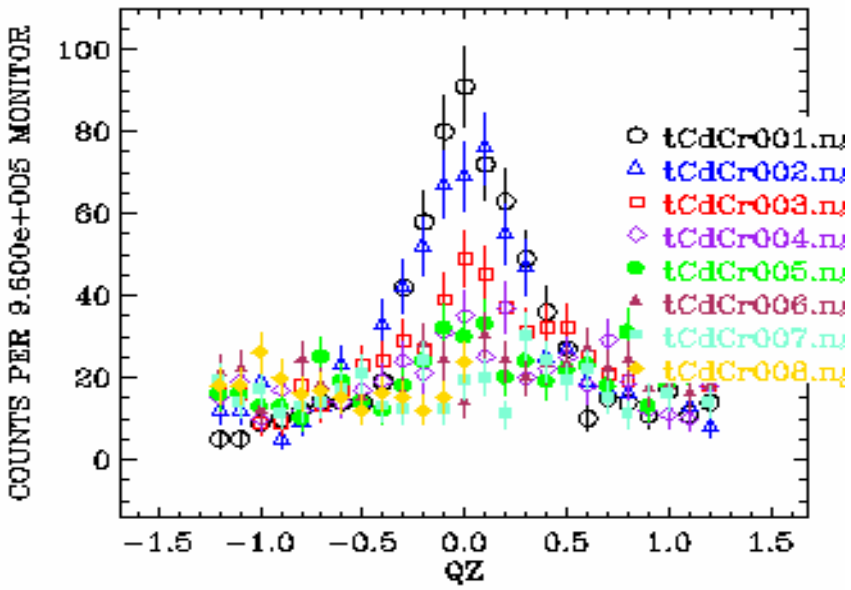
$$\propto |F(Q) \sum_{\mathbf{R}} (\mathbf{S}_{\mathbf{R}})_\perp e^{-i\mathbf{Q}\cdot\mathbf{R}}|^2$$



Spin wave excitation

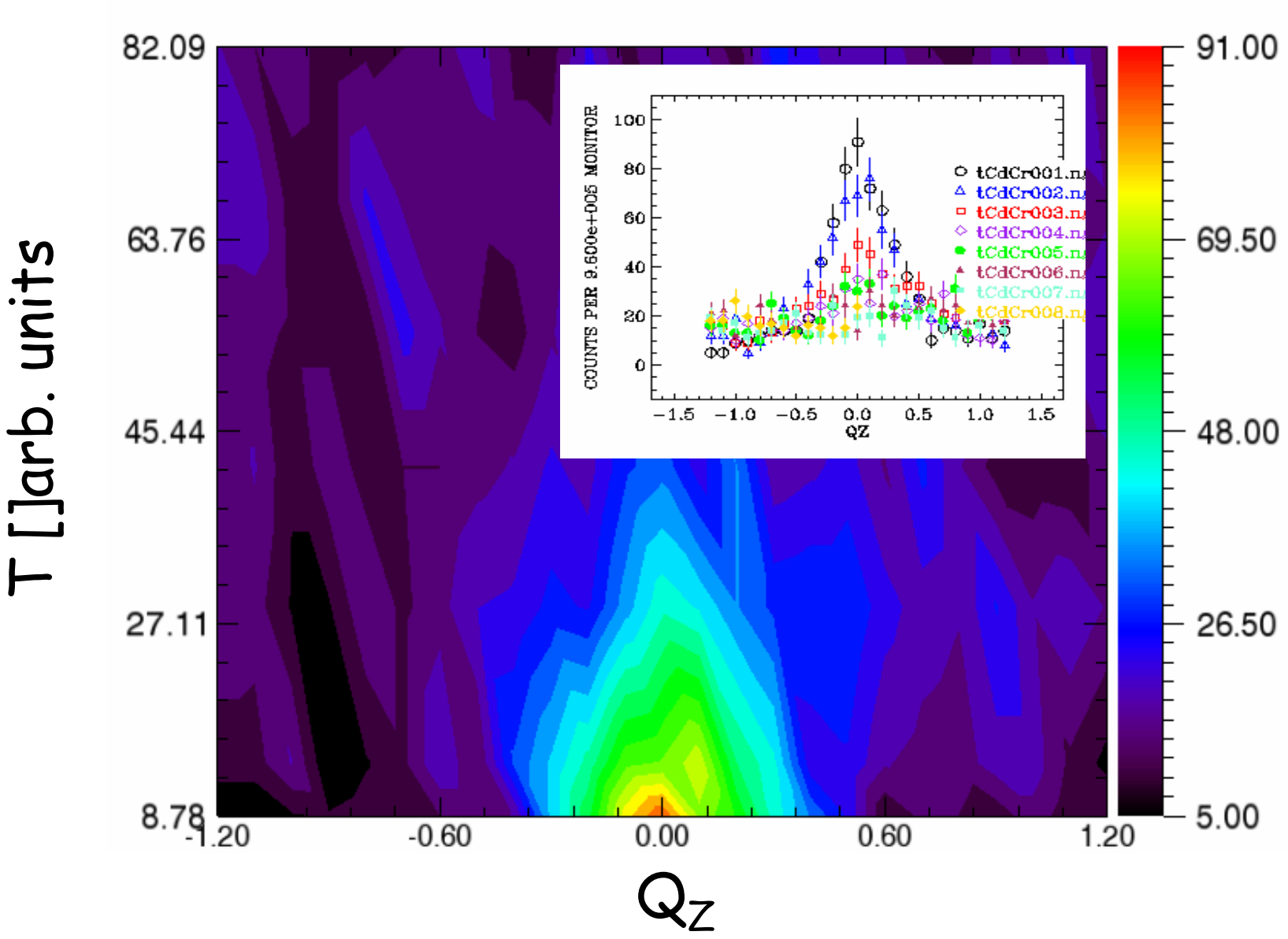
The experiment



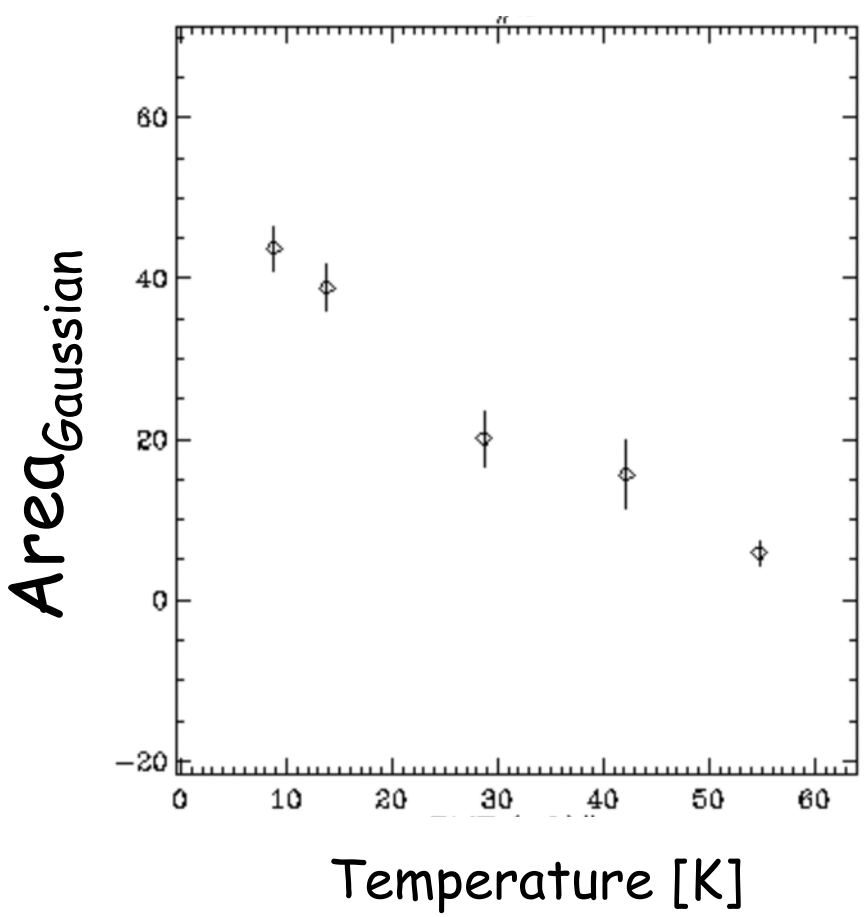


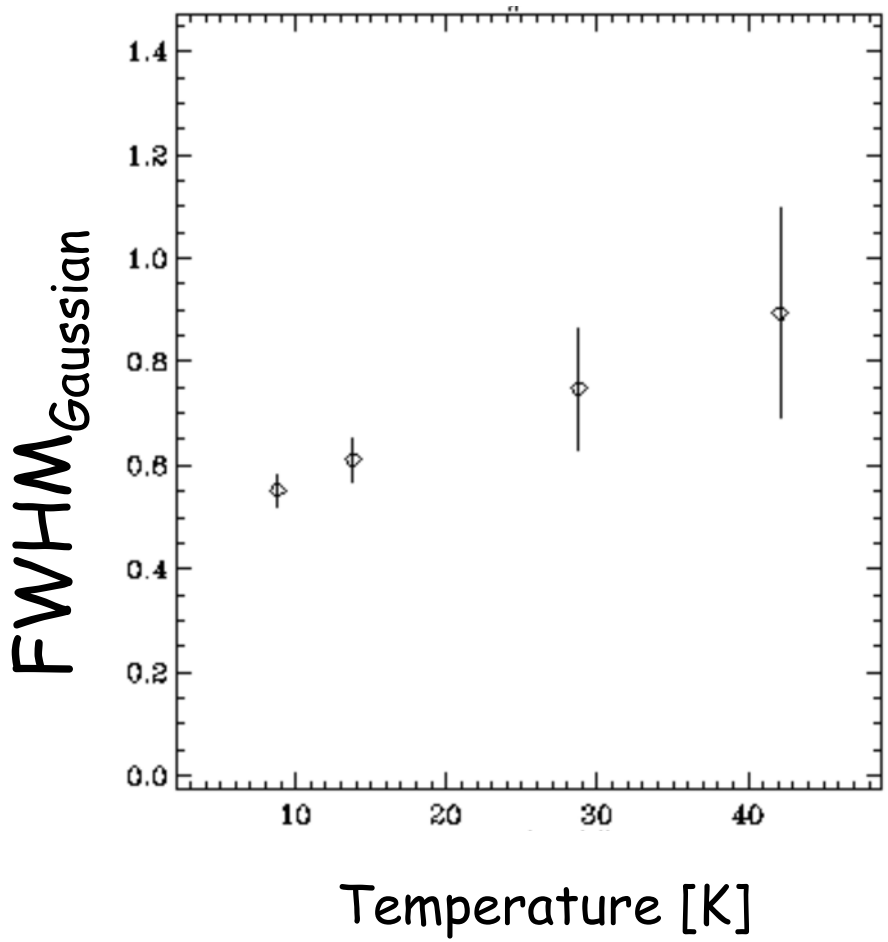
(1.24, 1.25, L) temperature scan

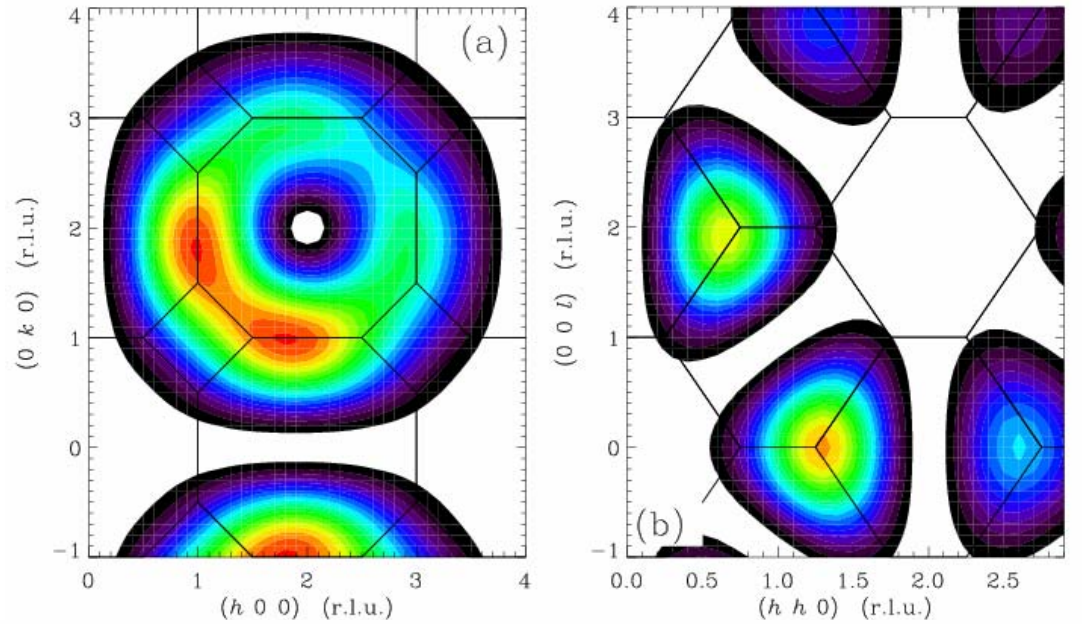
The experiment



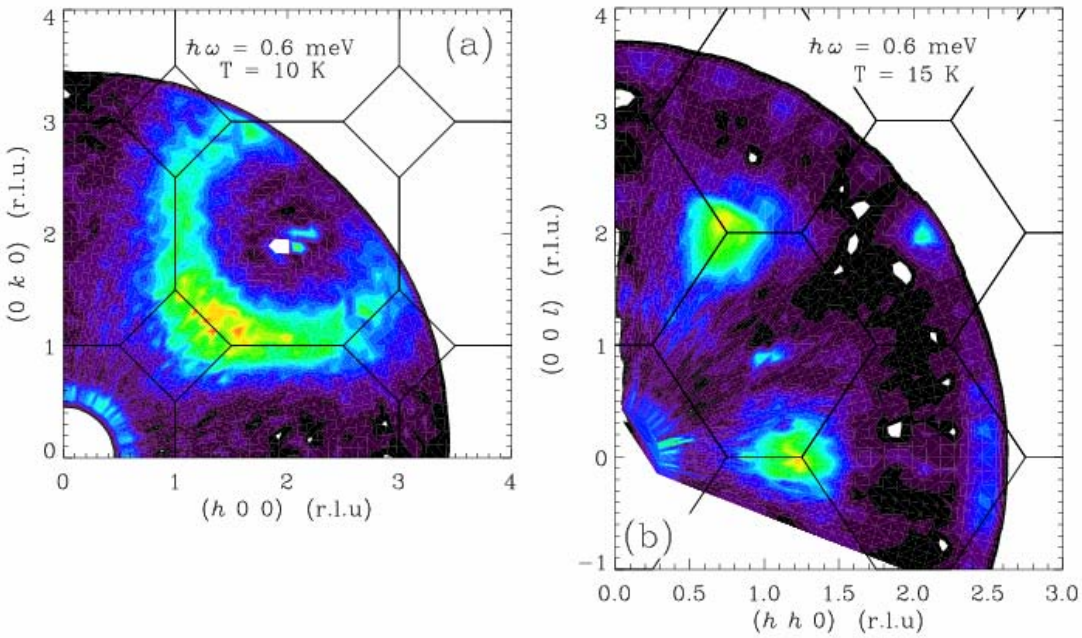
The experiment







Simulation



Data

Summary

* The antiferromagnetic interaction arises from Cr^{3+} ions in tetrahedral configurations

* Tetragonal antiferromagnetic frustration is relieved via spin wave driven formation of non-adjacent hexagonal spin configurations

* The model (simulation) shows good agreement with experimental results

* The strength of the spin correlation is clearly observed along the [1.25 1.25 L] direction, registered through the integrated area and FHWM of the Gaussian fittings

Acknowledgements

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