united nations educational, scientific and cultural organization
international atomic energy agency

the
abdus salam
international centre for theoretical physics

SMR 1216 - 12

Joint INFM - the Abdus Salam ICTP School on
"Magnetic Properties of Condensed Matter Investigated by Neutron Scattering and Synchrotron Radiation Techniques"

1 - 11 February 2000

Problem Class

Christian VETTIER
European Synchrotron Radiation Facility
Magnetic Scattering Group
B.P. 220
38042 Grenoble, France

Problem CoPt

- Scattering amplitude: $f = -\varepsilon' \cdot \varepsilon \,(f_0 + f' - i f'') + a_{res}$

$$a_{res} = \frac{i+x}{1+x^2}\{\varepsilon' \cdot \varepsilon (F_{11} + F_{1-1}) - i\,(\varepsilon' \times \varepsilon) \cdot z\,(F_{11} - F_{1-1}) + (\varepsilon' \cdot z)\,(\varepsilon \cdot z)(2F_{10} - F_{11} - F_{1-1})\}$$

$$x = \frac{(E_f - E_i)\,\hbar\omega}{\Gamma/2}$$

- Geometry incident p; horizontal scattering plane; vertical field (vertical z)

$$a_{res} = \frac{i+x}{1+x^2}\left\{\varepsilon' \cdot \varepsilon (n_p) - i\,(\varepsilon' \times \varepsilon) \cdot z\,(n_m)\right\}$$

- Determine f' and f"

  white line is in a_{res}

  continuum: step function convoluted by Lorentzian profile $\dfrac{i+x}{1+x^2}$

$$i f'' = iB + iA\int_0^{\infty} h(u-x)\,\frac{du}{1+u^2} = iB + iA\int_x^{\infty}\frac{du}{1+u^2} = iB + iA\left[\frac{\pi}{2} - \arctan(x)\right]$$

A is determined by the step across the edge and B by the value below

Problem CoPt

$B=n_{cs}$ $A=n_s/\pi$ $$f' = n_{cs} + \frac{n_s}{\pi}\left[\arctan(-x) + \frac{\pi}{2}\right]$$

real part tricky because of divergence

$$f' = C + n_s \int_0^\infty \frac{u}{1+u^2}\, h(u-x)\, du = C + n_s \int_x^\infty \frac{u}{1+u^2}\, du = C + \frac{n_s}{2}\int_{x^2}^\infty \frac{du}{1+u}$$

imagine a cut-off and adjust c at the edge x=0 $$f' = n_c + \frac{n_s}{2}\ln(1+x^2)$$

Problem CoPt

- polarised scattering amplitude:

$$f^{\sigma\sigma} = \left(f_0 + n_c + \frac{n_s}{2} \ln(1+x^2) + \frac{x}{1+x^2} n_p \right) - i \left(n_{cs} + \frac{n_s}{\pi} \left[\arctan(-x) + \frac{\pi}{2} \right] - \frac{n_p}{1+x^2} \right)$$

$$f^{\pi\pi} = \cos 2\theta \left(f_0 + n_c + \frac{n_s}{2} \ln(1+x^2) + \frac{x}{1+x^2} n_p \right) + \sin 2\theta \frac{n_m}{1+x^2} z$$

$$- i \cos 2\theta \left(n_{cs} + \frac{n_s}{\pi} \left[\arctan(-x) + \frac{\pi}{2} \right] - \frac{n_p}{1+x^2} \right) \quad - i \sin 2\theta \, \frac{x}{1+x^2} n_m \, z$$

- total intensity

$$I^z_{total} = (1 - P_\parallel) \left| f^{\sigma\sigma} \right|^2 + P_\parallel \left| f^{\pi\pi} \right|^2$$

$$R_a = \frac{I^+_{total} - I^-_{total}}{I^+_{total} + I^-_{total}}$$

Problem CoPt

- Work out R_a
- What can be expected?
- Discuss values in the paper. n_m

Problem Cr

- Cr cubic structure fcc $a=2.88Å$ small !

  K-edge at 5.989 keV

  magnetic structure spin density wave $(0,0,1-\delta)$

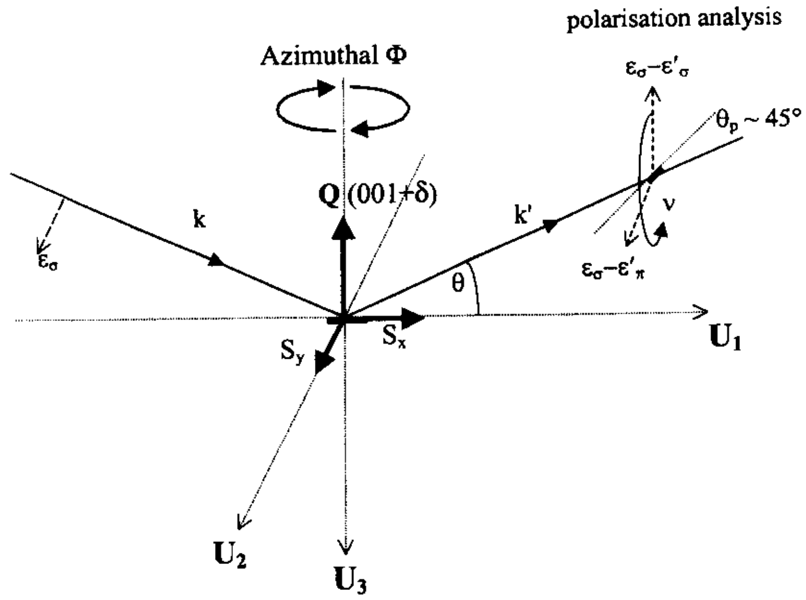
  T_n= 311K TSDW but T_{sf}=122K LDSW

- Measure L/S give experimental conditions

- Study resonances at K-edge

Problem Cr

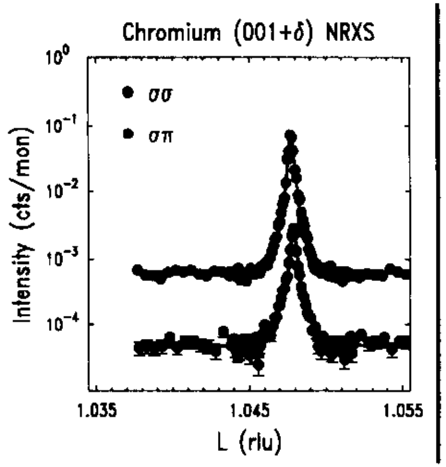
- Geometry



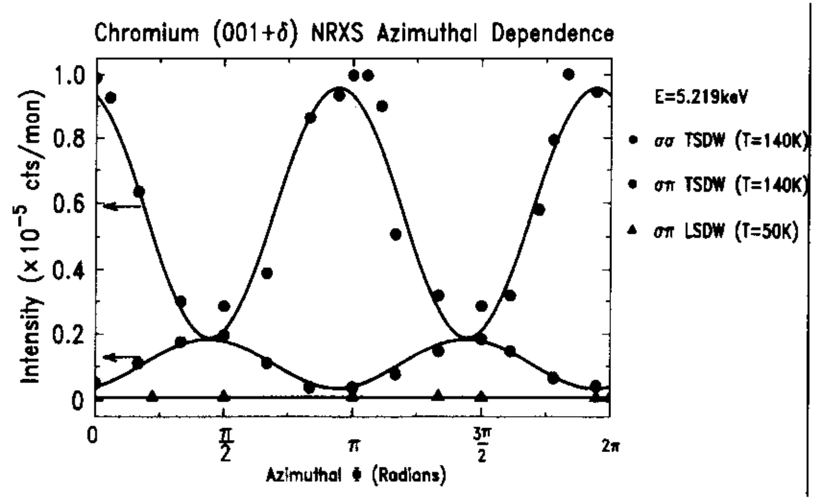
- Choice of energy below the K edge
- Choose proper analyser PG(004)
- This fixes the energy value at 5.219 keV (θ_B=45°)

Problem Cr

- Observe polarised signals



- S domains or helix?



- Why LSDW so low?

Problem Cr

- Could we measure S and L absolute values?

- averaged for intensities over ϕ

$$I_{\Phi}^{\sigma\sigma} = 5.7 \pm 0.5 \qquad I_{\Phi}^{\sigma\pi} = 1.1 \pm 0.2$$

- Work out L/S

Problem Cr

- move to resonance
- What can be observed?
- Consistency
- What sould you be able to do?
- Lineshape?