Clip session 2008

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Magnetic Quantitative Texture Analysis (MQTA) using neutron diffraction

Supervisors:

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Quantitative Texture Analysis (QTA)

NEUTRONS FOR SCIENCE

Quantitative texture analysis (QTA).

Orientation Distribution Function (ODF,f(g)) DV/V = f(g)dg :

f(g) represent the statistic distribution of the cristallite orientation.

Pole figures :

Represent the distribution of normals h=<hkl>* to the {hkl} planes of the sample, with $I_h(y)$ diffracted intensity.

The fundamental equation of texture analysis: $P_h(y) = \frac{1}{2\pi}\int_{hPy} f(g)d\bar{\varphi}$

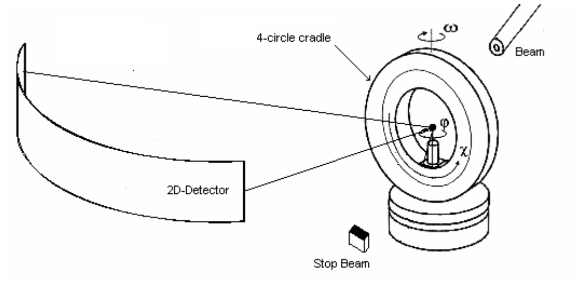
and magnetic texture analysis: $P_h(y,\vec{B}) = \frac{1}{2\pi}\int_{hPy} f_{n,m}(g)d\bar{\varphi}$

For no preferential orientation: $P_h(y)$= 1m.r.d

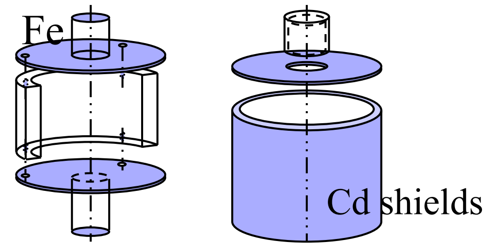
Magnetic Quantitative Texture Analysis (MQTA)

NEUTRONS
FOR SCIENCE

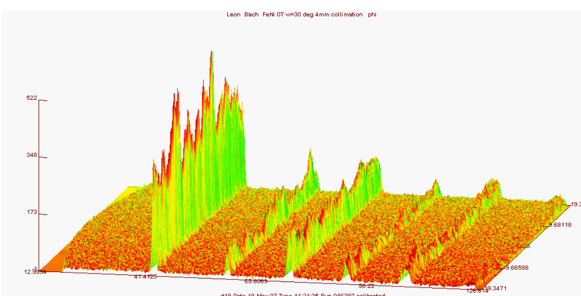
➢ *Magnetic Quantitative Texture Analysis.*

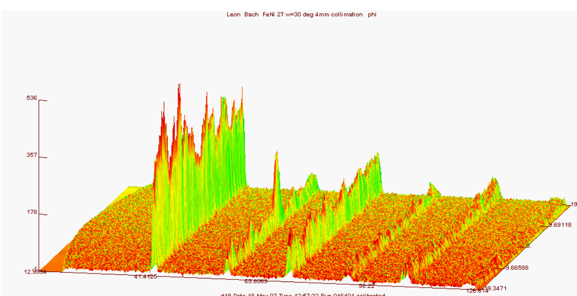


2-Circles cradle or 4-circles diffractometer

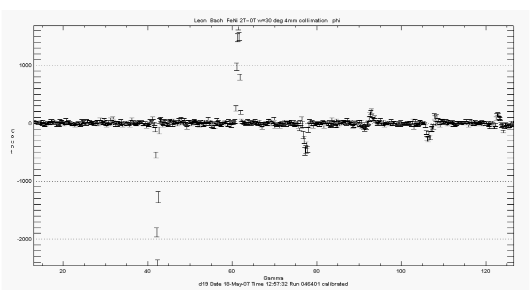


Magnetic sample holder to apply a fixed magnetic field during χ and φ rotations.





Debye-Scherrer diagrams measured for 90°= ϰ et φ= -175° without (left) and with a field of 0.5T (right) of soft-iron sample.



Difference between the two diagrams for 90°= ϰ et φ= -175°

Magnetic Quantitative Texture Analysis (MQTA)

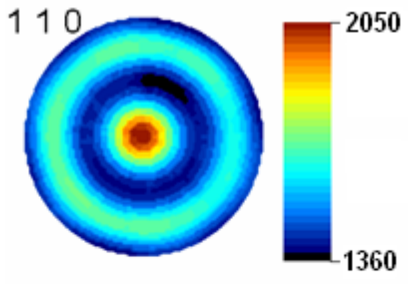
NEUTRONS FOR SCIENCE

➢ Nuclear pole figures.

Pole figures are composed by nuclear (n) and magnetic (m) part :

$$I_{\vec{h}}(\vec{y},0) = I_{\vec{h}}^{n}(\vec{y},0) + I_{\vec{h}}^{m}(\vec{y},0) \quad (1)$$

$$\text{With}: \vec{h} = \{hk\ell\} \text{ and } \vec{y} = (\vartheta_y, \varphi_y)$$



Pole figure on iron alloy without a field

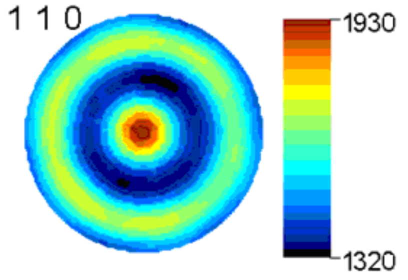
➢ Magnetic field $\vec{B}$

$$I_{\vec{h}}(\vec{y},\vec{B}) = I_{\vec{h}}^{n}(\vec{y},\vec{B}) + I_{\vec{h}}^{m}(\vec{y},\vec{B})$$

If the crystallites are not free to rotate under the magnetic field :

$$I_{\vec{h}}^{n}(\vec{y},\vec{B}) = I_{\vec{h}}^{n}(\vec{y},0)$$

$$\textit{hence}: I_{\vec{h}}(\vec{y},\vec{B}) = I_{\vec{h}}^{n}(\vec{y},0) + I_{\vec{h}}^{m}(\vec{y},\vec{B}) \quad (2)$$



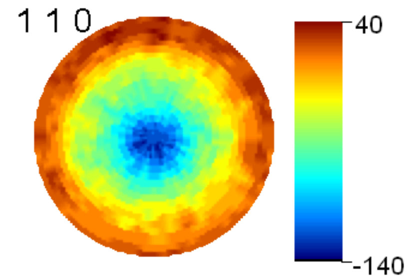
Pole figure on iron alloy with a field

Magnetic Quantitative Texture Analysis (MQTA)

➢ The first promising MODF.

First magnetic pole figures deduce for iron alloy.

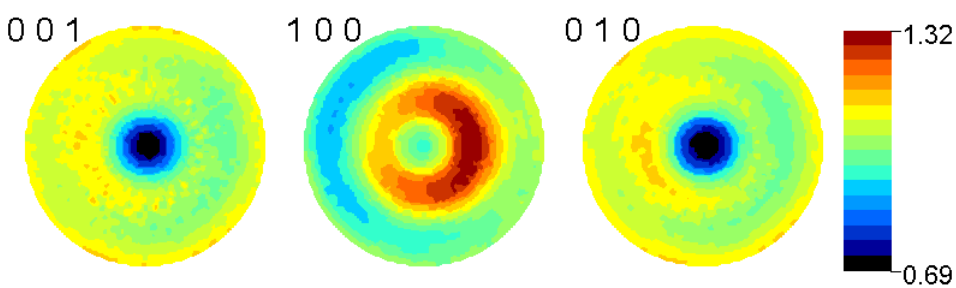
$$\Delta I^{m}_{\vec{h}}(\vec{y},\vec{B}) = I_{\vec{h}}(\vec{y},\vec{B}) - I_{\vec{h}}(\vec{y},0)$$



Difference with and without field

We deduce from (2)- (1) the magnetic pole figures :

$$I^{m}_{\vec{h}}(\vec{y},\vec{B}) = I_{\vec{h}}(\vec{y},\vec{B}) - I_{\vec{h}}(\vec{y},0) + I^{m}_{\vec{h}}(\vec{y},0) = I^{m}_{\vec{h}}(\vec{y},0) + \Delta I^{m}_{\vec{h}}(\vec{y},\vec{B})$$

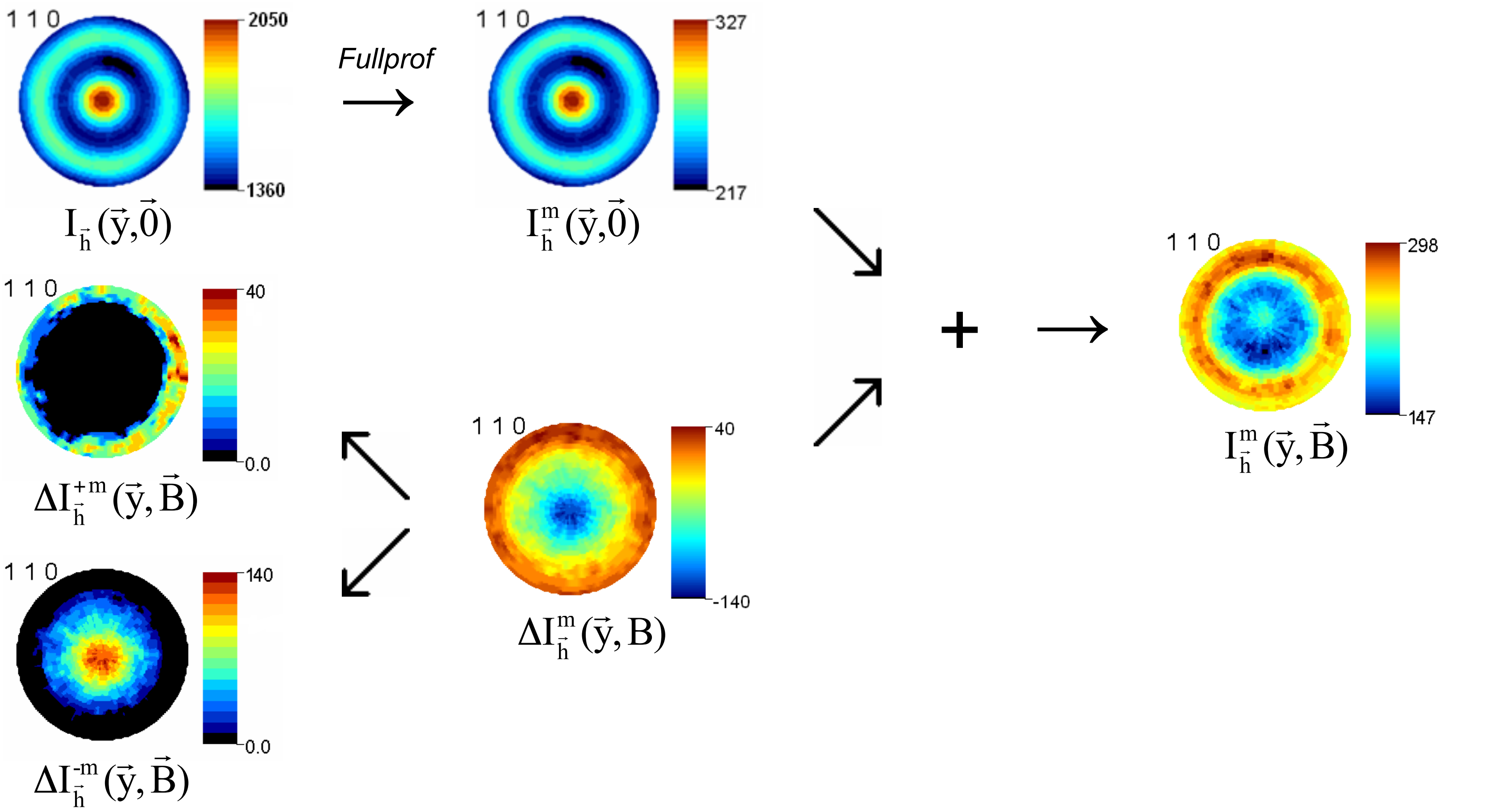


Magnetic pole figure recalculated.

ODF min, max	*0.64 2.26*
Texture Index F²	*1.0294*
Entropy S	*-0.0144*
Average RP	*0.2427*
Average RP1	*0.3041*

Magnetic Quantitative Texture Analysis (MQTA)

- *Magnetic pole figures determination.*



Interesting issues from such developments can be outlined:

- \- It could inform on how magnetic moments are linked to individual crystallites in the structure, how this link depends on external applied magnetic fields and how the macroscopic magnetisation establishes (e.g. by magnetic moment rotations) under applied fields.
- \- Using tensor approaches, similarly as what was developed for other anisotropic properties, the MODF may serve as a predictive tool in the quantitative estimate of macroscopic magnetic properties of oriented samples [1].
- \- Analysis of MODF allows having a global approach for the magnetic texture.
- \- As a non-destructive technique, the MODF technique would be useful to characterise real samples, using the newly developed formalism in a combined approach [2] for powder and in the orientation imaging [3] for Laue diagrams, for industrials and geologists for instance.

References :

[1]: M. Morales, D. Chateigner, D. Fruchart: *Journal of Magnetism and Magnetic Materials* , **257(2)**, 2003, 258-269.

[2]: M. Morales, D. Chateigner, L. Lutterotti, J. Ricote: *Materials Science Forum*, **408-412**, 2002, 113-118.

[3] H.-R. Wenk, F. Heidelbach, D. Chateigner, F. Zontone: *Journal of Synchrotron Radiation*, **4**, 1997, 95-101.

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Thanks For Your Attention