# GdFe with Au Review

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Shpyrko Group Meeting

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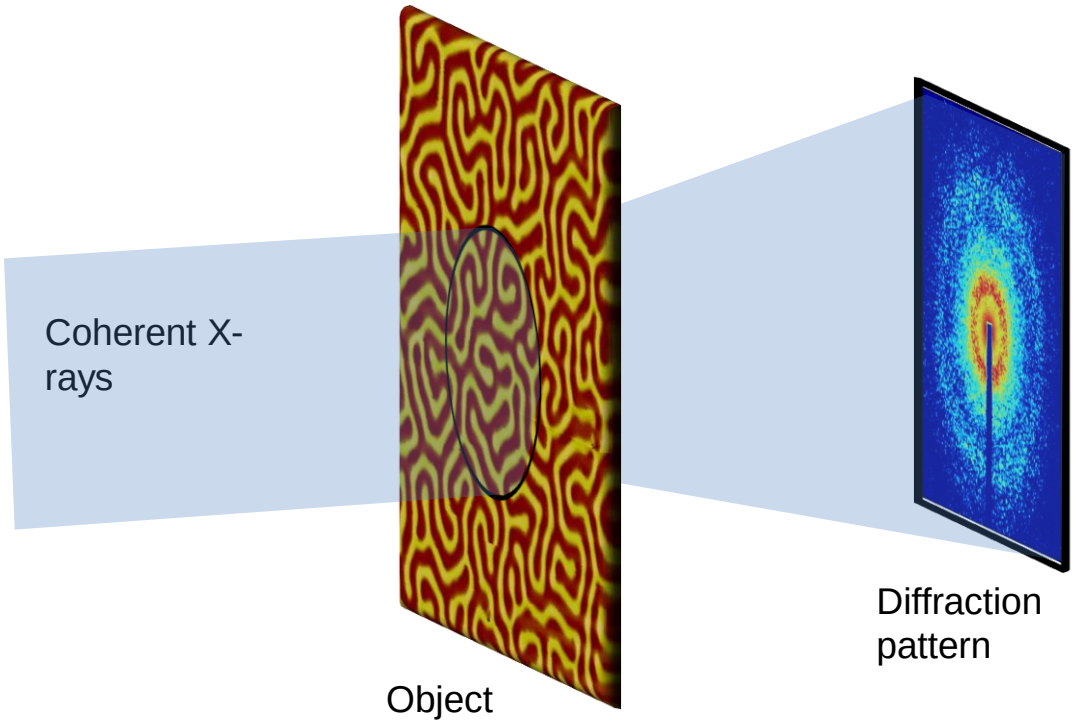
# Interaction of linearly polarized light with perpendicular anisotropic magnetic thin films in transmission geometry

$$I = \left|\mathcal{F}\{\tilde{E}(r_\perp, z)\}\right|^2 = |\mathcal{F}\{E_0(r_\perp)C(r_\perp)\}|^2 + |\mathcal{F}\{E_0(r_\perp)M(r_\perp)\}|^2$$

Charge Structure: $C(r_\perp) = e^{-k_0 z_j(r_\perp)[\mathrm{B}^j + i\Delta^j]}$

Magnetic Structure: $M(r_\perp) = -iC(r_\perp)k_0 z_j(r_\perp)\left[\beta^j + \mathrm{i}\delta^j\right]\hat{m}_z^j(r_\perp)$



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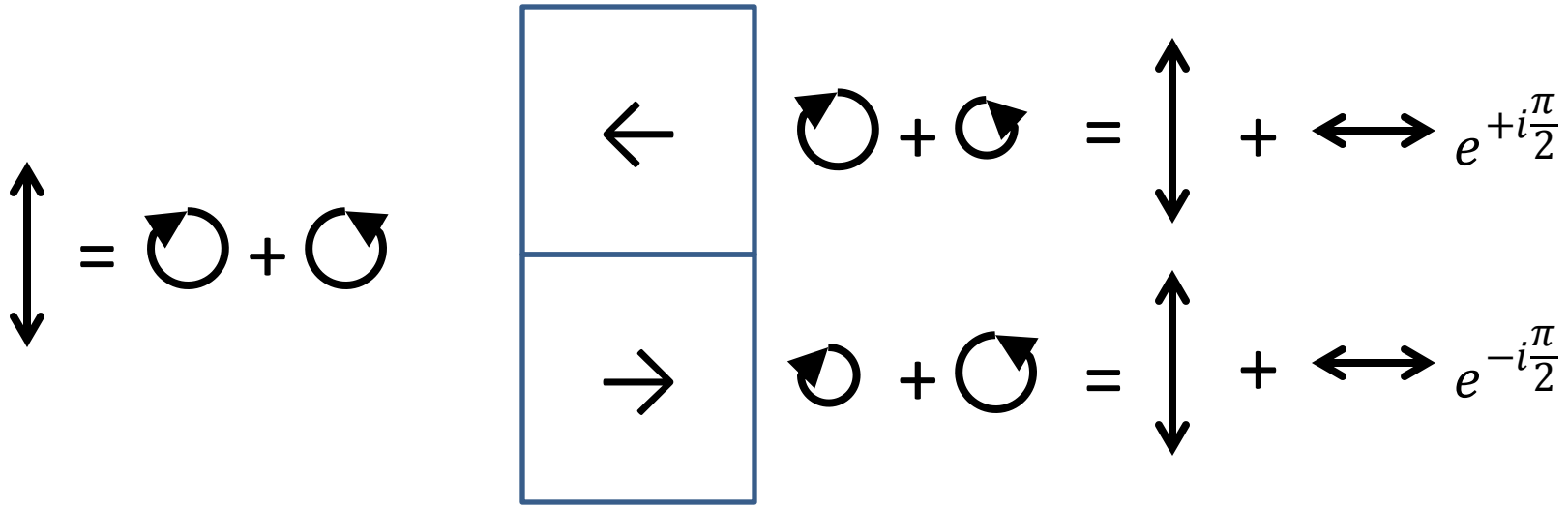
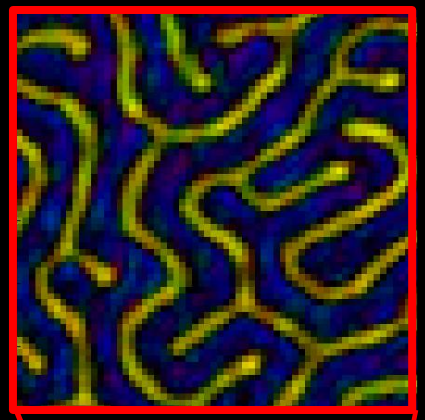
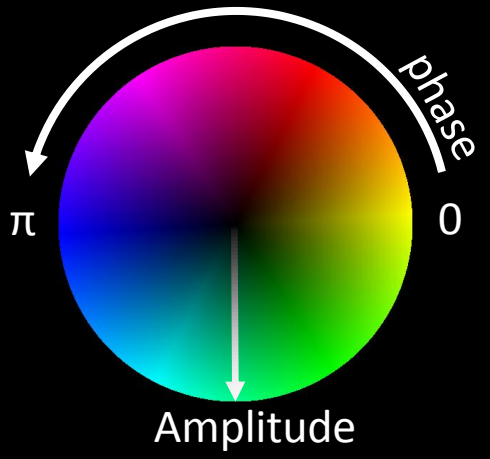
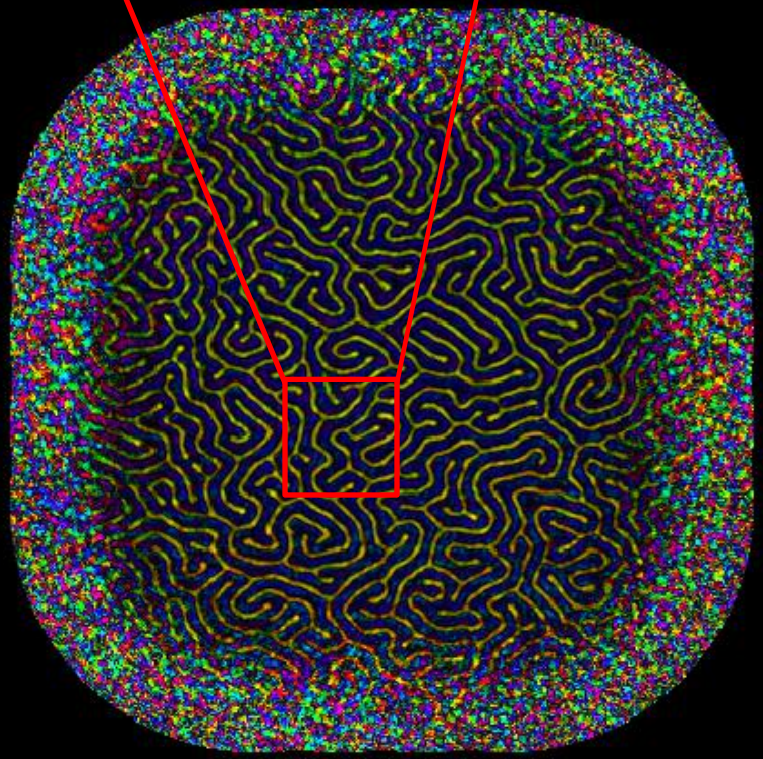


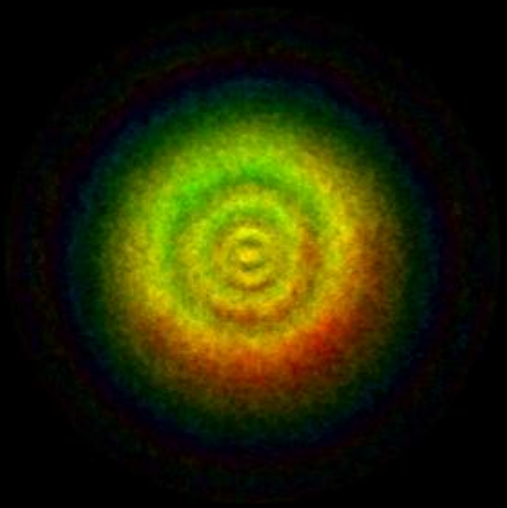




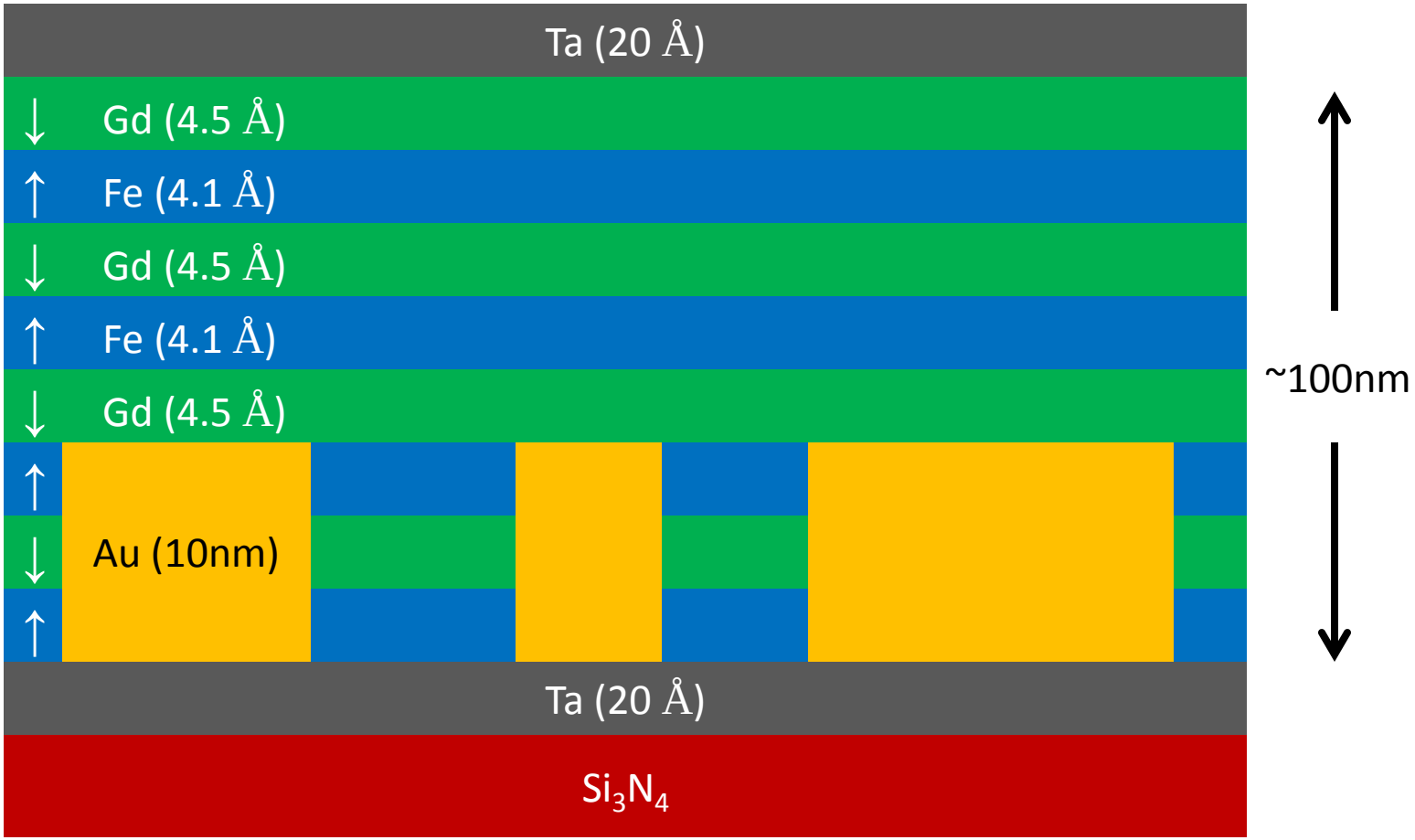
Reconstructed Magnetic Structure

5µm



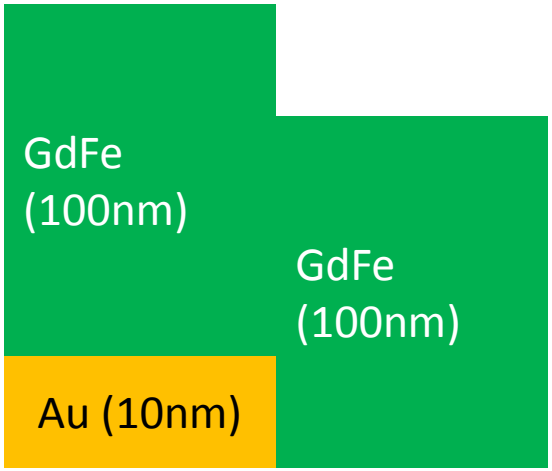
Reconstructed
X-ray probe

# Au patterned GdFe layered thin film



# Charge Contrast

Best Case



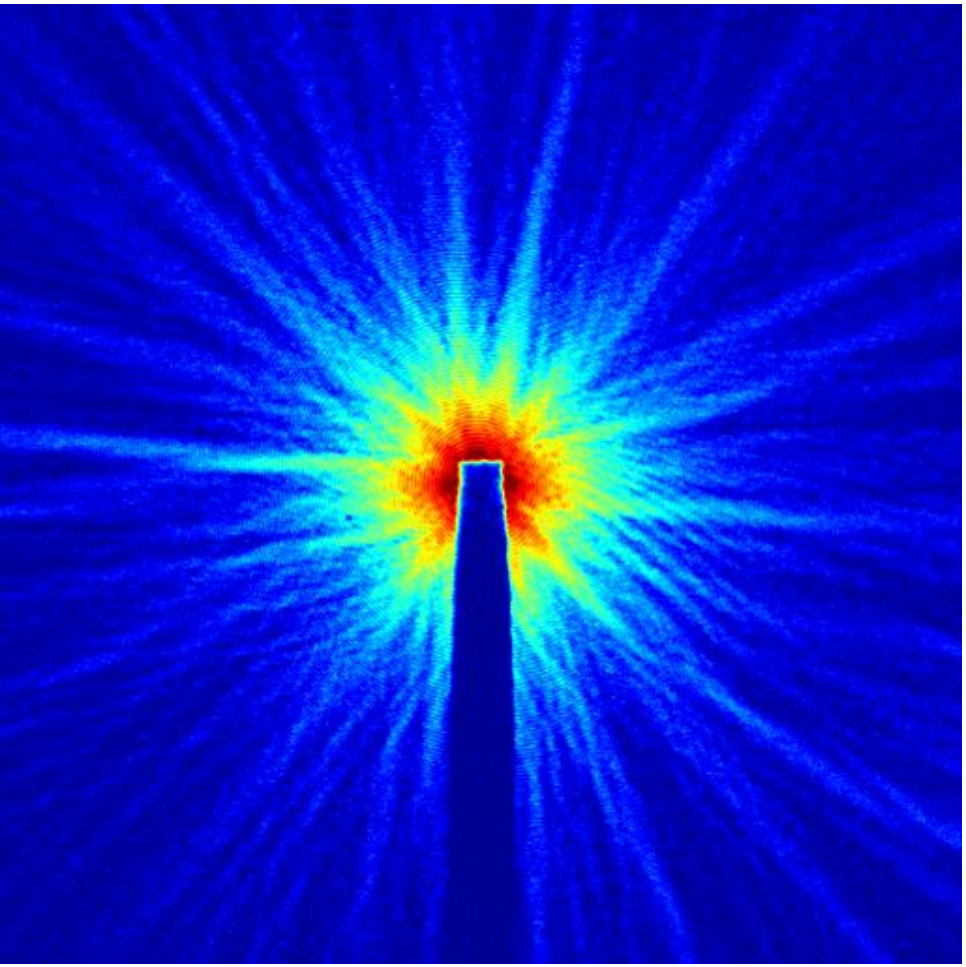

$$\frac{I_{wit\,hAU}}{I_{no\,AU}} = 0.9315$$

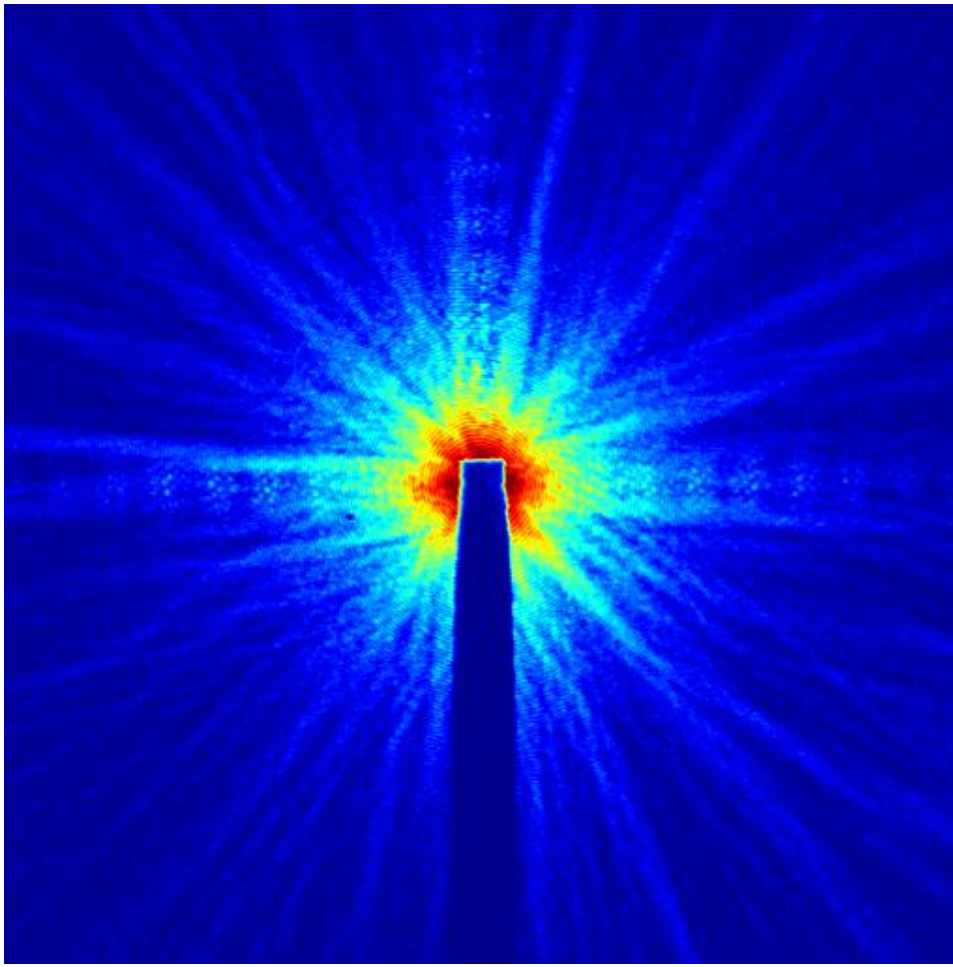
Poor Case


Off Res: $\frac{I_{wit\,hAU}}{I_{no\,AU}} = 0.989$

On Res: $\frac{I_{wit\,hAU}}{I_{no\,AU}} = 1.052$

# Weak Scattering

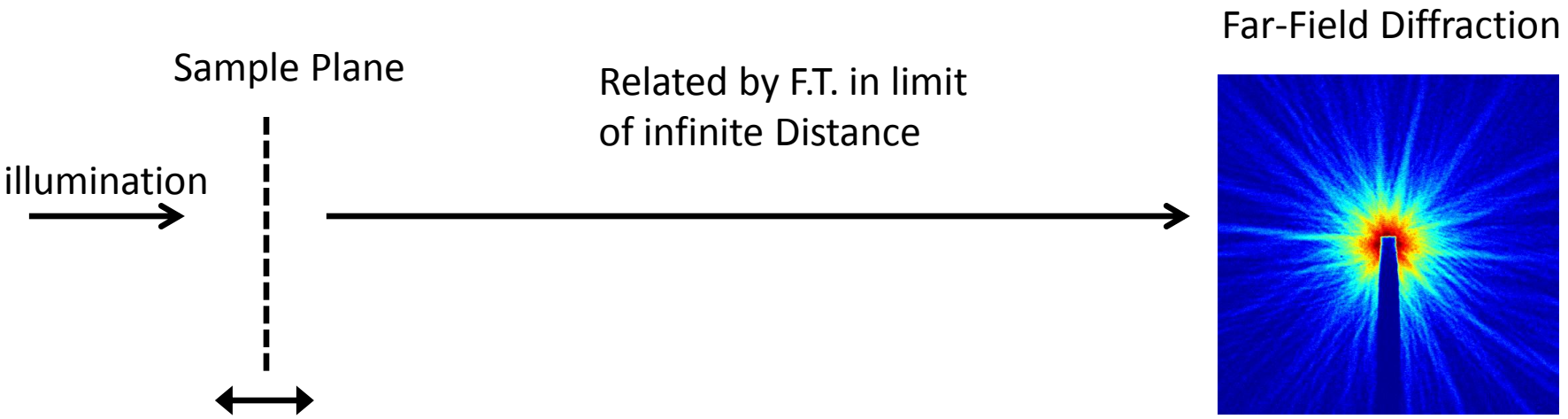


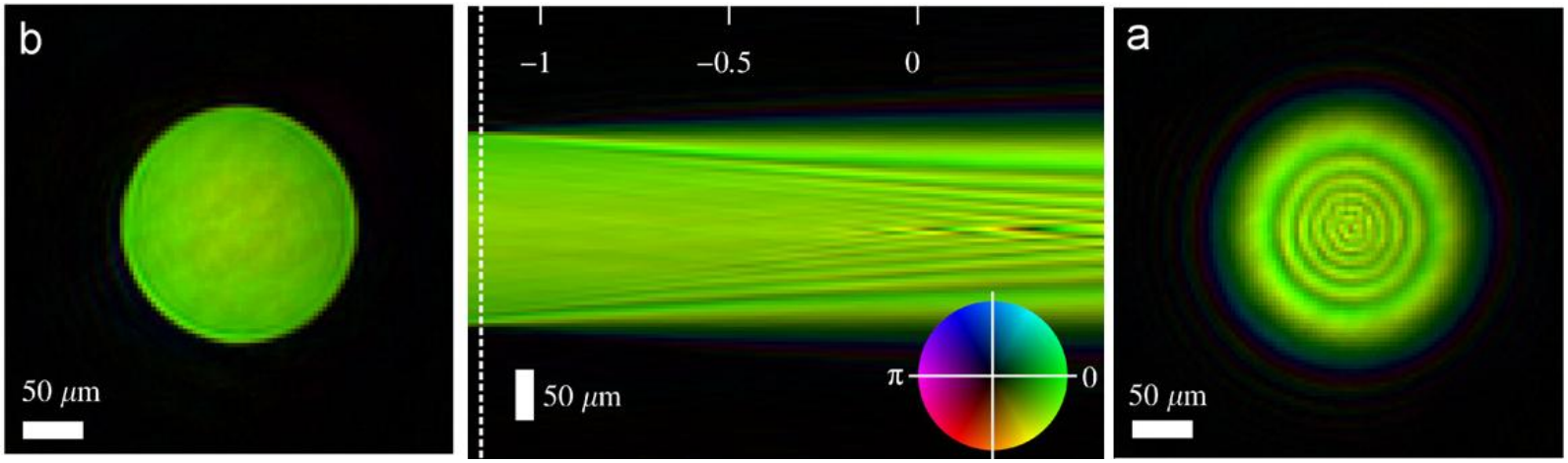


No sample (pinhole scattering)

Off Resonance

# Problem of Weak Scattering




P. Thibault, et al, Ultramicroscopy 109 (2009) 338–343

# Weak Approximation

$$I_{mag} \cong I_{on} - \frac{\Re\{c_{on}\}}{\Re\{c_{off}\}} e^{-(\mu_{on}-\mu_{off})z} I_{off} + \left(\frac{\Re\{c_{on}\}}{\Re\{c_{off}\}} - 1\right) e^{-\mu_{on} z} I_{WF}$$

$$c_{on} = k_0\left[c_1\left(\mathrm{B}_{\mathrm{Gd}}^{on} + i\Delta_{\mathrm{Gd}}^{\mathrm{on}}\right) + c_2\left(\mathrm{B}_{\mathrm{Fe}}^{\mathrm{off}} + i\Delta_{\mathrm{Fe}}^{\mathrm{off}}\right) - \left(\mathrm{B}_{\mathrm{Au}}^{off} + i\Delta_{\mathrm{Au}}^{\mathrm{off}}\right)\right]$$

$$\mu_{on} = 2k_0\left\{c_1 \mathrm{B}_{\mathrm{Gd}}^{on} + c_2 \mathrm{B}_{\mathrm{Fe}}^{\mathrm{off}}\right\}, \mathrm{B}_{Gd}^{on} \gg \mathrm{B}_{Fe}^{off}$$

$$c_{off} = k_0\left[c_1\left(\mathrm{B}_{\mathrm{Gd}}^{off} + i\Delta_{\mathrm{Gd}}^{\mathrm{off}}\right) + c_2\left(\mathrm{B}_{\mathrm{Fe}}^{\mathrm{off}} + i\Delta_{\mathrm{Fe}}^{\mathrm{off}}\right) - \left(\mathrm{B}_{\mathrm{Au}}^{off} + i\Delta_{\mathrm{Au}}^{\mathrm{off}}\right)\right]$$

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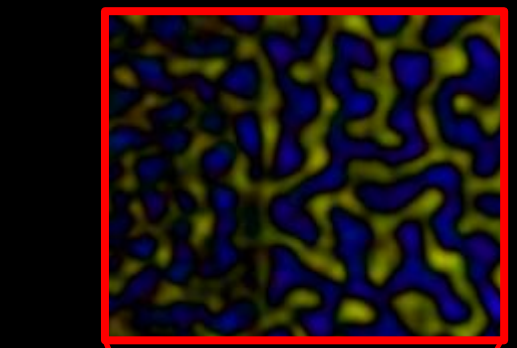
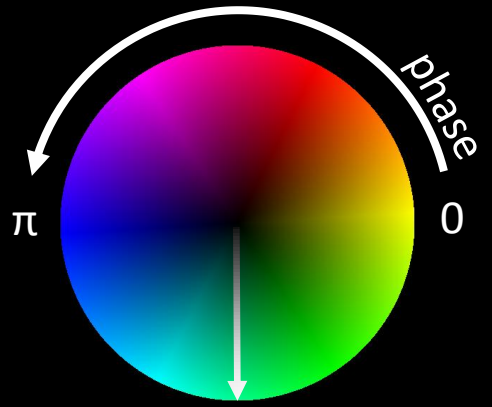
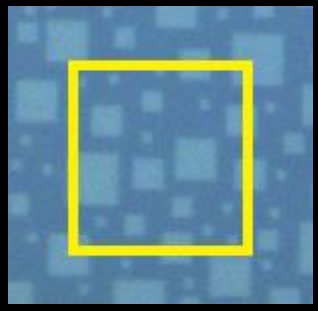
$$z_{Gd}(r_\perp) = c_1 z_{GdFe}(r_\perp),\ z_{Fe}(r_\perp) = c_2 z_{GdFe}(r_\perp), c_1 + c_2 = 1$$

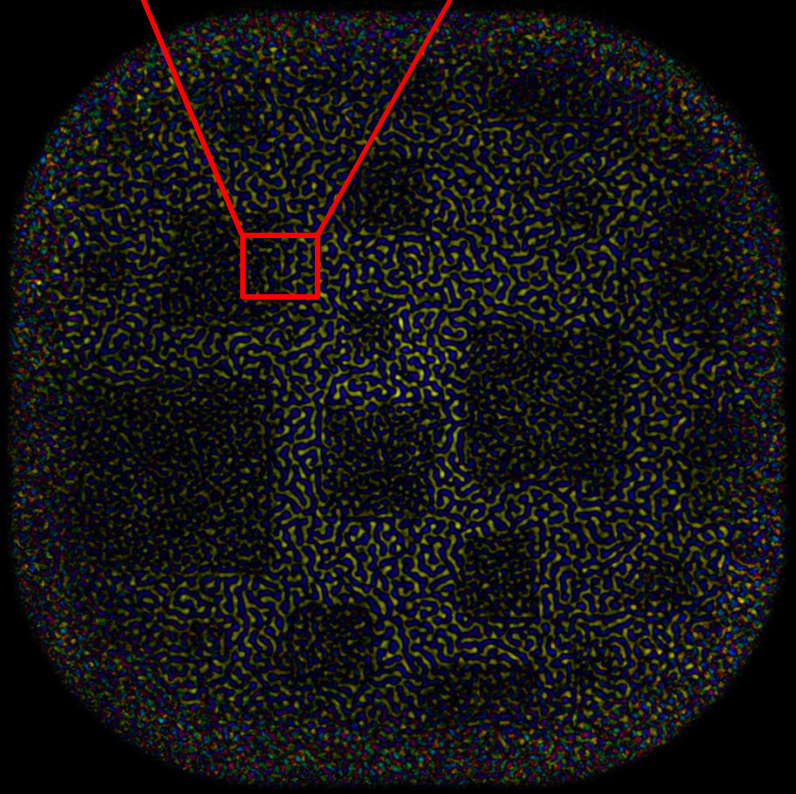
$$z_{Au}(r_\perp) + z_{Gd}(r_\perp) + z_{Fe}(r_\perp) = z$$





visible light
microscope



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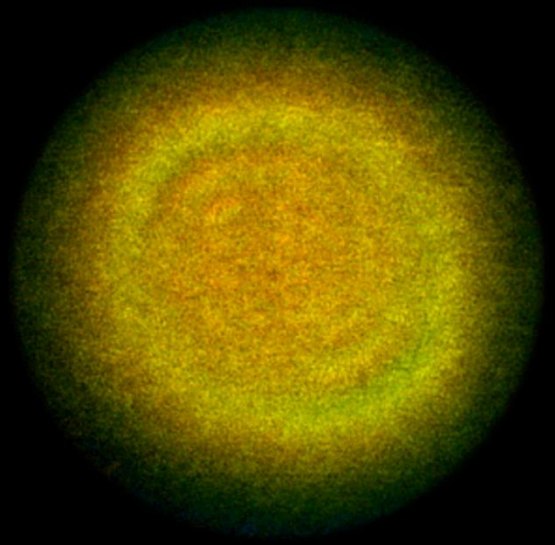
5µm



Reconstructed
X-ray probe

# Weak Scattering Constraint

$$\tilde{\psi} = \sqrt{\frac{I_m}{I_{WF}}}\widetilde{E_0}e^{i\Delta\theta}$$

$$\alpha = \frac{\zeta_{\mathrm{m}} + I_{WF}}{\sqrt{I * I_{WF}}} = \frac{I_m/|C_0|^2 + I_{WF}}{2\sqrt{I_m * I_{WF}}}$$

$$\cos(\Delta\theta_R - \theta_c)\cosh(\Delta\theta_I) = |C_0|\alpha, \qquad \sin(\Delta\theta_R - \theta_c)\sinh(\Delta\theta_I) = 0$$