Problem set #13; due Wednesday, April 24, in class.

1. (a) Calculate the x-ray index of refraction and critical angle for total external reflection for Cu K_α x-rays incident on Al_2O_3. (b) Compare your calculation for the index of refraction with the results of more sophisticated calculations at the LBL web-site.

2. Compare the strength of the x-ray atomic scattering factor f_x (remember to multiply dimensionless x-ray scattering factor by the classical electron radius) to the strength of the atomic scattering factor for electrons f_e for Fe at the Bragg angle of the (200) reflection. The bcc lattice constant of Fe is 0.29 nm. You can find a table of f_e values here. You can find calculations of f_x at this site. Scroll down the index and click on "scattering factors". Use the $B = 0$ result.

3. Calculate the extinction length for x-rays and electrons for the (400) reflection of Si. Use $\lambda = 1.54$ Å for x-rays and $\lambda = 3$ pm for electrons. You can find a table of f_e values here. You can find calculations of f_x at this site. Scroll down the index and click on "scattering factors". Use the $B = 0$ result. Recall that the extinction length of a two-beam diffraction condition is

$$\xi = \frac{\pi \cos\theta_B}{N\lambda F_{hkl}}, \tag{1}$$

where θ_B is the Bragg angle, N is the number of unit cells per unit volume, and F_{hkl} is the structure factor of that unit cell. For x-rays, remember to multiply the dimensionless x-ray atomic scattering factor by the classical electron radius to get a structure factor with the correct units of length. Si is a diamond structure crystal with a lattice constant of 0.543 nm.