Topical projects in research (FFYS7039). 2 points.

Monte-Carlo Simulations of Thomson Scattering

Consider Thomson scattering of low energy photons in a spherical homogeneous cloud of cold electron gas. Let $\tau = Rn_e\sigma_T$ be Thomson optical depth of the cloud. Let seed photons be injected in the center of the cloud. The differential cross-section for Thomson scattering is

$$\frac{d\sigma}{d\Omega} = \sigma_T \frac{3}{16\pi}(1 + \cos^2\alpha),$$

where α is the scattering angle, i.e. the scattering probability at a given angle α is proportional to $(1 + \cos^2\alpha)$.

Collect photons when they escape from the sphere. Record the number of scatterings that a photon undergoes before escaping and the time it spends in the cloud before escaping. Plot the distribution of the number of scatterings, $f(n)$. Where the maximum is reached ? What is the mean number of scatterings

$$\langle n \rangle = \frac{\sum_n n f(n)}{\sum_n f(n)}?$$

What is the dispersion $D = \langle n^2 \rangle - \langle n \rangle^2$? Consider three choices of $\tau = 0.5, 1, 10$ (you can consider more cases if you wish). Approximate $\langle n \rangle = A\tau + B\tau^2$, and compute the coefficients A and B that would best describe the $\langle n \rangle(\tau)$ dependence.

Plot the distribution of the escape time (time between injection and escape). What relation this distribution has to the distribution of the number of scatterings?

How results differ when one injects seed photons homogeneously and isotropically all over the sphere? Repeat all the calculations for this case.

You can use any random number generator (e.g. from Numerial Recipes).