Project Activity

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Phase 1 - Scenario

Let us consider an infinite homogenous medium characterized by the following coefficients:

$$\mu_a^{\circ} = 0.1\ cm^{-1}$$

$$\mu_s^{'\circ} = 10\ cm^{-1}$$

$$D = \frac{1}{3\mu_s'} = Diffusion\ coefficient\ [cm]$$

An absorption region is located at distance r from the origin, and the absorption perturbation (point-like) is $\delta\mu_a = 0.1\ cm^{-1}$, the volume $V_i = 1\ cm^3$. In addition, the Source and the Detector are assumed to be placed in the same position.

We work in $time\ domain$: $t = 0 : 10\ ns$.

$\textbf{Assumption :}$ we imposed that both source and detector are positioned in the origin of the medium in order to further semplify the requested expressions. In this way, r represents either the distance origin-perturbed region and the distance source/detector-perturbed region. In particular, we assumed $r = 0.1\ cm$.

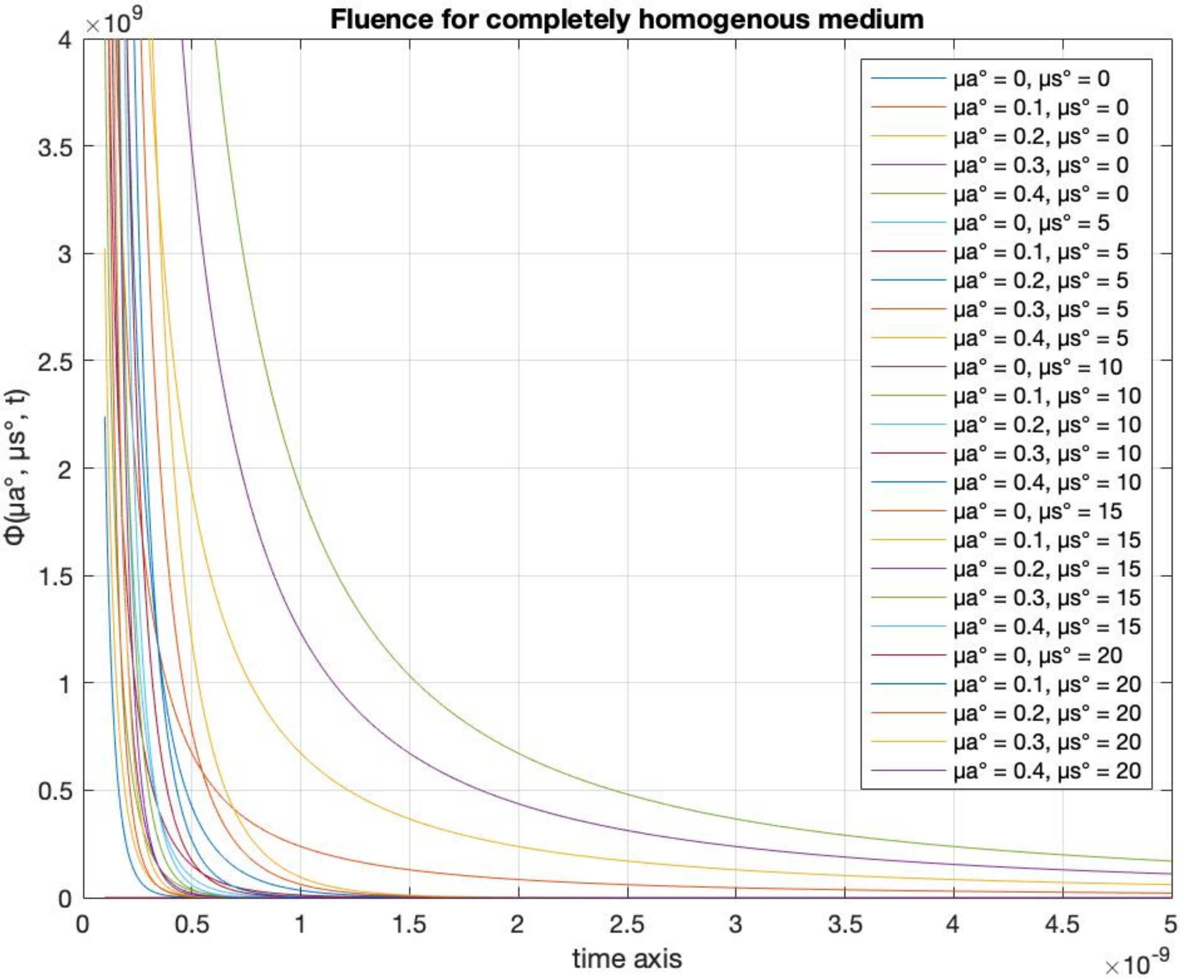
Fluence Rate $\phi_o(\mu_a^o, \mu_s'^o, t)$

The fluence rate function for a completely homogenous medium in a point P at a distance $r = 0.1\ cm$ from the source, as function of time t, is presented. In this case, the following curves are plotted by varying the parameters

$$\mu_a^\circ : from\ 0\ to\ 0.4\ cm^{-1}$$
$$\mu_s'^\circ : from\ 5\ to\ 20\ cm^{-1}$$

The required formula is given by:

$$\phi_o(\mu_a^o, \mu_s'^o, t) = \frac{c}{(4\pi Dct)^{\frac{3}{2}}} exp\left(-\frac{r^2}{4Dct} - \mu_a^o ct\right) \tag{1}$$



Absorption perturbation $\delta\phi_a^o(r, t)$

The time dependent fluence rate for an absorption perturbation, given a completely homogenous medium and a point-like inhomogeneity at distance r from the source/detector, is given by:

$$\delta\phi_a^o(r, t) = -\frac{c^2}{(4\pi Dc)^{\frac{5}{2}} t^{\frac{3}{2}}} \delta\mu_a \frac{2}{r} Vexp\left(\frac{r^2}{Dct} - \mu_a^o ct\right) \tag{2}$$

Contrast function $C(t)$

The contrast function is obtained by dividing the equation (2) by equation (1), hence:

$$C(t) = \frac{\delta\phi_a^o}{\phi_o} \tag{3}$$

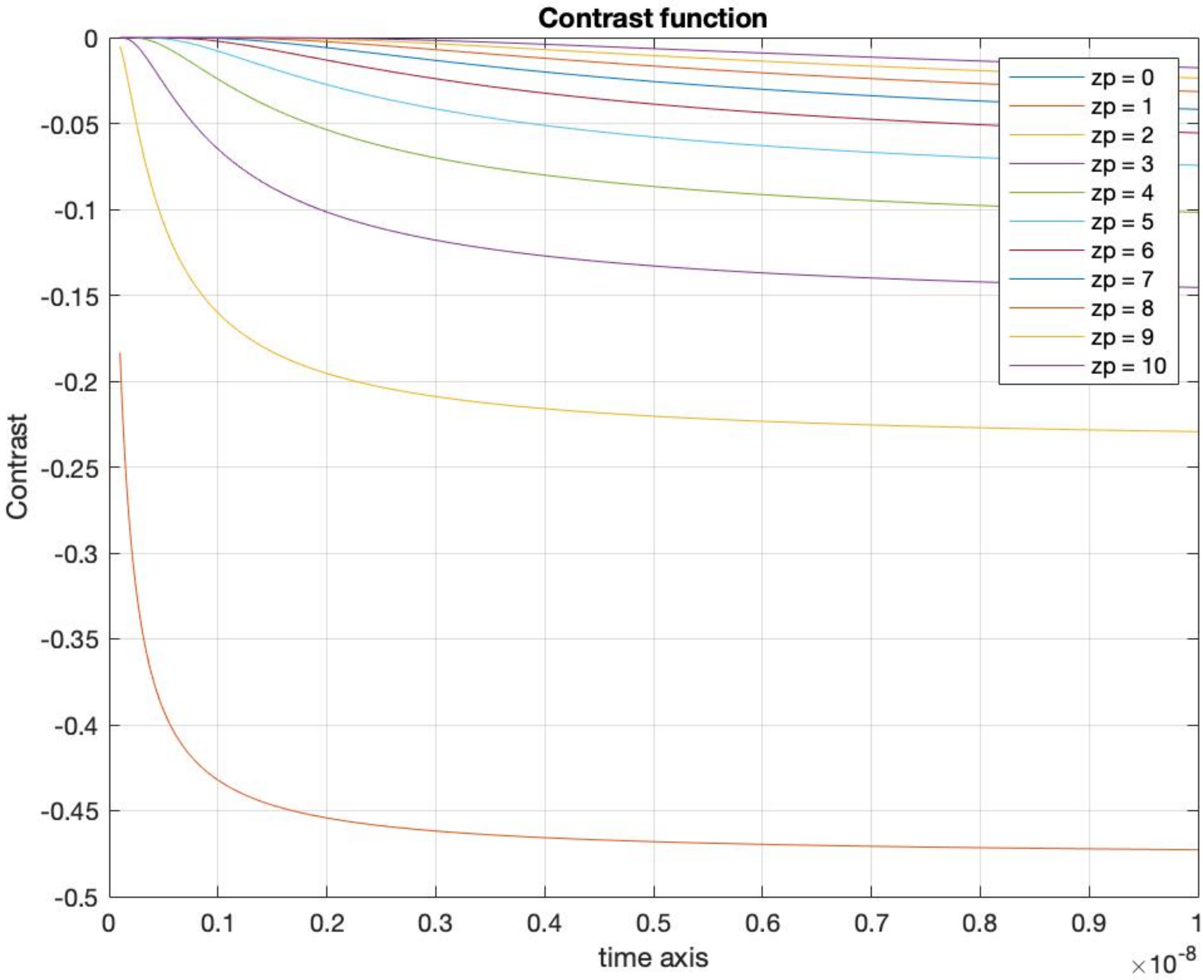
And, by exploiting all the mathematical passages, we obtain:

$$C(t) = -\frac{c}{4\pi Dc} \delta\mu_a \frac{2}{r} Vexp\left(-\frac{3r^2}{4Dct}\right) \tag{4}$$

Plot 1

$\mu_a^o,\ \mu_s^{'o}$ - as default.

$Perturbation\ coordinates:\ x_p = y_p = 0$, zp varying.

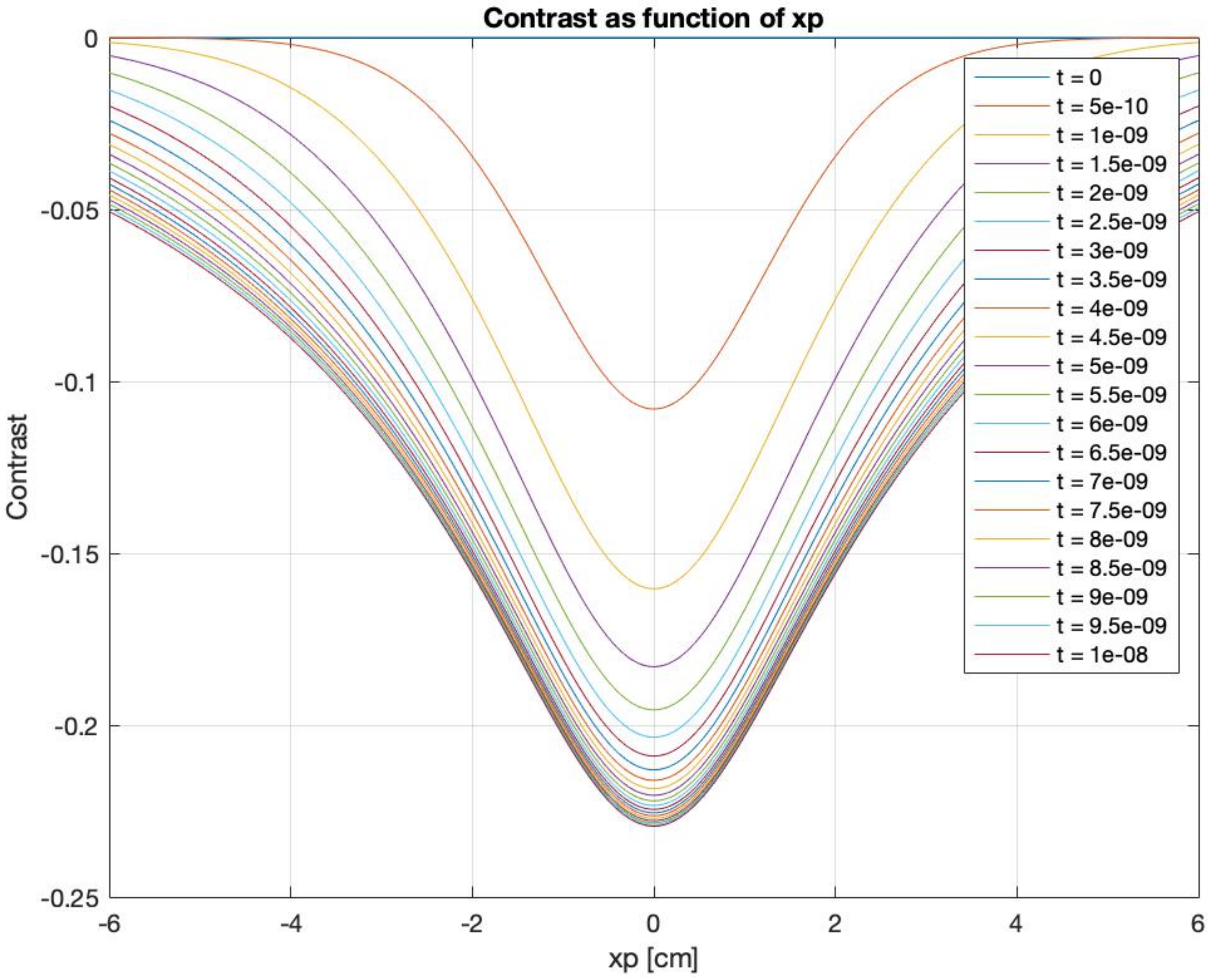


Plot 2

$$Perturbation\ coordinates:$$

$$x_p:\ from\ -6\ to\ 6\ cm,\ y_p = 0,\ z_p = 2\ cm$$

t varying



Contrast as function of xp
Contrast
xp [cm]
0
-0.05
-0.1
-0.15
-0.2
-0.25
-6
-4
-2
0
2
4
6
t = 0
t = 5e-10
t = 1e-09
t = 1.5e-09
t = 2e-09
t = 2.5e-09
t = 3e-09
t = 3.5e-09
t = 4e-09
t = 4.5e-09
t = 5e-09
t = 5.5e-09
t = 6e-09
t = 6.5e-09
t = 7e-09
t = 7.5e-09
t = 8e-09
t = 8.5e-09
t = 9e-09
t = 9.5e-09
t = 1e-08