Study of transport effects

Objectives

- Study transport effects in source-driven systems
- Consider source-oscillated problems (physically meaningful)
- Define limits of validity of diffusion approximation

Summary

- Solution of the transport equation in the frequency domain
- Application of acceleration techniques
- Study of numerical effects
- Study of transport effects

Transport Model

- Oscillated Source

$$S(x, y, t) = S_0(x, y)e^{i\omega t}$$

- Asymptotic behavior of the solution

$$\varphi(x, y, \hat{\Omega}, t) = \phi(x, y, \hat{\Omega})e^{i\omega t}$$

- Pseudo-stationary equation to be solved

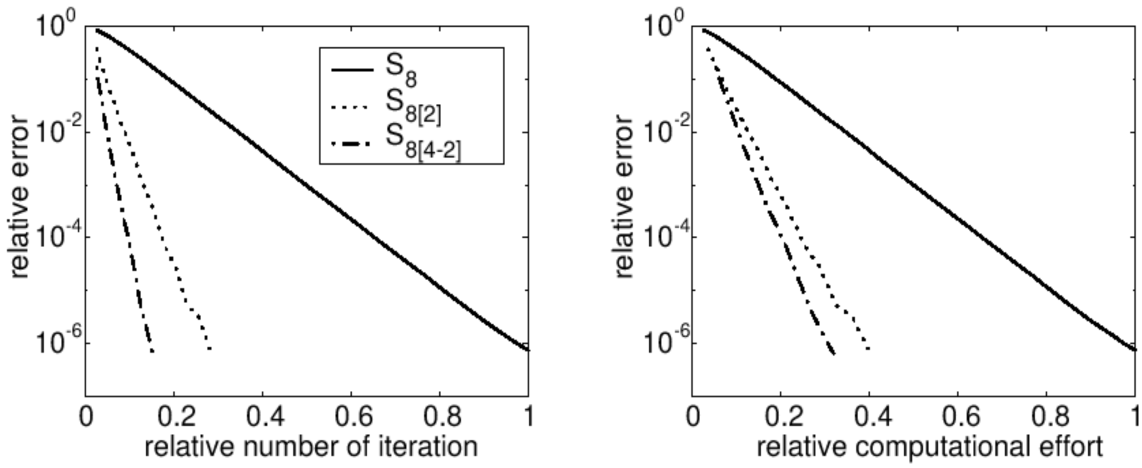
$$\hat{\Omega} \cdot \boldsymbol{\nabla}\phi(x, y, \hat{\Omega}) + \left[\Sigma(x, y) + \frac{i\omega}{v}\right]\phi(x, y, \hat{\Omega}) =$$

$$= \Theta_s\left[\phi\right] + \Theta_f\left[\phi\right] + \frac{1}{4\pi}S_0(x, y)$$

Numerical solution

- S_N discretized equation in Fourier-transformed space
- Synthetic technique based on lower-order discrete ordinate models (effectiveness depends on the ratio $\omega / \boldsymbol{v}$)

Effectiveness of acceleration methods



σ=1 mfp $^{-1}$, *c= 0.9*, *ω/v=0*

σ=1 mfp $^{-1}$

c= 0.9

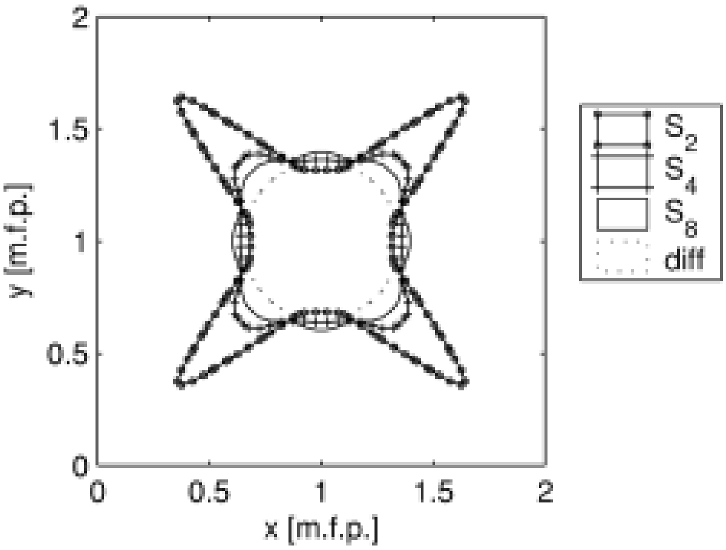
	S_8		$S_{8[4-2]}$	
$\omega/v\ [mfp^{-1}]$	ρ_{it}	ρ_t	ρ_{it}	ρ_t
0	1.00	1.00	0.08	0.28
10^{-3}	1.00	1.00	0.08	0.28
10^{-1}	1.00	1.00	0.08	0.28
1	0.35	0.35	0.08	0.28
10	0.08	0.09	0.08	0.28

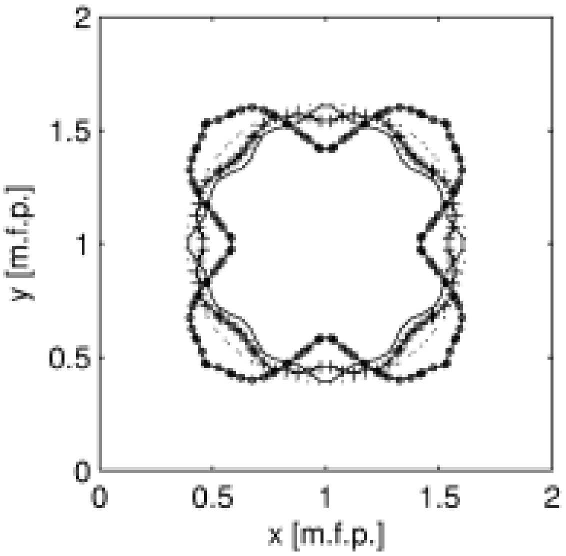
Numerical effects

- Presence of the Ray Effect on the amplitude and the shape of the response, depending on:
  - angular approximation
  - value of c

Angular approximation

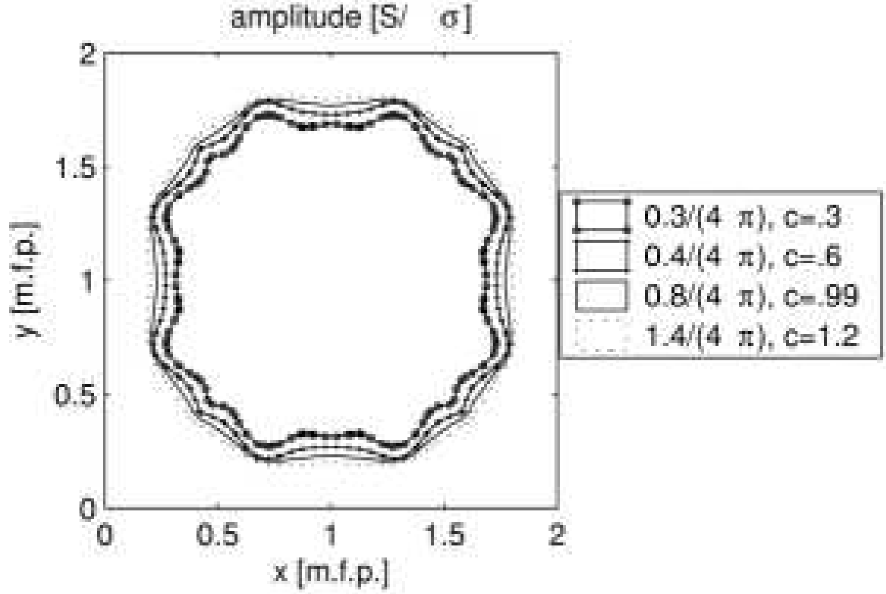
(ω/v=0.1 mfp^{-1}; c= 0.5)

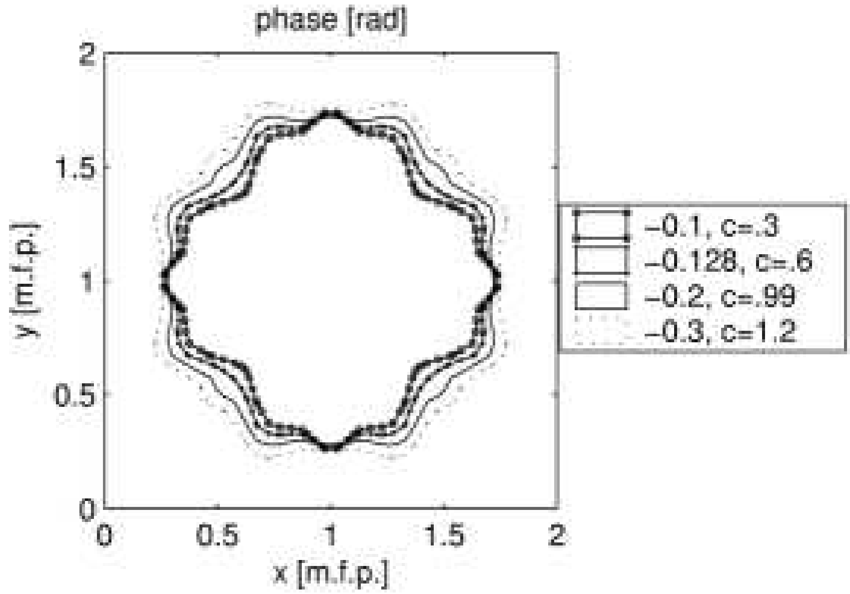




Value of c

(ω/v=0.1 mfp^{-1}; S_4 approximation)





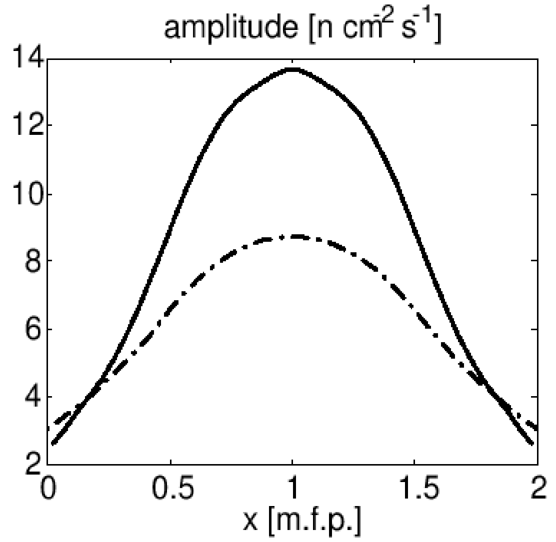
Transport effects

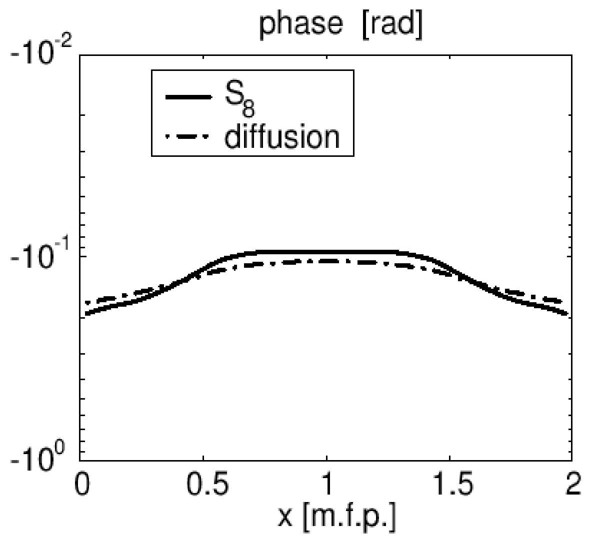
- Different configuration have been studied in transport and diffusion approximation to determine the role of transport effects as a function of:
  - system configuration
  - frequency of the source

Dimension of the system

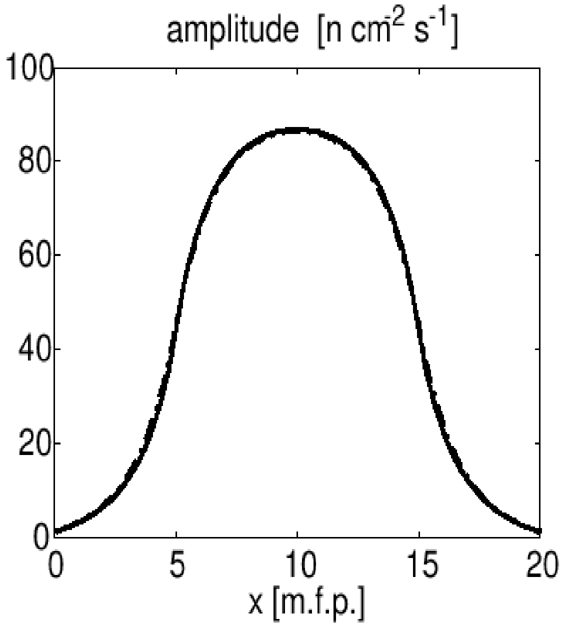
($\omega/v=0.1\ mfp^{-1}$; $c=0.9$)

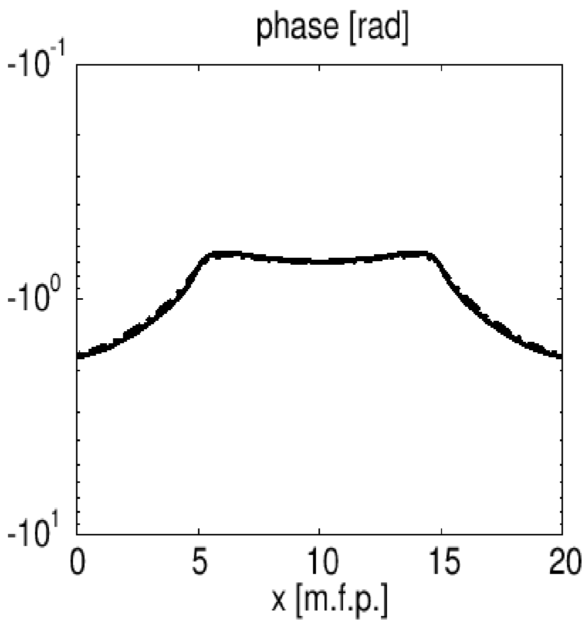
Optically thin system





Optically large system





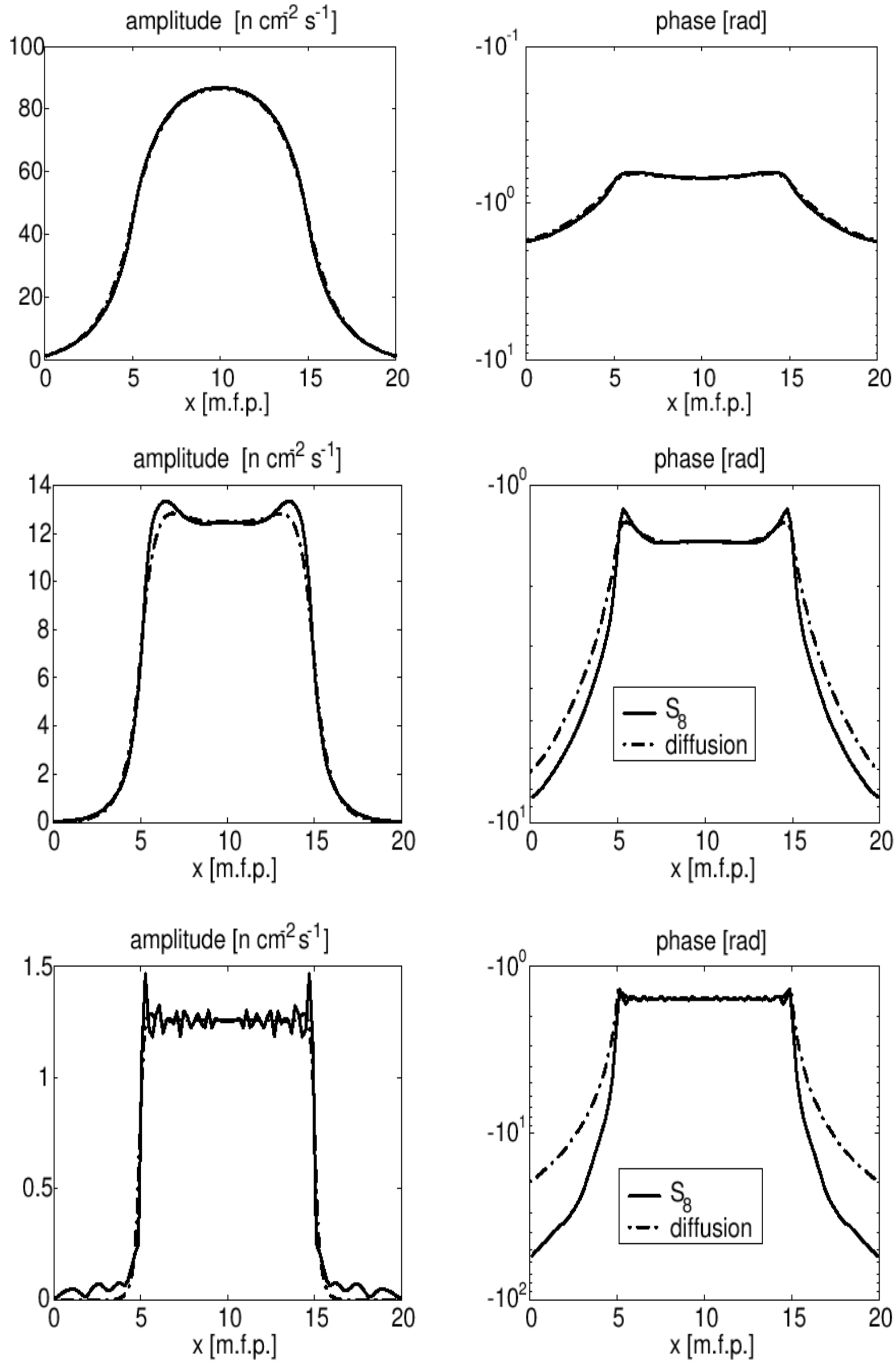
Frequency of the source

(σ=1 mfp $^{-1}$; c=0.9)

$\omega/v=0.1$ mfp^{-1}

$\omega/v=1$ mfp^{-1}

$\omega/v=10$ mfp^{-1}

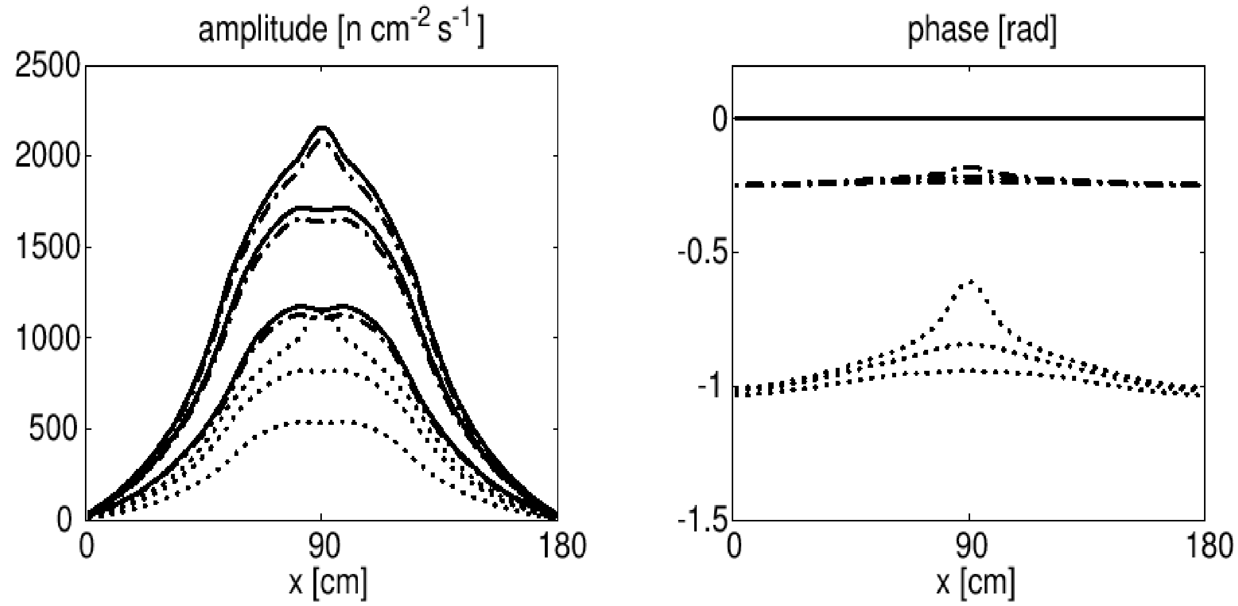


MUSE calculation

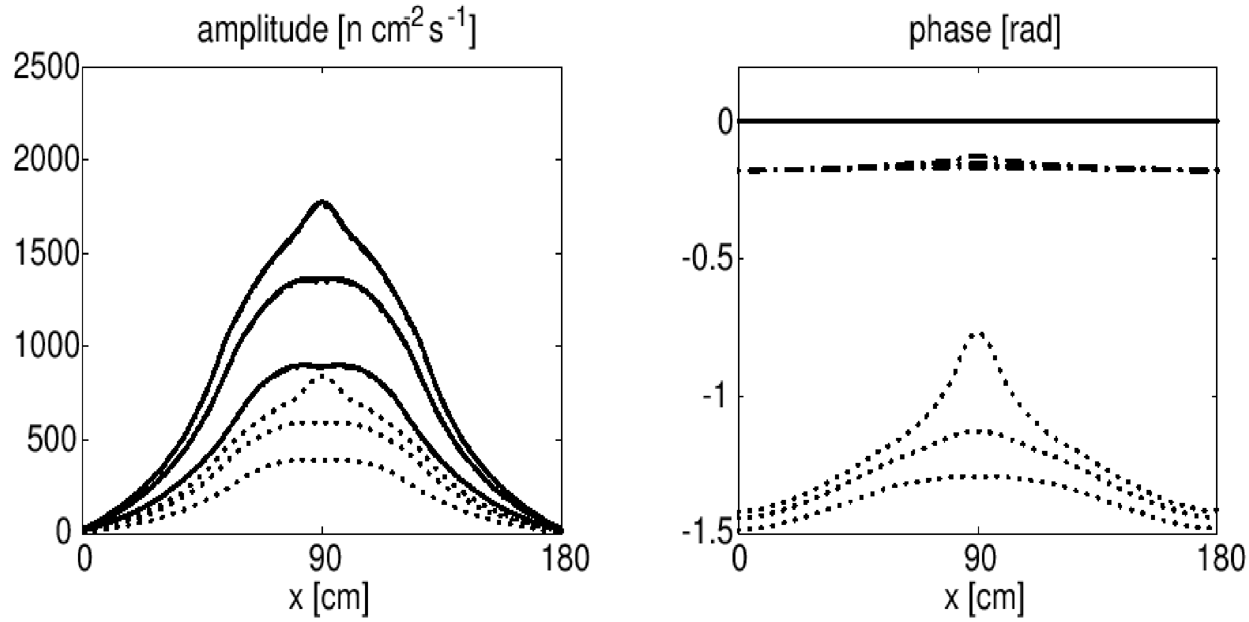
- Calculations have been run for a x-y configuration of the MASURCA reactor for the MUSE experiment, in transport and diffusive approximation, and the role of transport effects has been enlightened.

One-group solution

Transport model

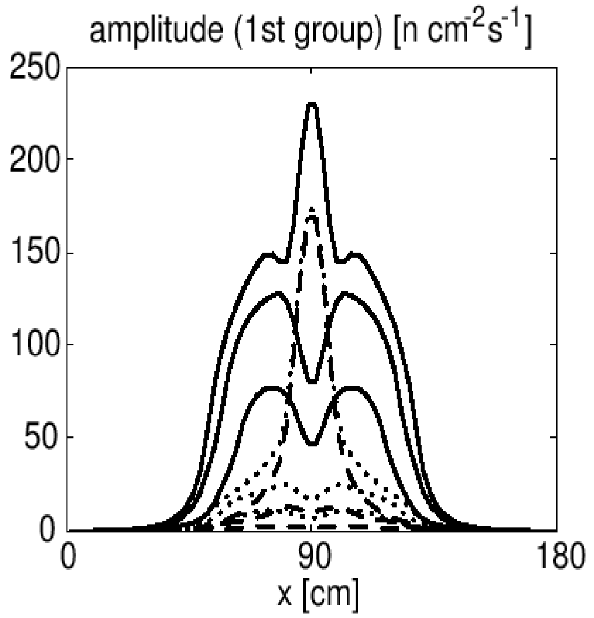


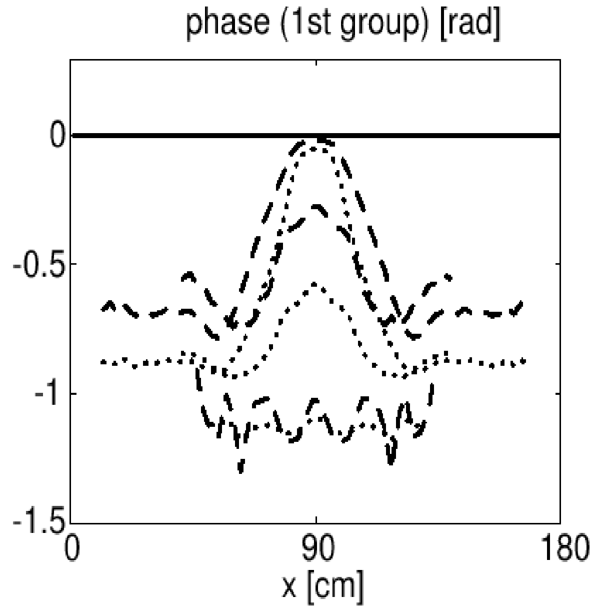
Diffusion approximation



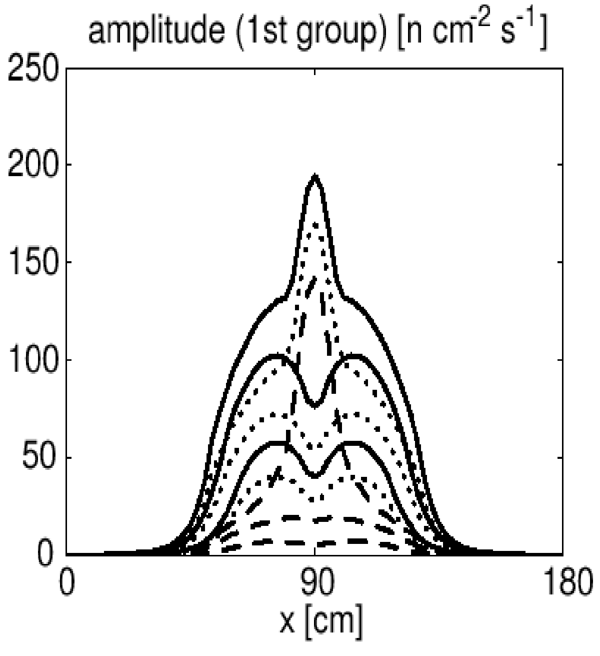
Three-group solution - First Group

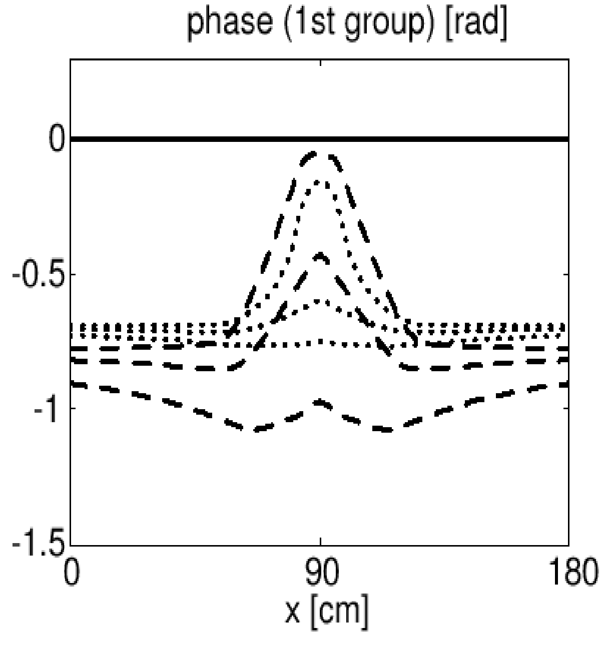
Transport model





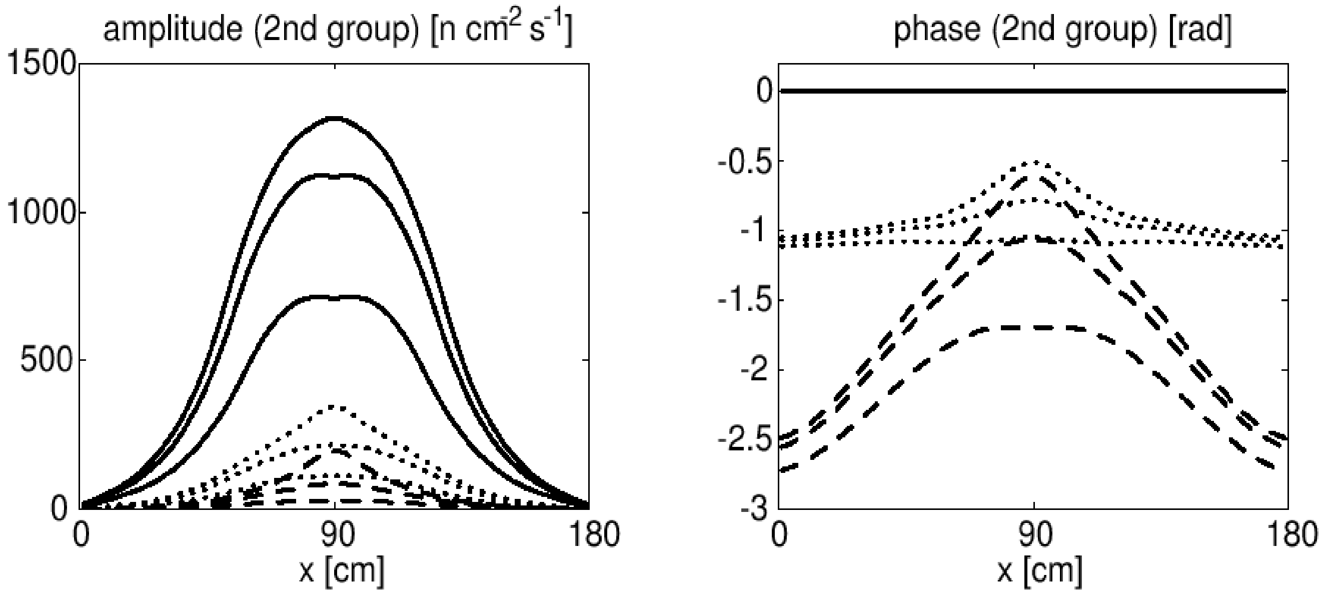
Diffusion approximation



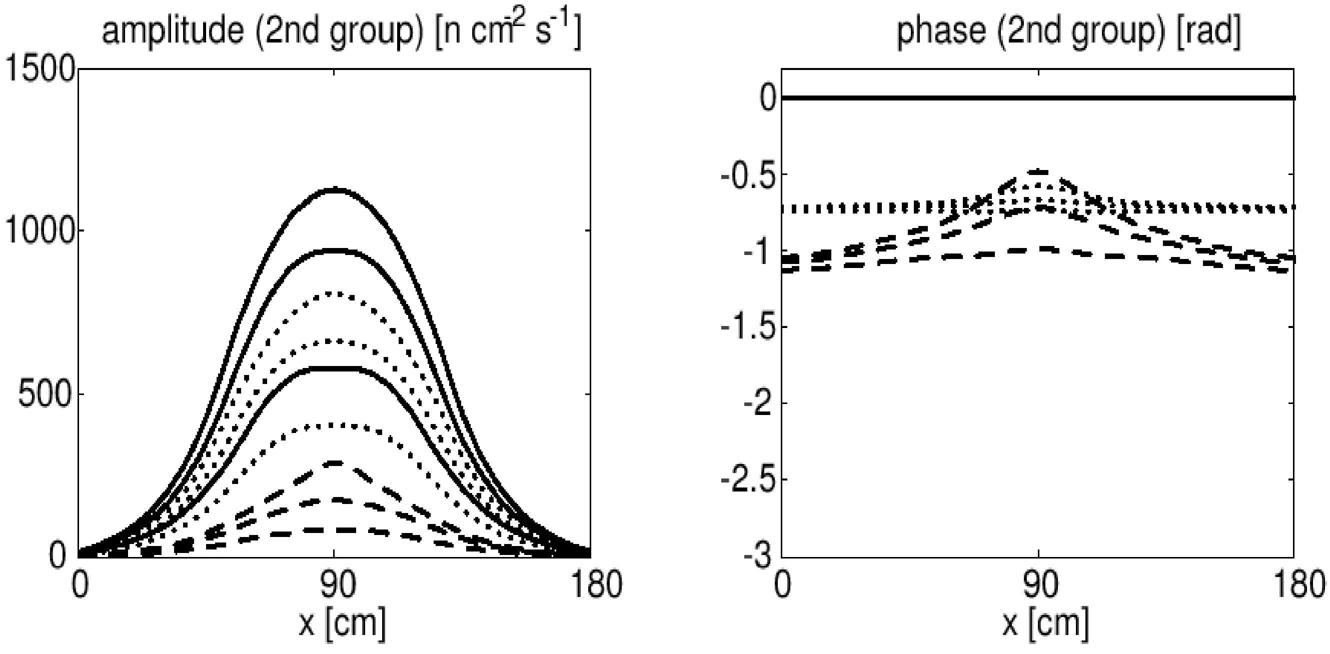


Three-group solution - Second Group

Transport model

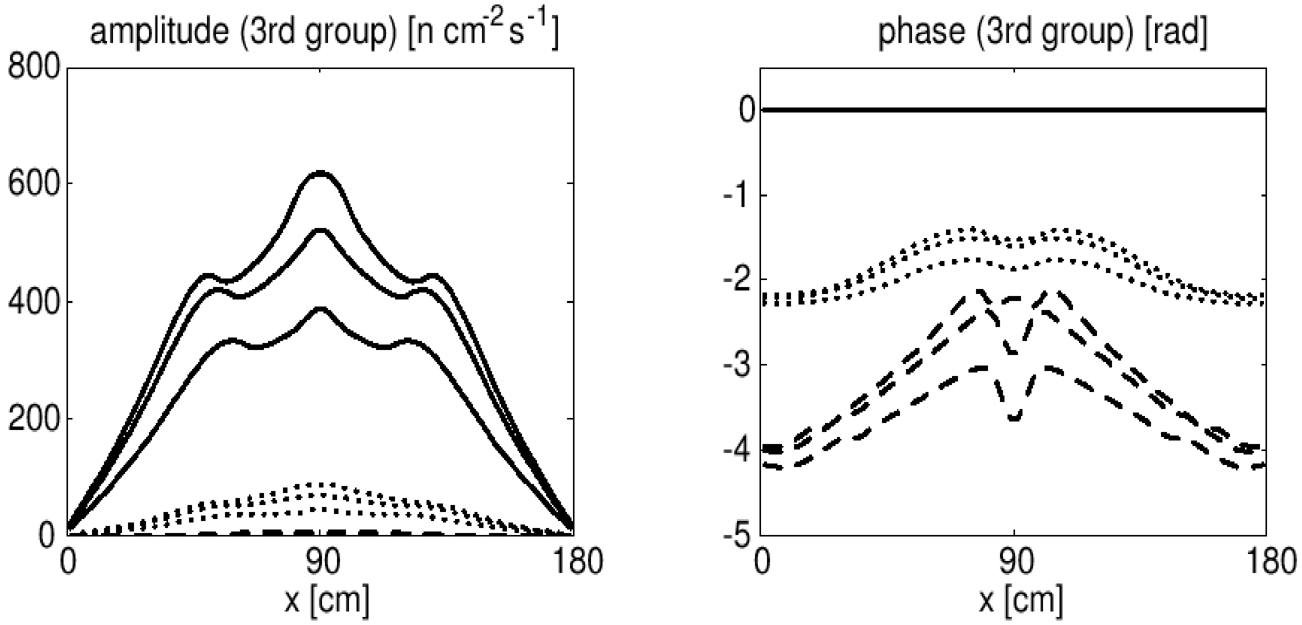


Diffusion approximation



Three-group solution - Third Group

Transport model



Diffusion approximation