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On the use of a diffusion equation model for sound energy flow prediction in acoustically coupled spaces

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Geometrical acoustics

- Sound rays
- Energy based

Diffusion equation model

- Sound energy density:
  solution of a diffusion equation

F. Ollendorff, ACOUSTICA, 1969

J. Picaut, et. al., Acust. Acta Acust. 1997

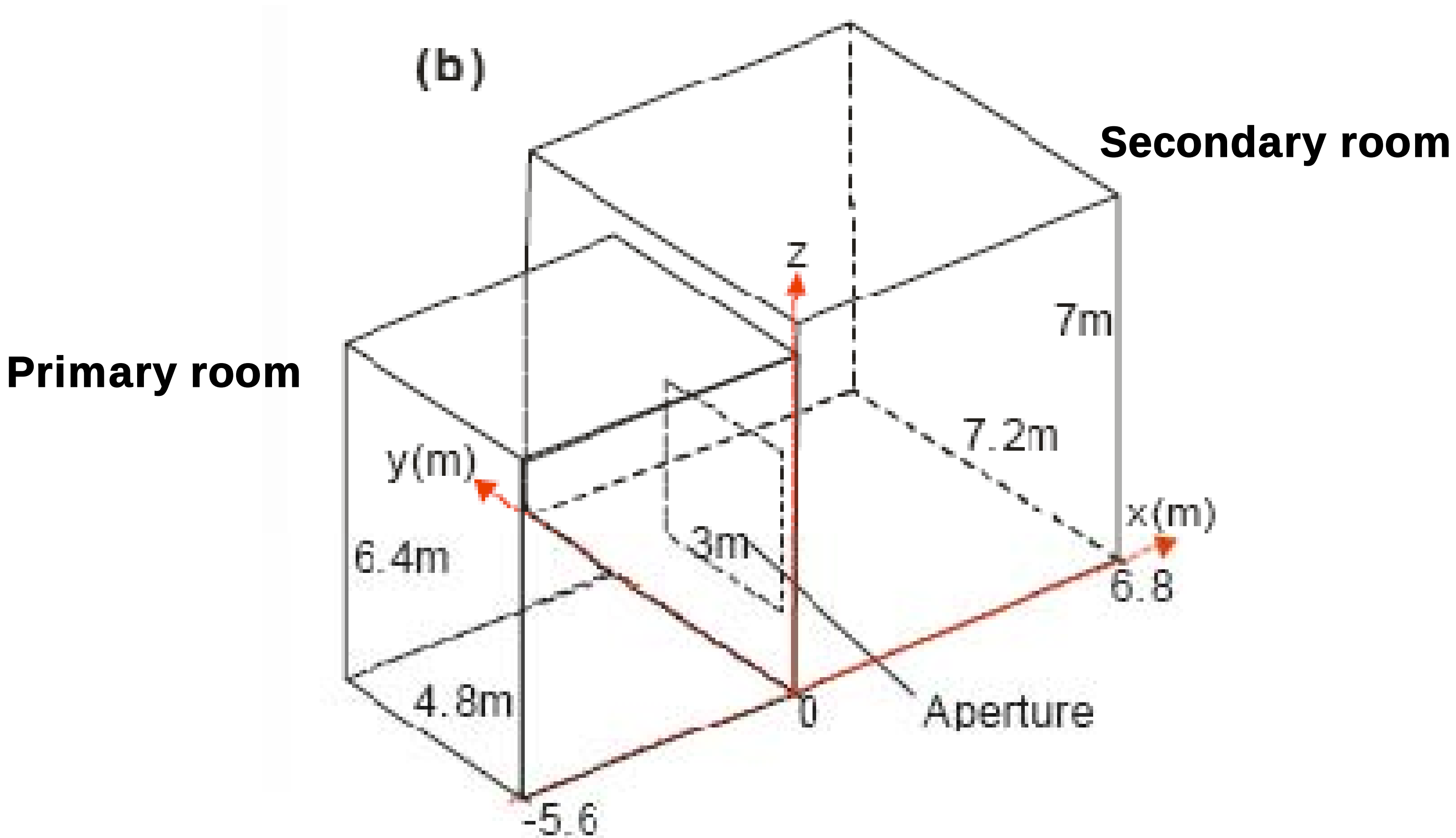
Diffusion equation

$$D\frac{\partial w(r,t)}{\partial n}+\frac{c\alpha}{2(2-\alpha)}w(r,t)=0$$

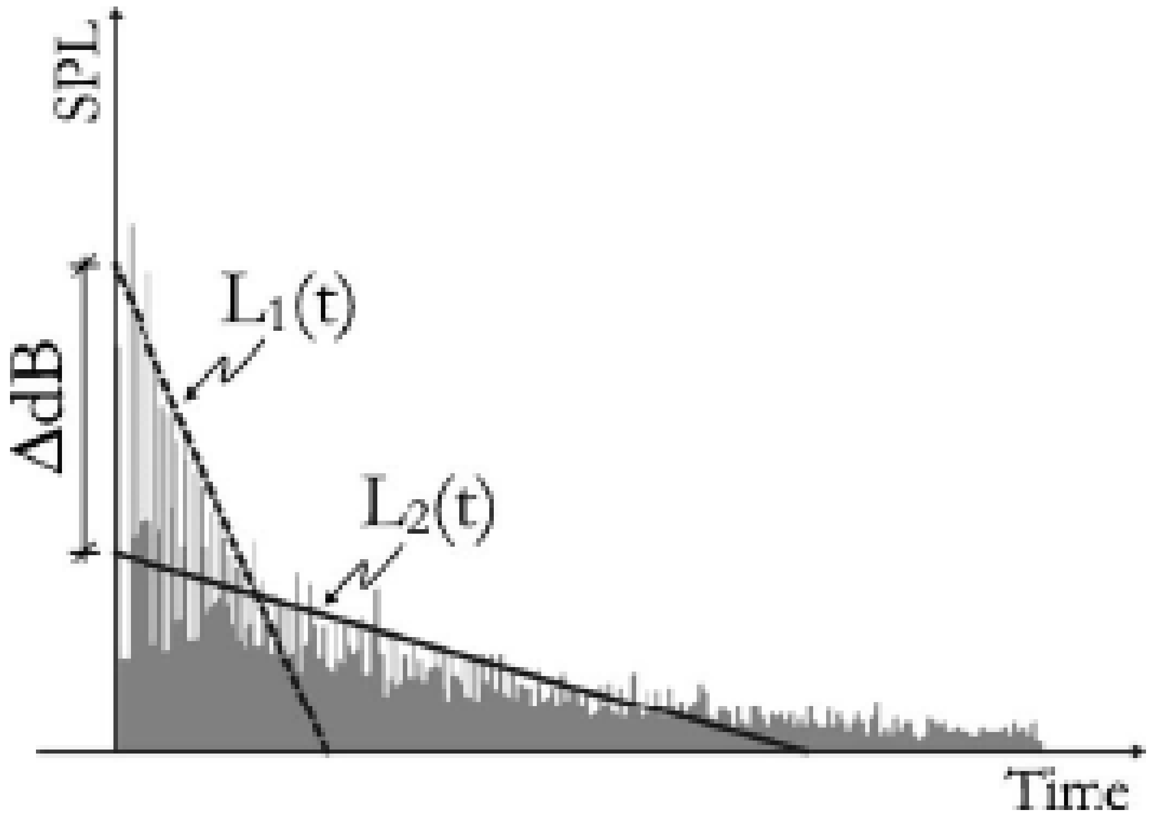
Interior Equation

Jing & Xiang, J. Acoust. Soc. Am. , 2008

Coupled room



Double-sloped energy decay



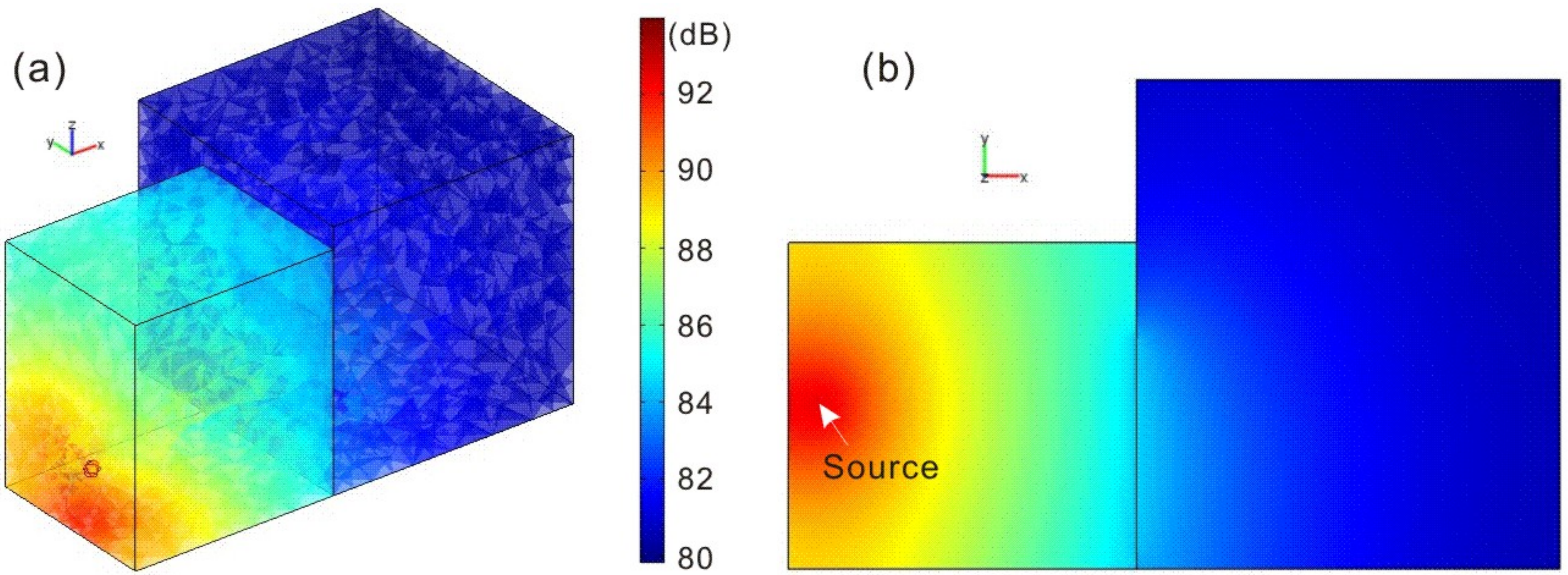
Bradley&Wang, 2005

Application in coupled spaces

- Assign diffusion coefficients based on each individual mean free path

- Valid when the aperture is smaller

Sound pressure level (SPL)

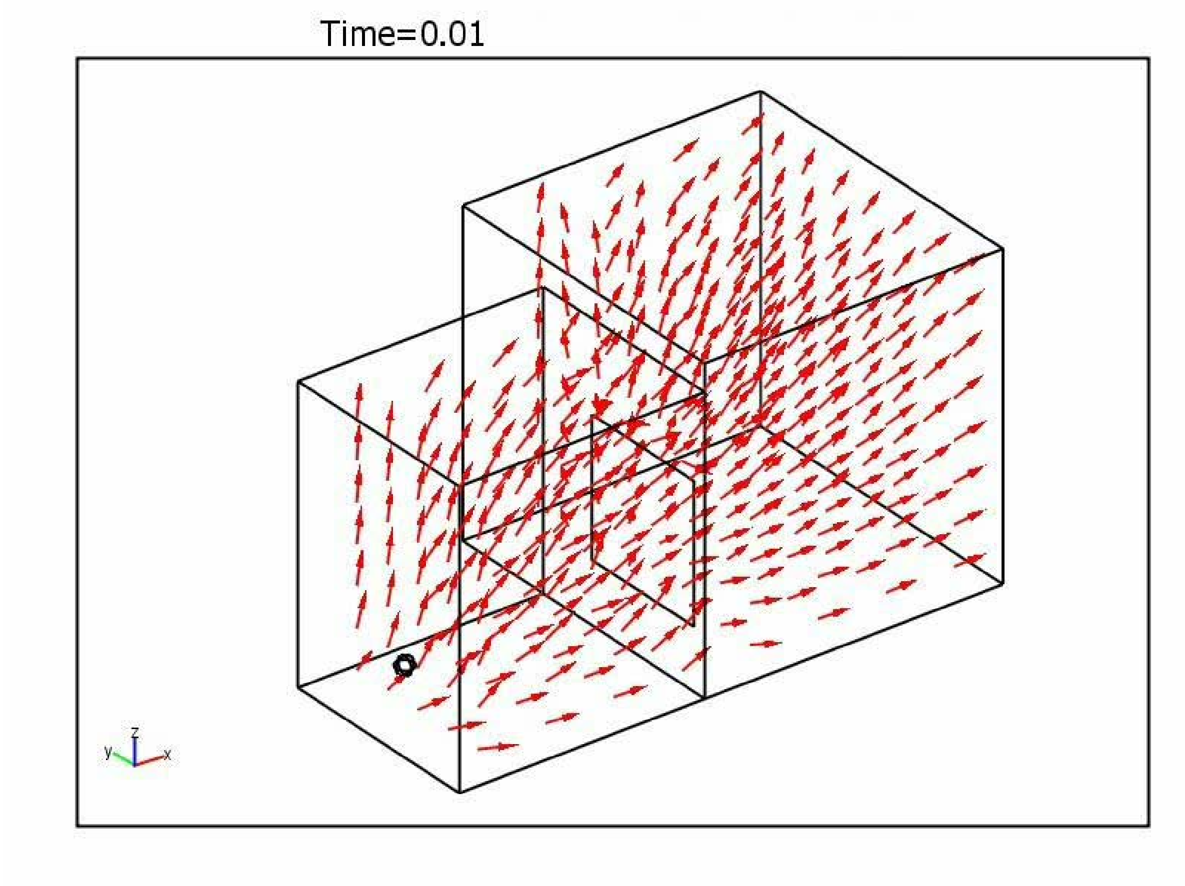


Energy flow

$$\mathbf{J} = -D \,\mathrm{grad}\, w(\mathbf{r}, t)$$

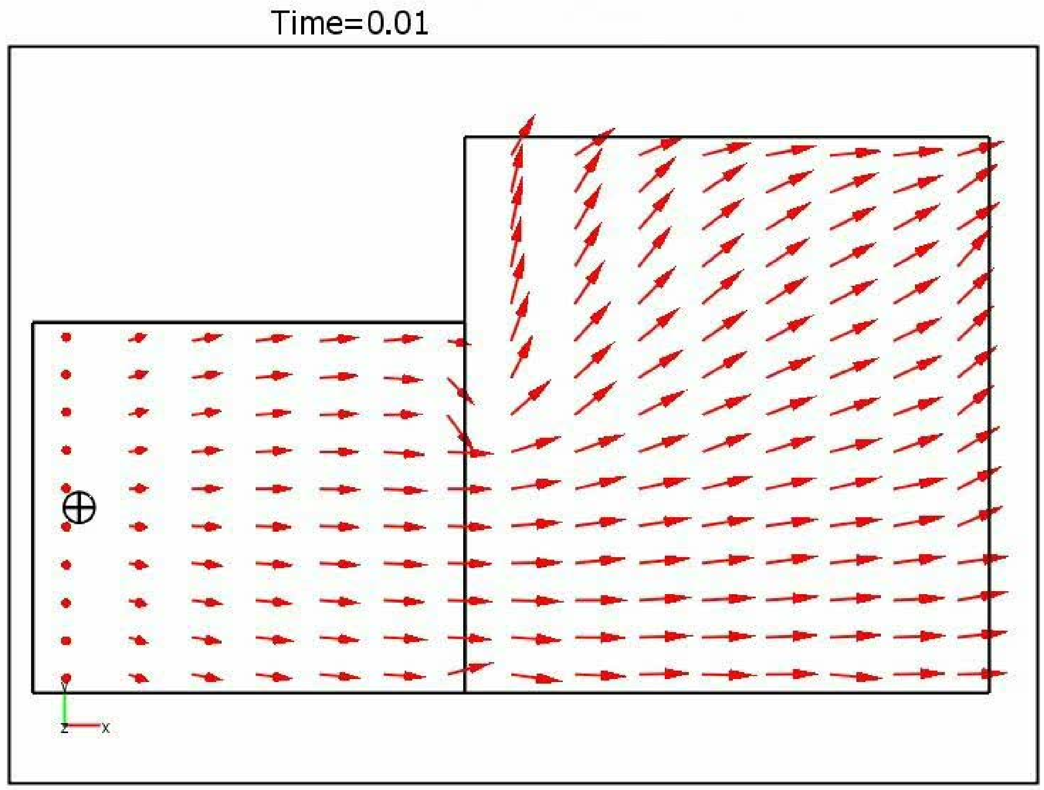
Flow animation (T1<T2)

- **3D**



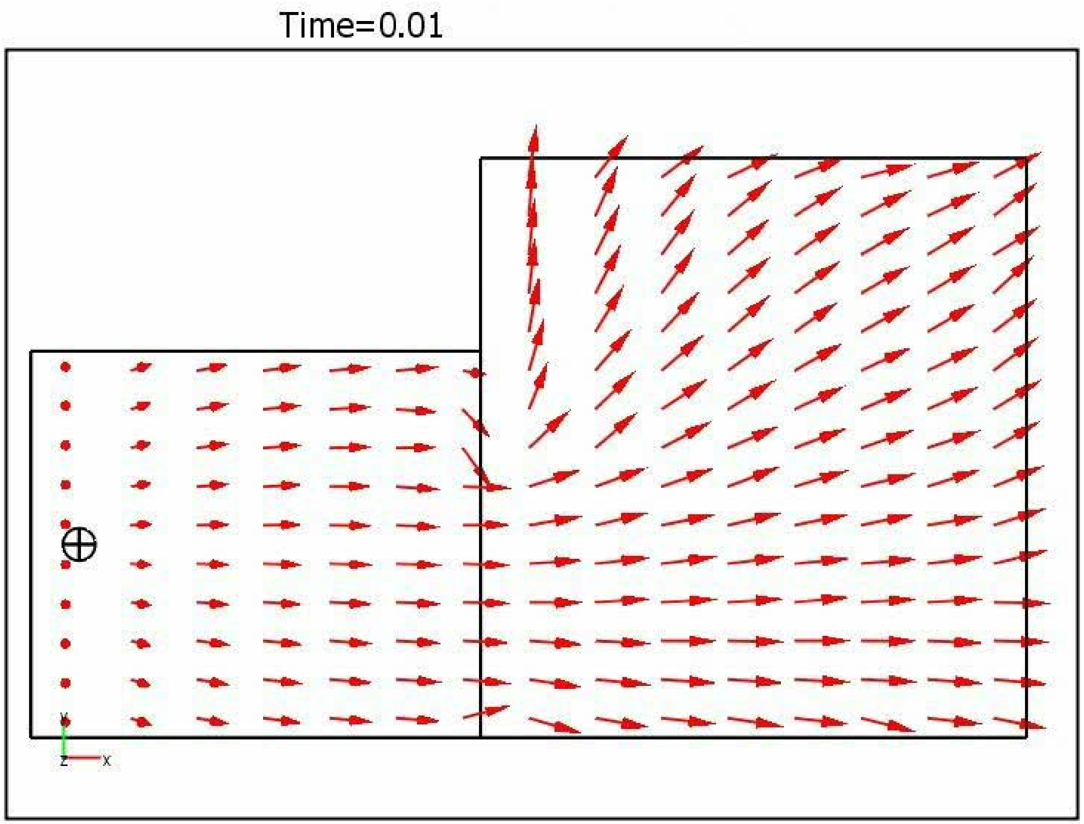
Flow animation (T1<T2)

- **2D**



Flow animation (T1>T2)

- **2D**

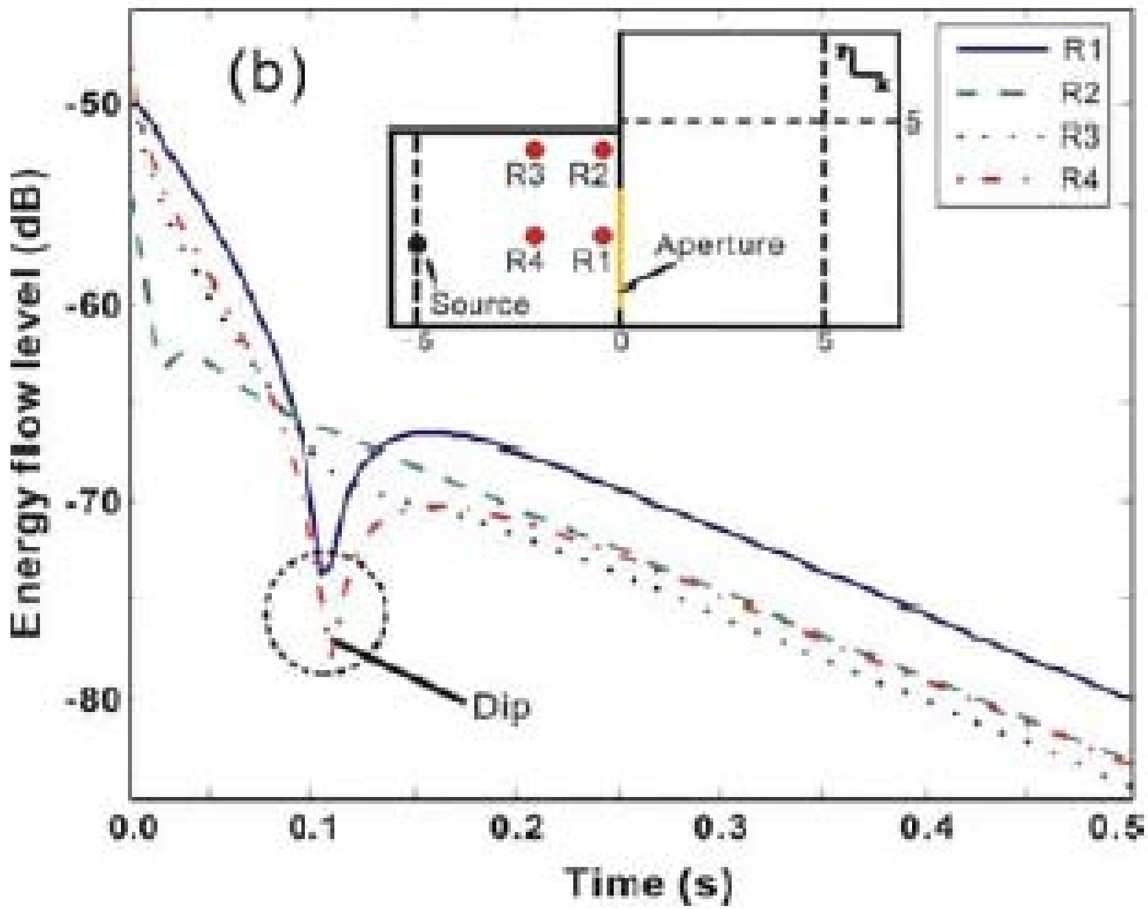


Energy flow amplitude

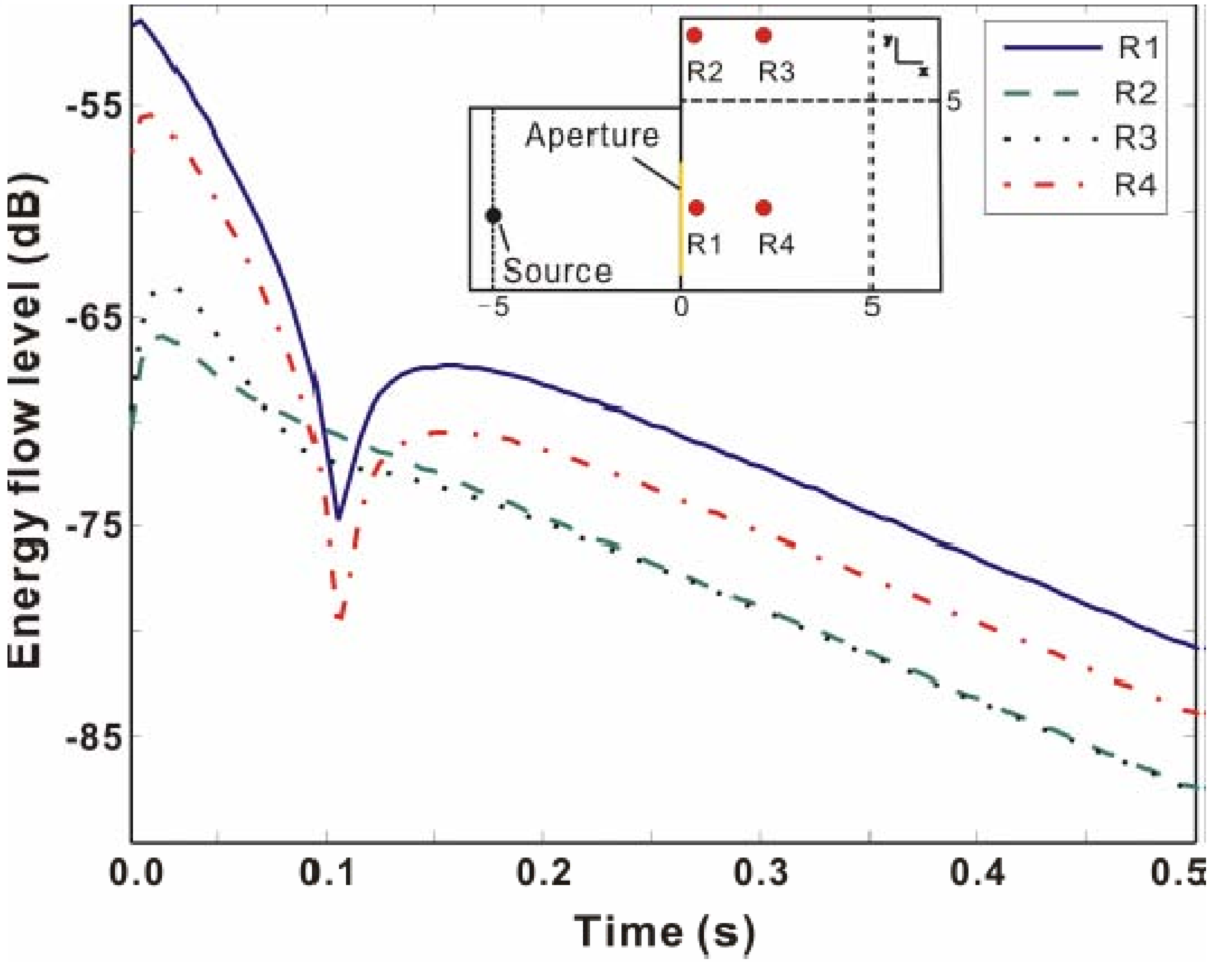
$$J_L(\mathbf{r},t) =$$

$$10 \ \log\left[\left(\frac{\partial w(\mathbf{r},t)}{\partial x}\right)^2 + \left(\frac{\partial w(\mathbf{r},t)}{\partial y}\right)^2 + \left(\frac{\partial w(\mathbf{r},t)}{\partial z}\right)^2 \right) \right]^{\frac{1}{2}}$$

Energy flow decay



More…



Energy flow level (dB)
-55
-65
-75
-85
0.0
0.1
0.2
0.3
0.4
0.5
Time (s)
R1
R2
R3
R4
Aperture
Source
R2 R3
R1 R4
5
-5
0
5

Summary

- **Diffusion equation**
- **Energy flow direction**
- **Energy flow decay**

End

- Thank you!!

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