CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

LABORATOIRE DE PHYSIQUE DE LA MATIÈRE CONDENSÉE
CNRS-ECOLE POLYTECHNIQUE

Increased damping in irregular resonators

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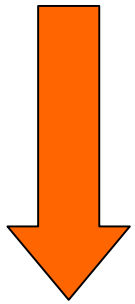
149th ASA meeting, Vancouver, 16-20 May, 2005.

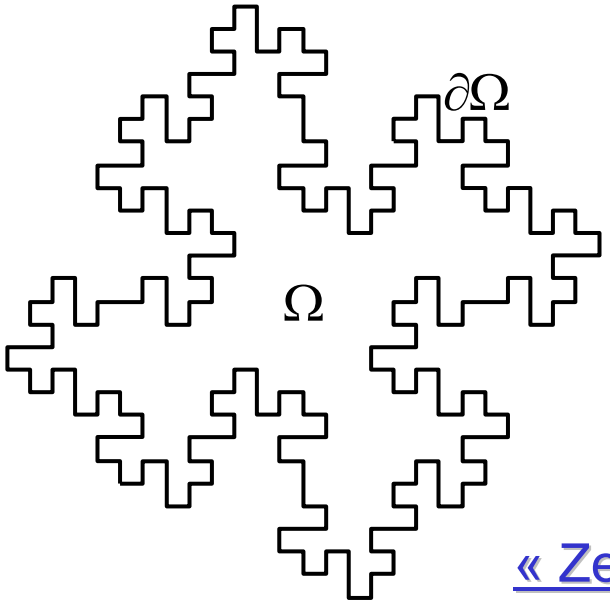
SCOPE OF THE TALK

GEOMETRICAL IRREGULARITY



MODE LOCALIZATION

INCREASED LOSSES



Eigenmodes of a pre-fractal cavity

$$\left(\Delta + k^2\right)p = 0 \qquad \text{in } \Omega$$

$$\vec{n}\cdot\vec{\nabla}p = -jk\varepsilon p \quad \text{on } \partial\Omega$$

(ε : reduced surface admittance)

« Zero-loss » eigenmodes: $\boxed{\varepsilon << 1}$

$$\Delta\psi_n = -k_n^2\psi_n \qquad \text{in } \Omega$$

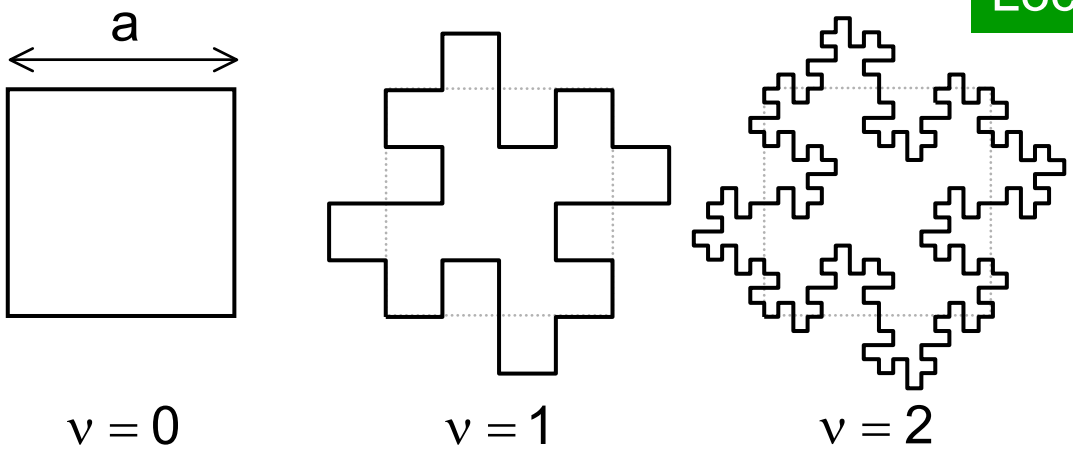
$$\vec{n}\cdot\vec{\nabla}\psi_n = 0 \qquad \text{on } \partial\Omega$$

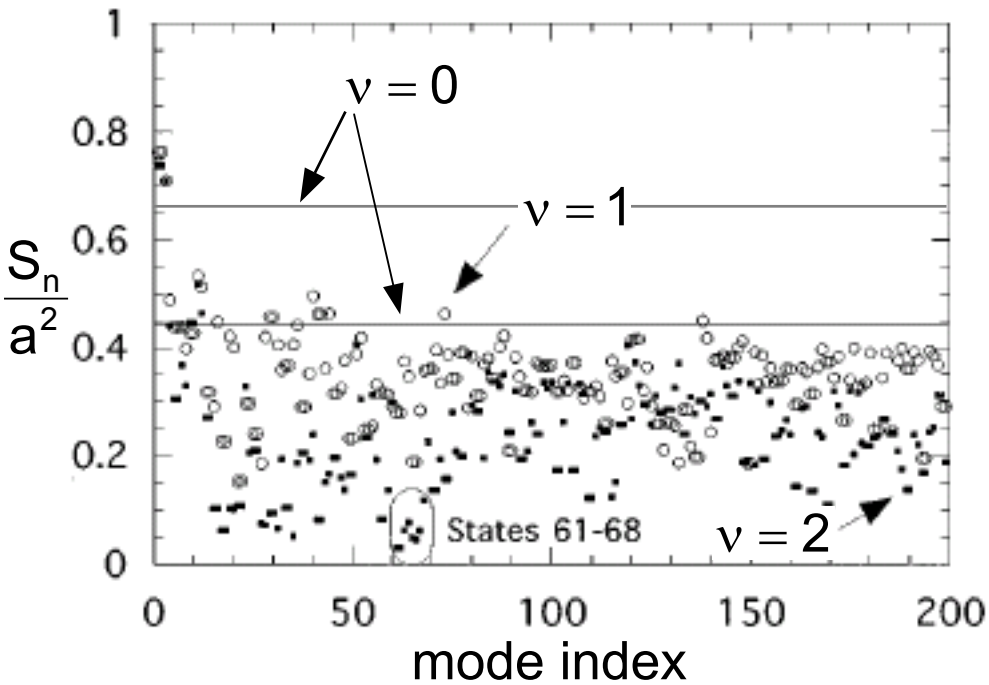
modes normalized : $\int_\Omega |\psi_n|^2 dS = 1$

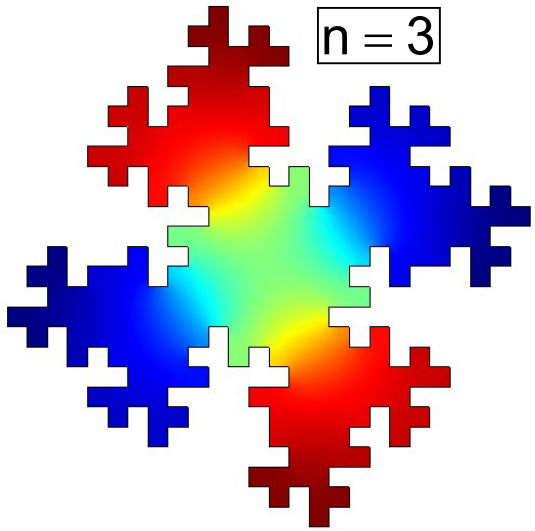
Characterization of localization:

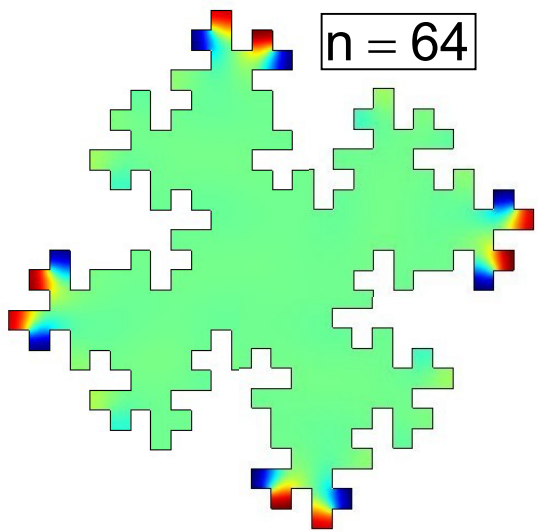
existence surface: $\boxed{S_n = \dfrac{1}{\int_\Omega |\psi_n|^4 dS}}$

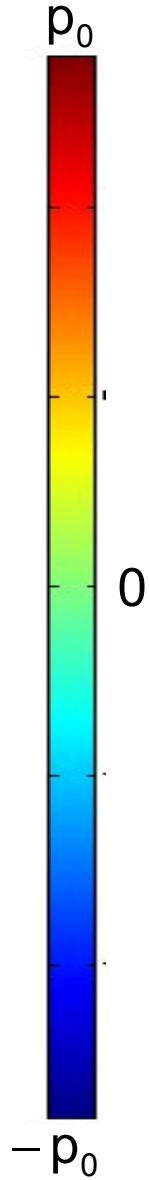
Localization in a pre-fractal cavity





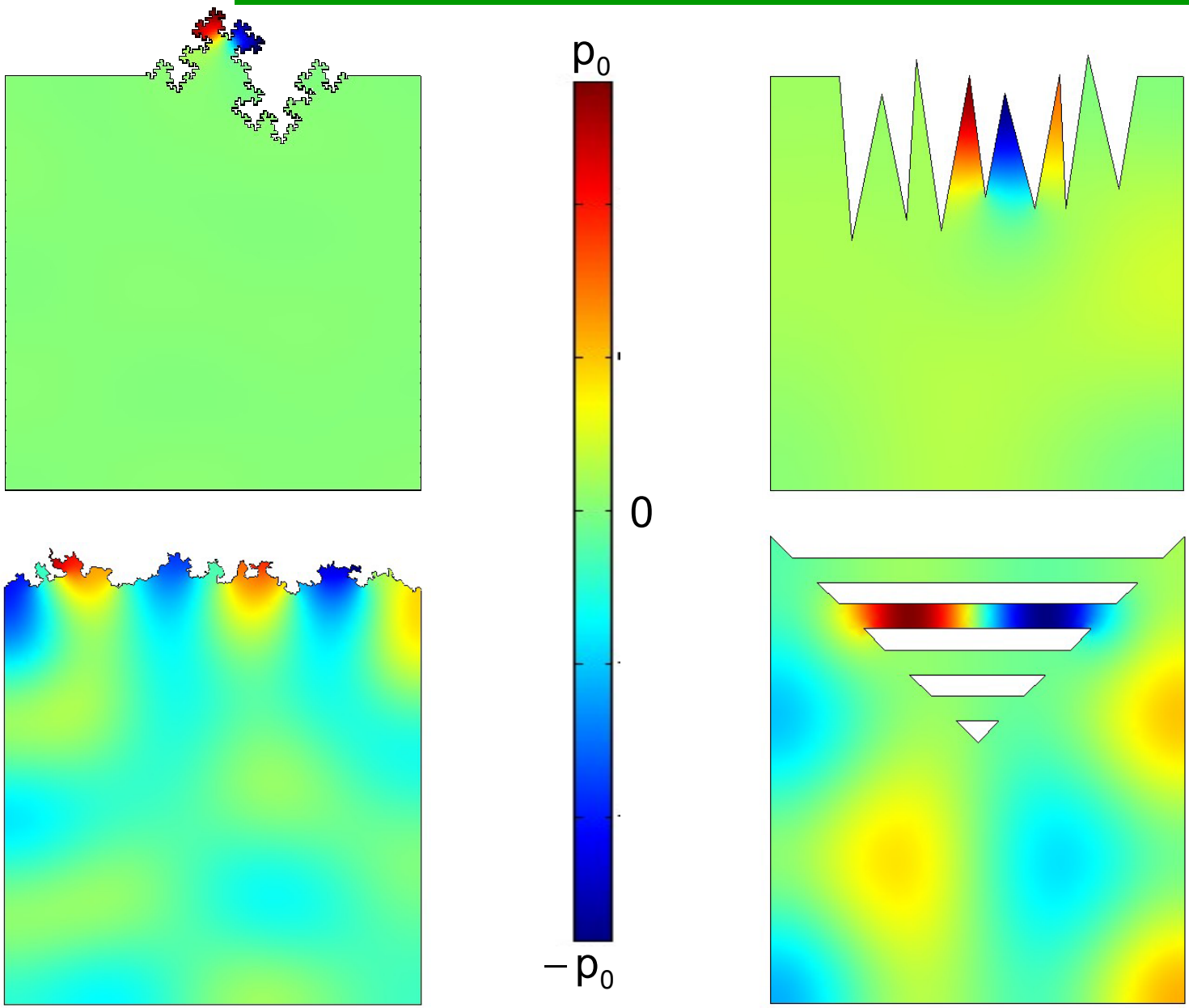


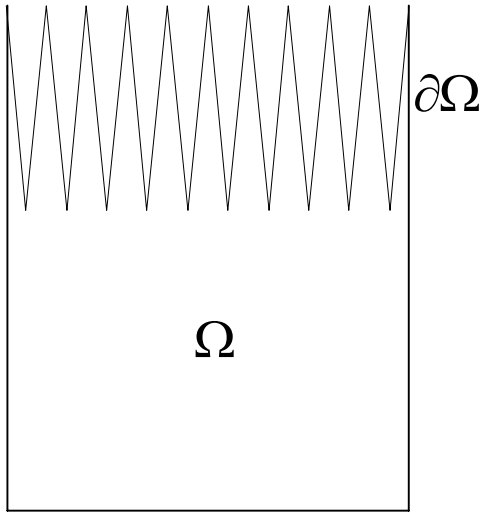




[Sapoval *et al.*, J. Acoust. Soc. Am. **102**(5), 2014-2019 (1997).]

Any type of geometrical irregularity creates localization



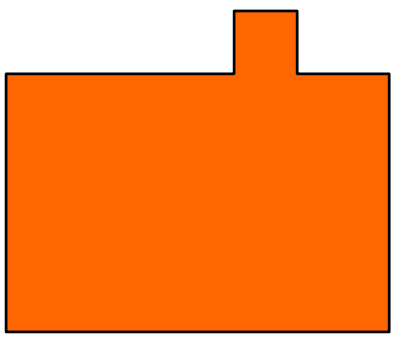


Under the assumption of weak losses ($\varepsilon << 1$):

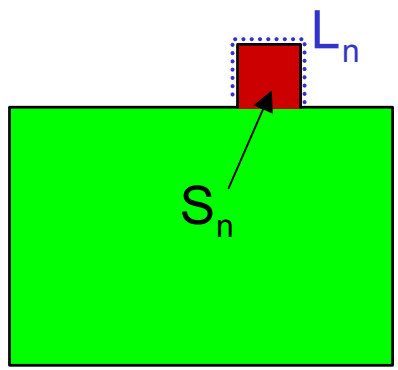
$$Losses \propto \int_{\partial\Omega} |\psi_n|^2 \, dL \approx \frac{existence}{existence} \frac{perimeter}{surface}$$

Localized modes exhibit larger losses

non localized mode

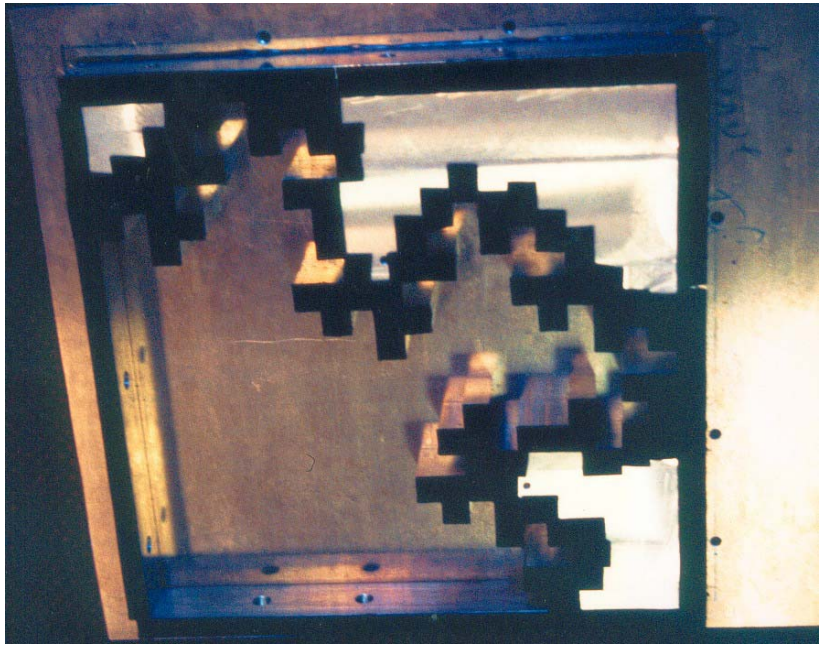


localized mode

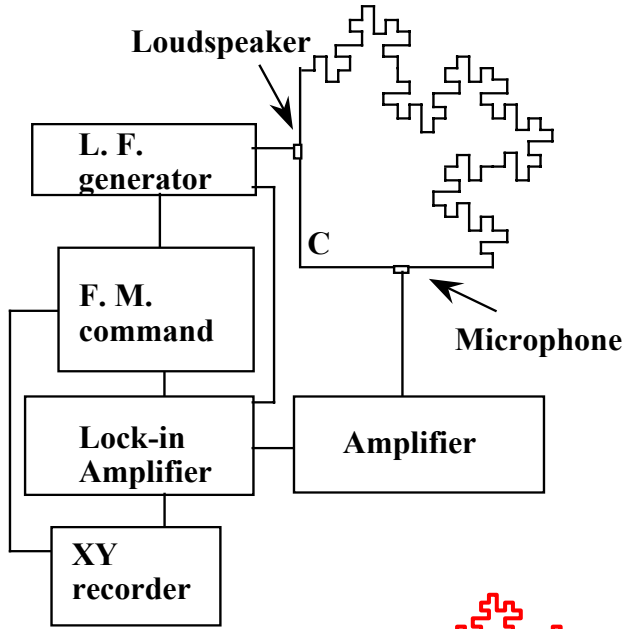


$$Losses \propto \frac{\text{cavity perimeter length}}{\text{cavity surface area}}$$

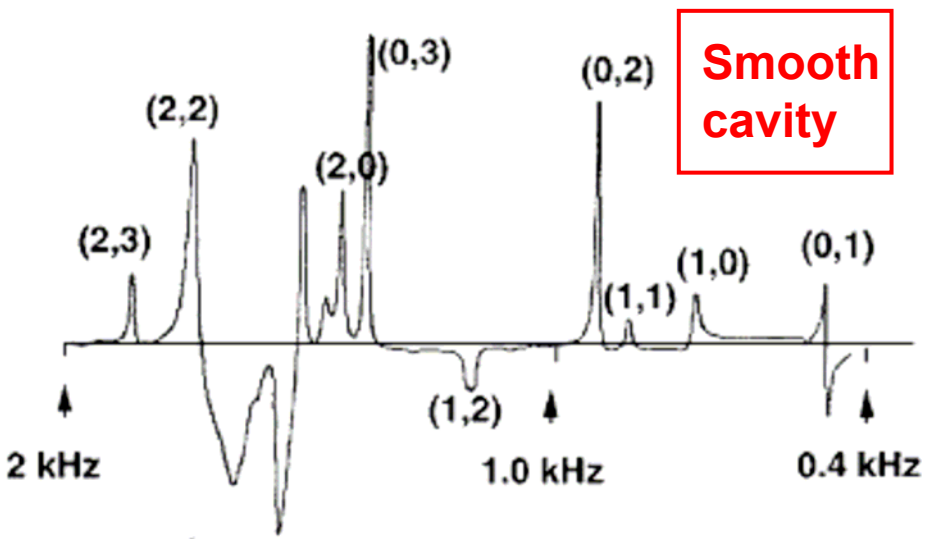
$$\psi_n = \frac{1}{\sqrt{S_n}} \Rightarrow Losses \propto \frac{L_n}{S_n}$$

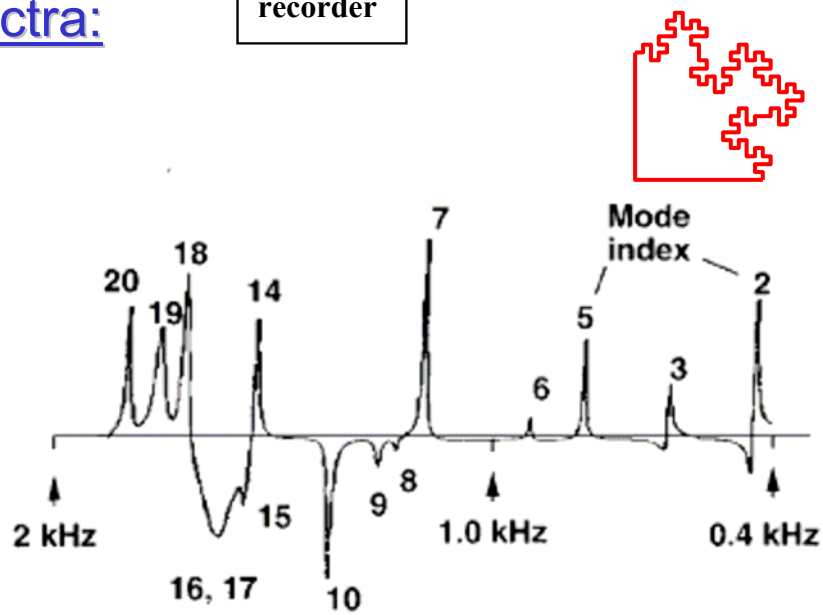


Experimental study



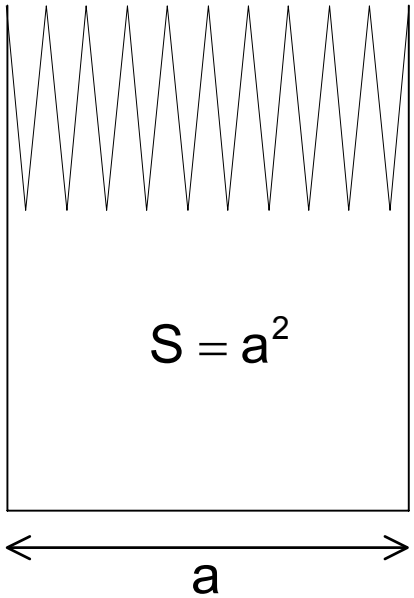
Transmission spectra:

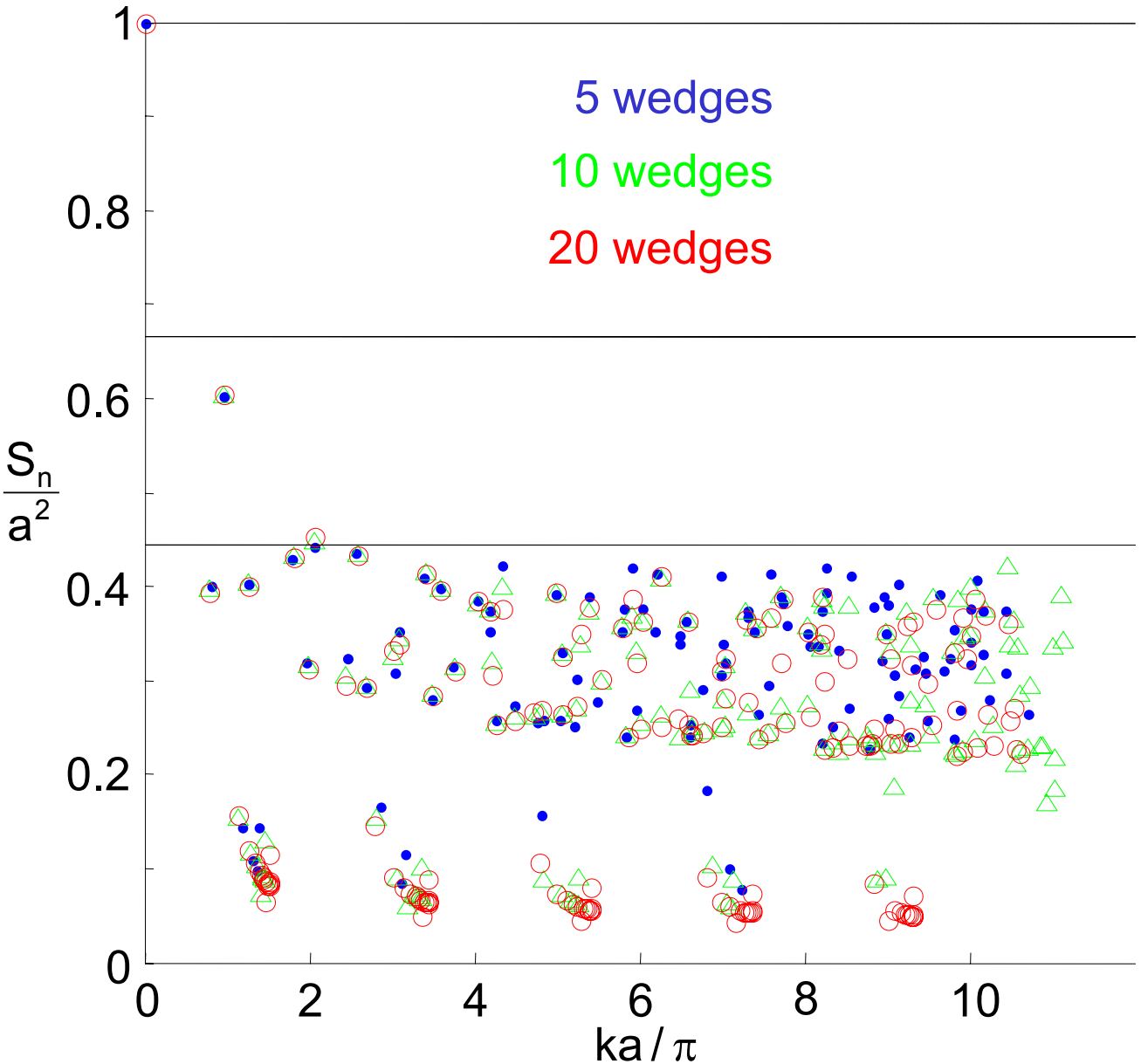




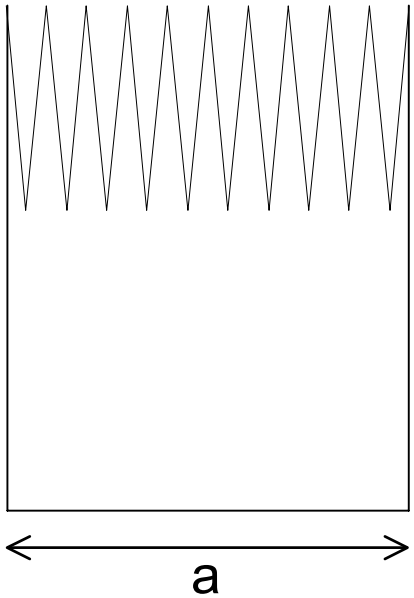
[Hébert *et al.*, J. Acoust. Soc. Am. **105**(3), 1567-1574 (1999).]

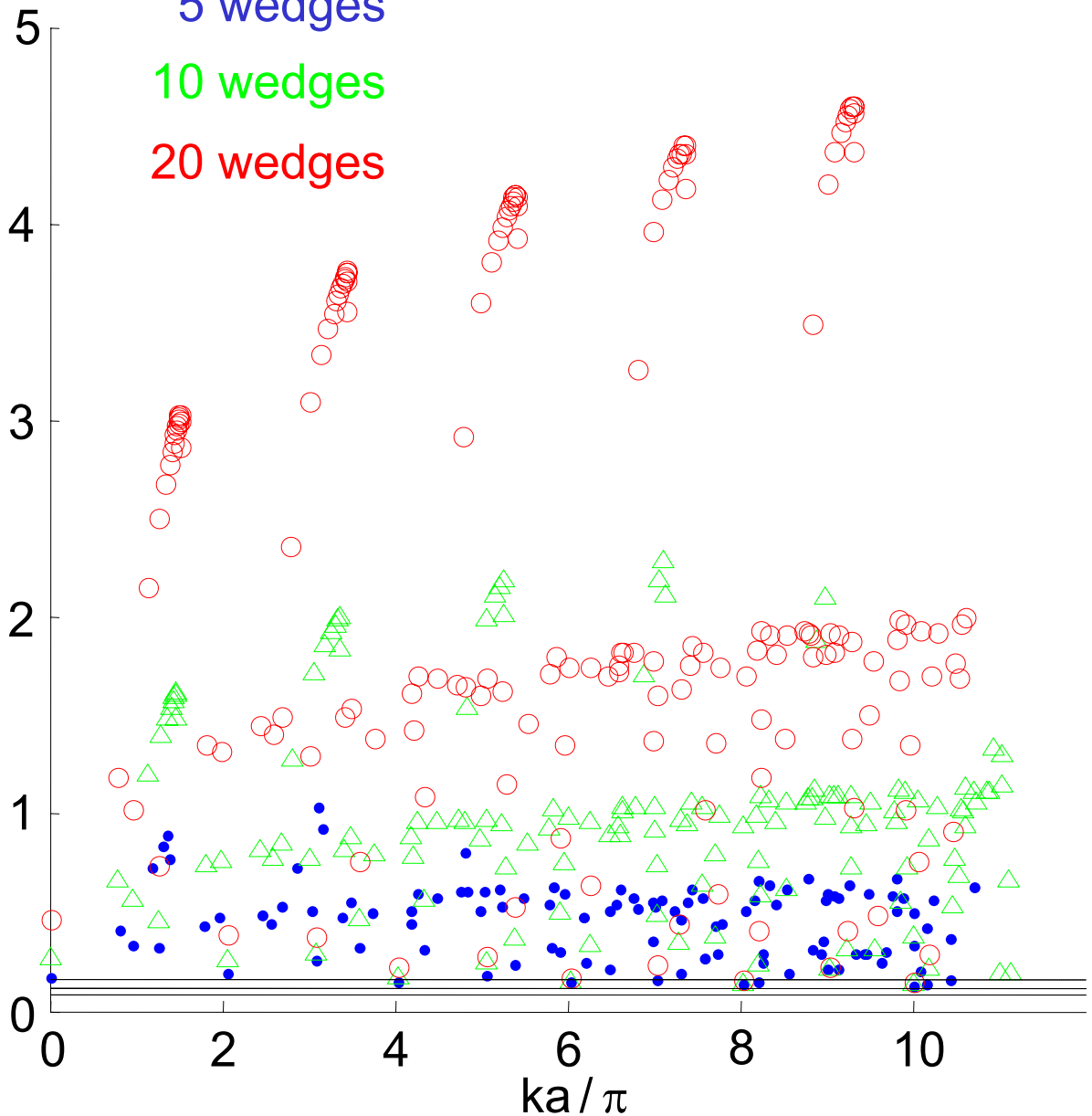
Localization in the cavity



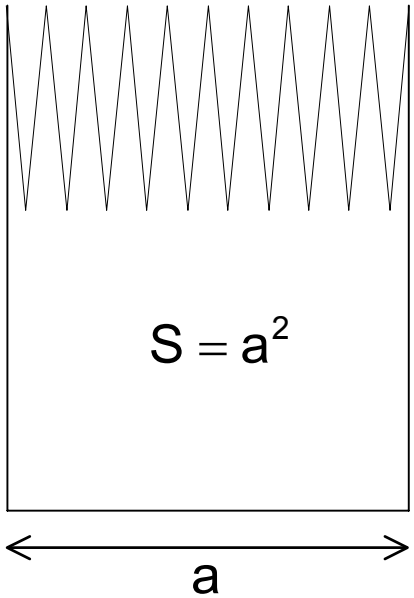


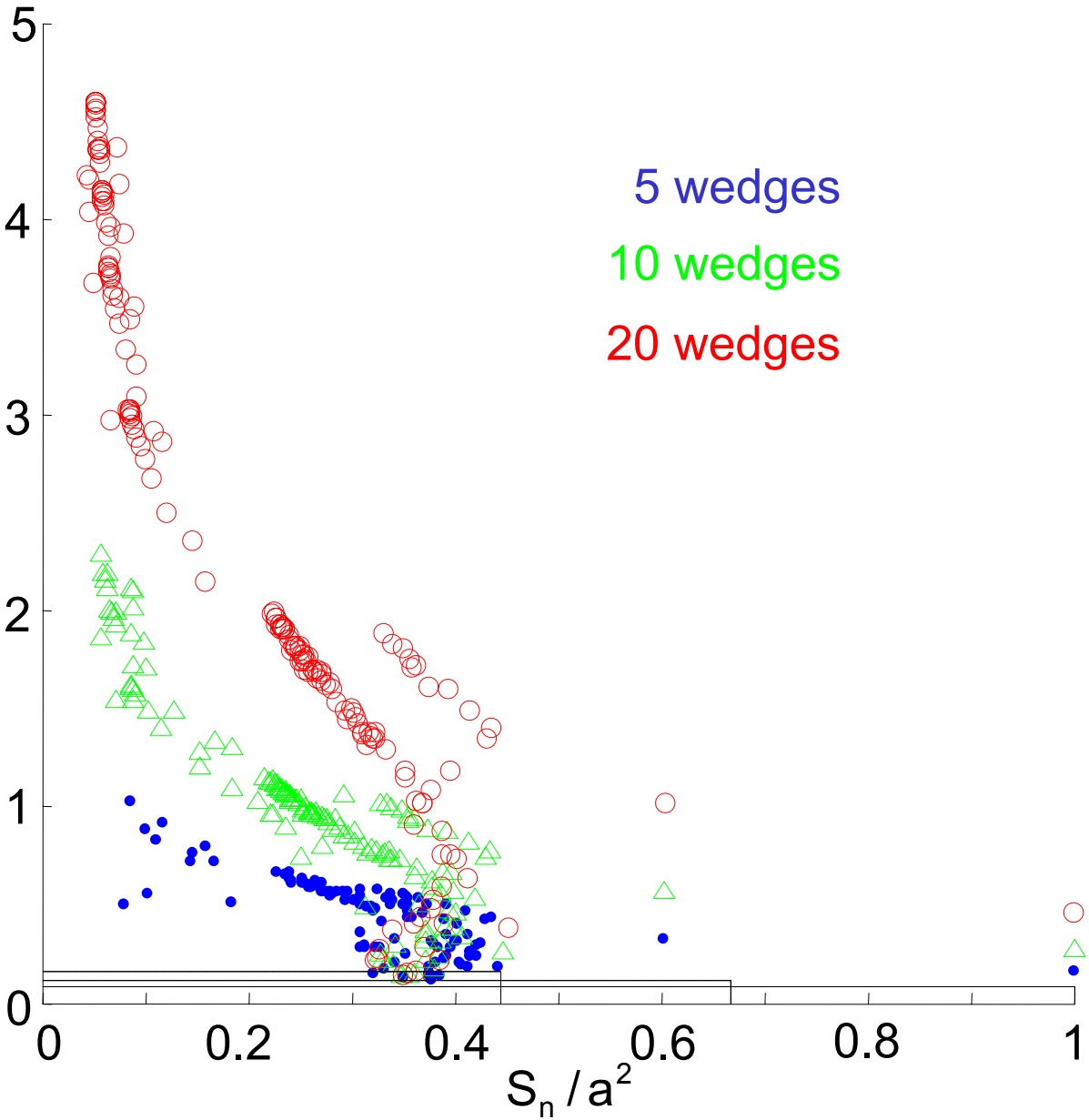
Losses in the cavity





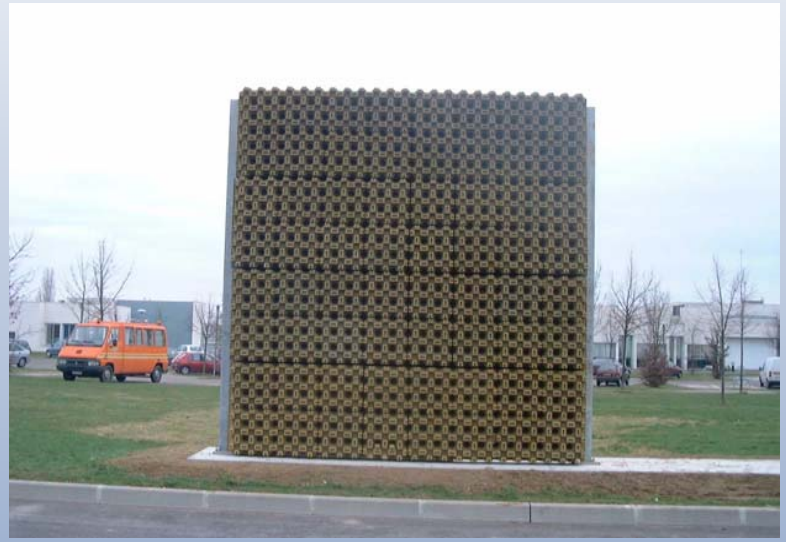
Losses vs Localization

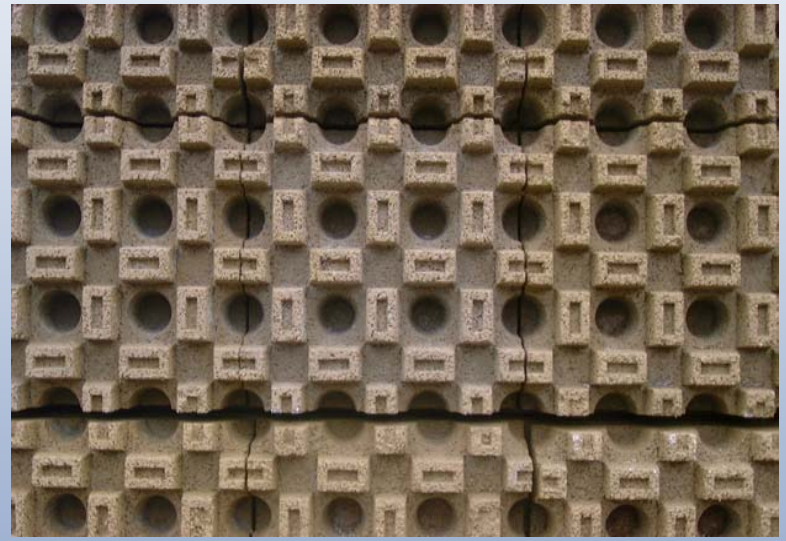




(pat.pend.)

Irregular noise barrier: « Fractal wall »

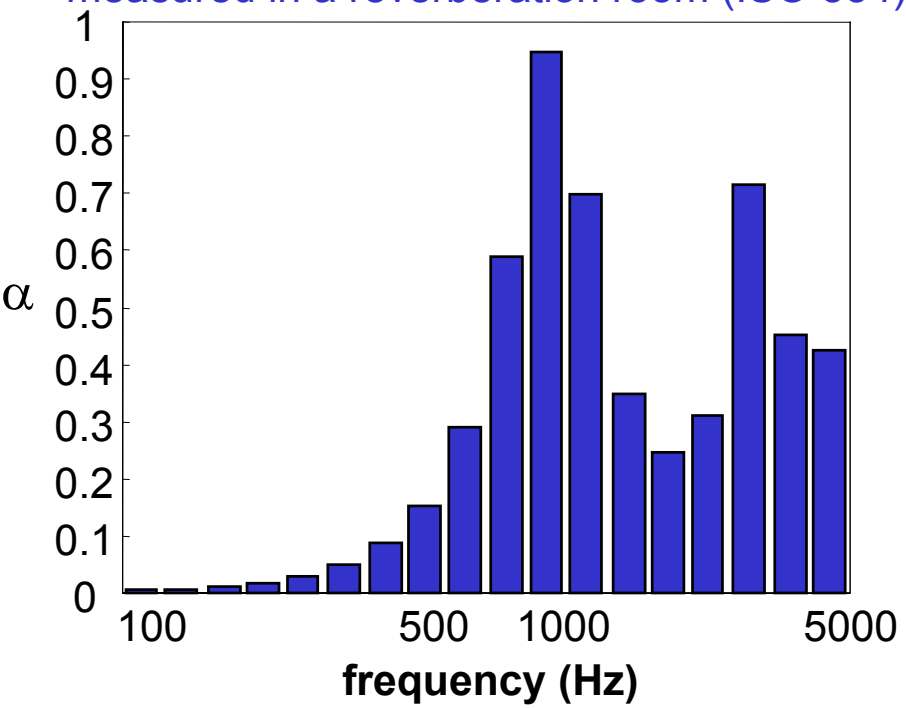




Test on Sound Absorption Performance: Standard EN 1793

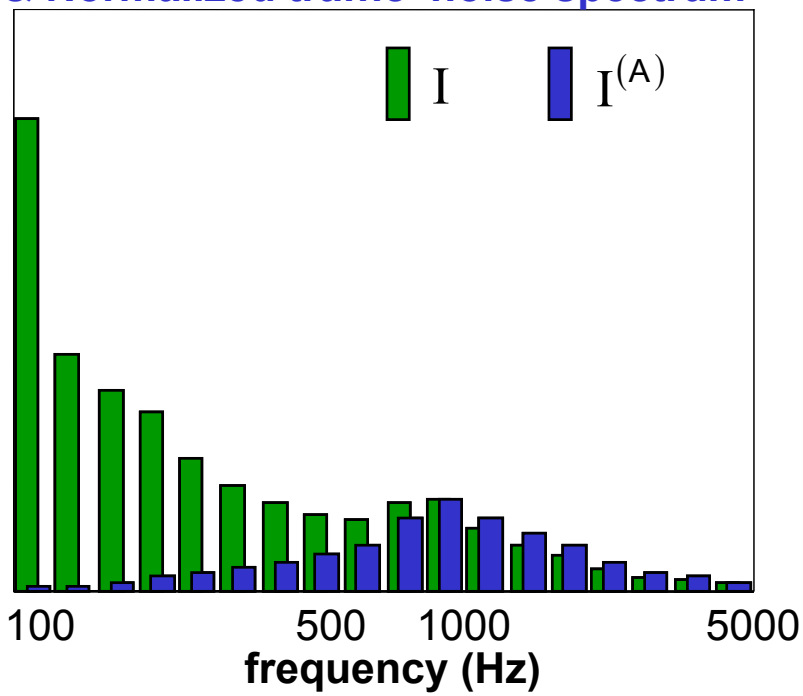
Absorption coefficient

measured in a reverberation room (ISO 354)



Traffic noise spectrum

& Normalized traffic noise spectrum



Single-number rating:

$$DL_\alpha = -10\log_{10}\left(1 - \frac{\sum_i \alpha_i I_i^{(A)}}{\sum_i I_i^{(A)}}\right)$$

« Fractal wall »:

$DL_\alpha = 17\,dB(A)$

(best on the EU market: 11 dB(A))

Increased damping in irregular resonators

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