The full Brillouin gain calculation

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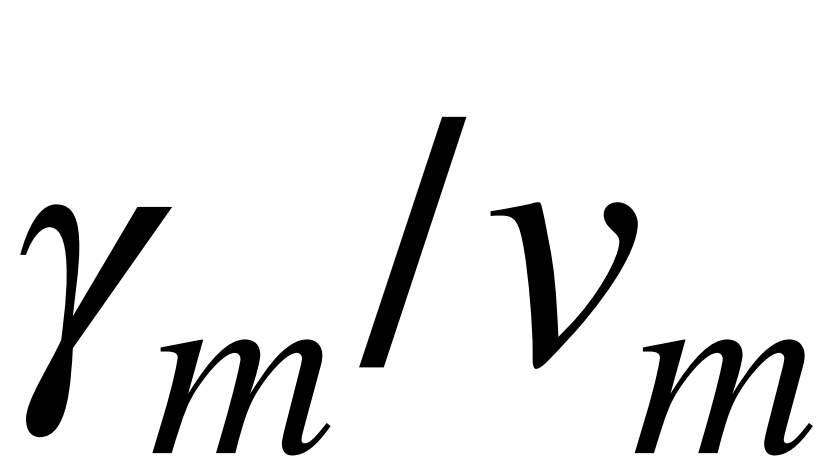
Wombat 2022, Erlangen, June 14th 2022. Gustavo Wiederhecker.

- Steady state:

- Lossy mechanical wave (large

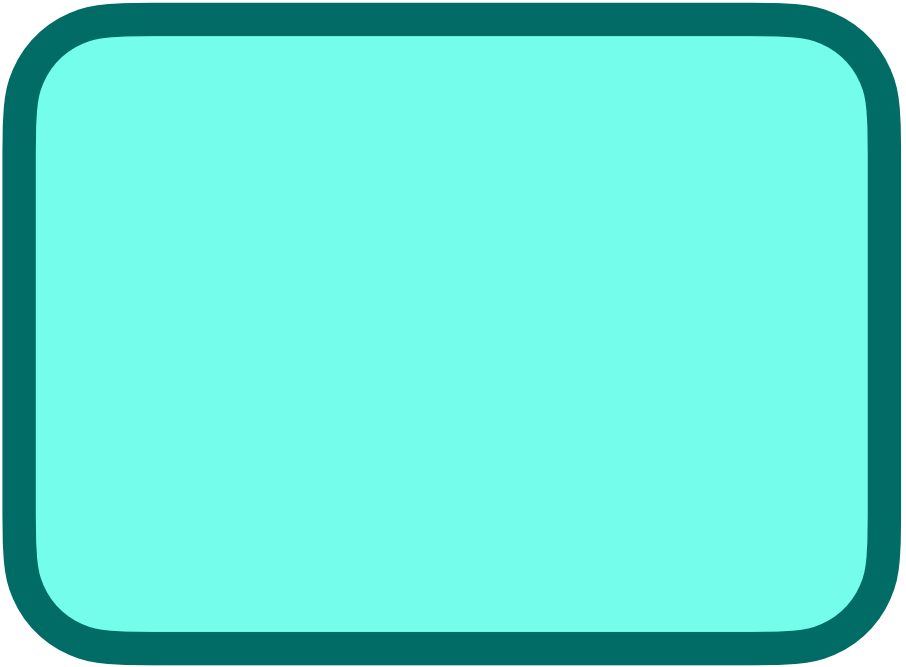
$$\partial_t = 0$$

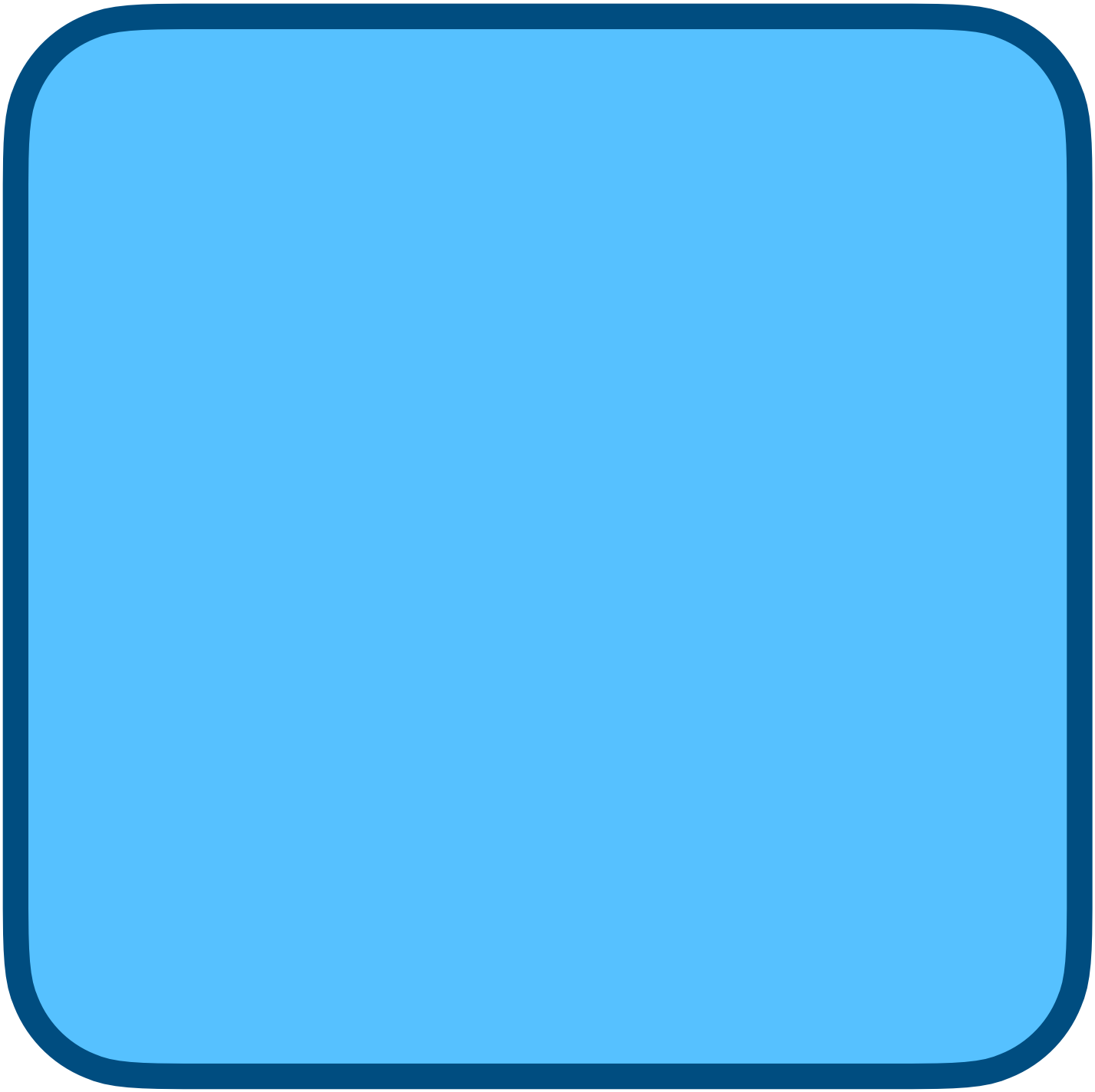


$$\partial_z P_p = -G_B P_p P_s - \alpha_p P_p$$

$$\partial_z P_s = \pm G_B P_p P_s \mp \alpha_s P_s$$

$$G_B(\Omega) = Q_m \frac{2\omega_p \mathscr{L}(\Omega)}{\bar{m}_{\text{eff}} \Omega_m^2} \left| \int f_{\text{mb}}^{\text{wg}} dl + \int f_{\text{pe}}^{\text{wg}} dA \right|^2$$





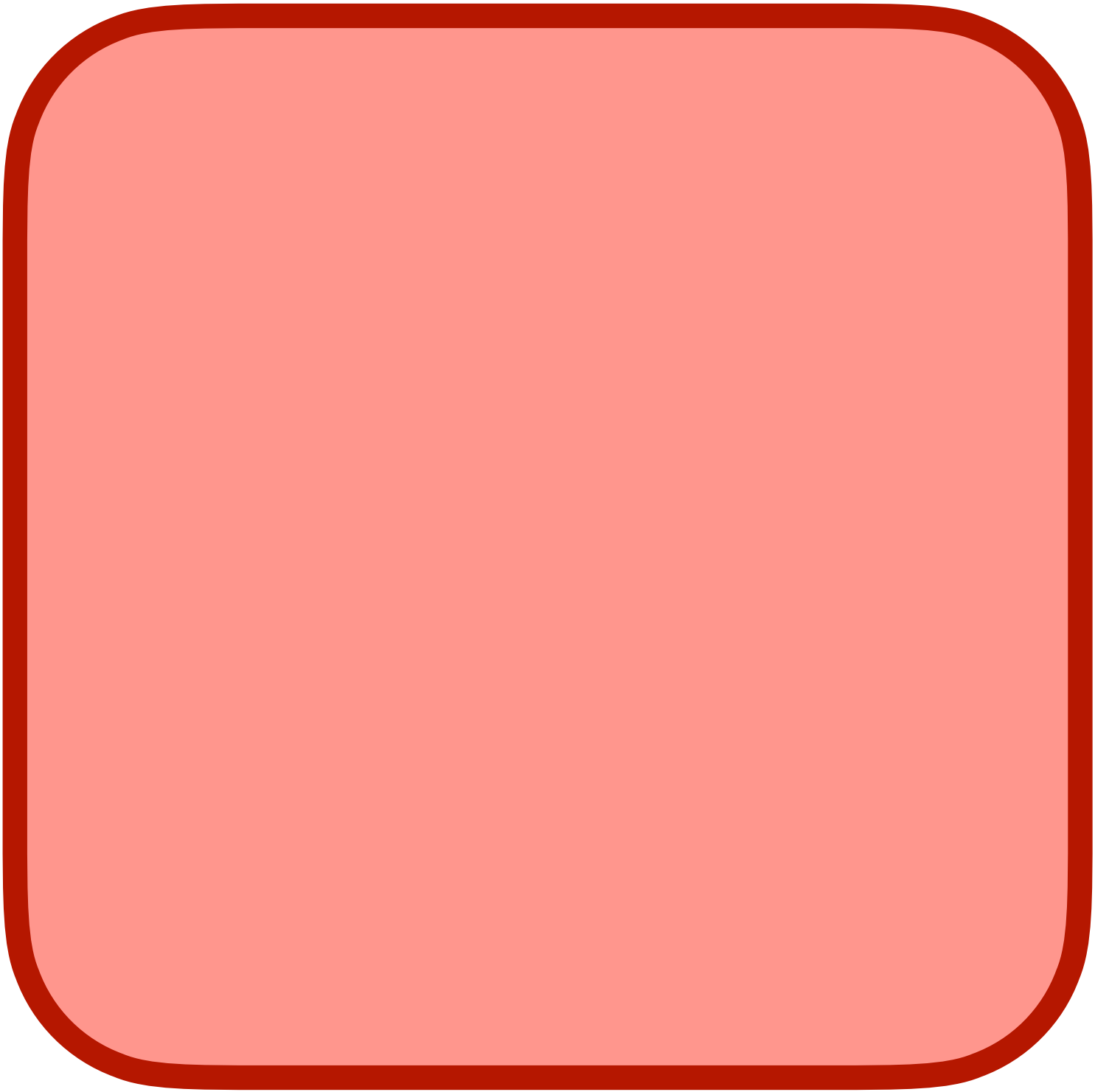
Lorentzian


lineshape


Overlap (MB)

$$\bar{m}_{\text{eff}} = \frac{1}{\max \left| \mathbf{u}_m \right|^2} \int \rho \left| \mathbf{u}_m \right|^2 dA$$

Overlap (PE)



1. Wiederhecker, G. S., Dainese, P. & Alegre, T. P. M. Brillouin optomechanics in nanophotonic structures. APL Photonics 4, (2019).

Effective mass

$$N_{\mathrm{i}}^{\mathrm{wg}} = \left(2\Re \left(\int \mathbf{E}_{\mathrm{i}} \times \mathbf{H}_{\mathrm{i}}^{*} \cdot \hat{z} dA \right) \right)^{1/2}$$

$$N_{\mathrm{i}}^{\mathrm{cav}} = \left(\varepsilon_0 \int \varepsilon \left| \mathbf{E}_{\mathrm{i}} \right|^2 dV \right)^{1/2}$$

Overlap (MB)

Overlap (PE)

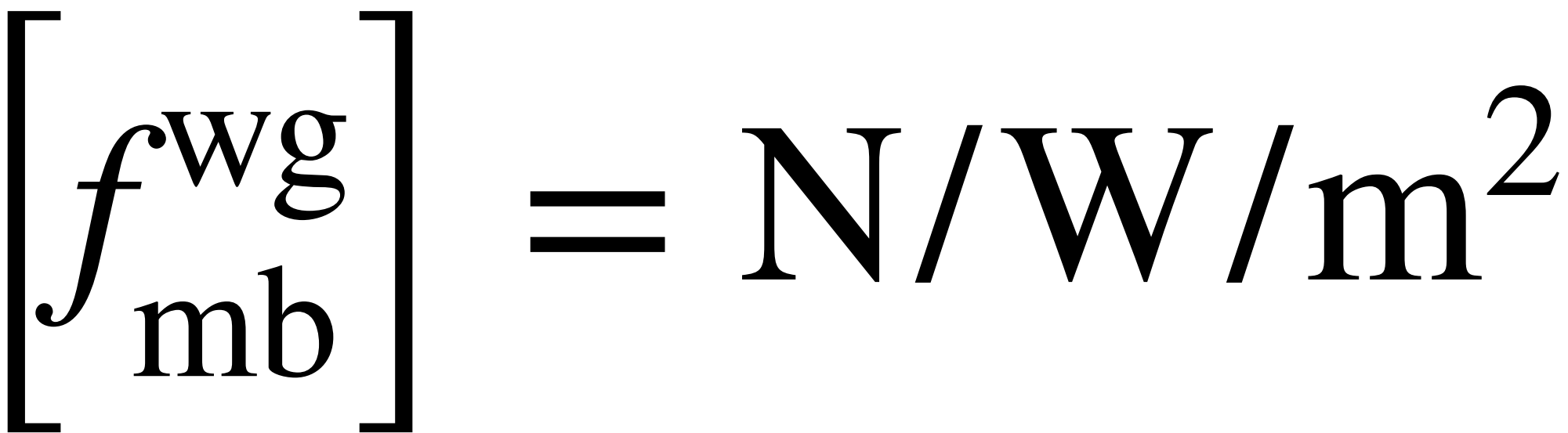
Mode normalization

Effective mass

$$f_{\mathrm{mb}}^{(\mathrm{wg})} = \frac{\mathbf{u}^* \cdot \hat{n} \left(\delta\varepsilon_{\mathrm{mb}} \mathbf{E}_{\mathrm{p},\parallel}^* \cdot \mathbf{E}_{\mathrm{s},\parallel} - \delta\varepsilon_{\mathrm{mb}}^{-1} \mathbf{D}_{\mathrm{p},\perp}^* \cdot \mathbf{D}_{\mathrm{s},\perp} \right)}{\max(|\mathbf{u}|) N_{\mathrm{p}}^{(\mathrm{wg})} N_{\mathrm{s}}^{(\mathrm{wg})}}$$

$$f_{\mathrm{pe}}^{(\mathrm{wg})}=\frac{\mathbf{E}_{\mathrm{p}}^{*}\cdot\delta\boldsymbol{\varepsilon}_{\mathrm{pe}}^{*}\cdot\mathbf{E}_{\mathrm{s}}}{\max(|\mathbf{u}|)N_{\mathrm{p}}^{(\mathrm{wg})}N_{\mathrm{s}}^{(\mathrm{wg})}}$$

$$\left[f_{\mathrm{pe}}^{\mathrm{wg}} \right] = \mathbf{N/W/m^3}$$



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