On computing the physical sources of jet noise

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Introduction

Objective

To understand the physical sources of jet noise.

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Motivation

- By-pass ratio is limited
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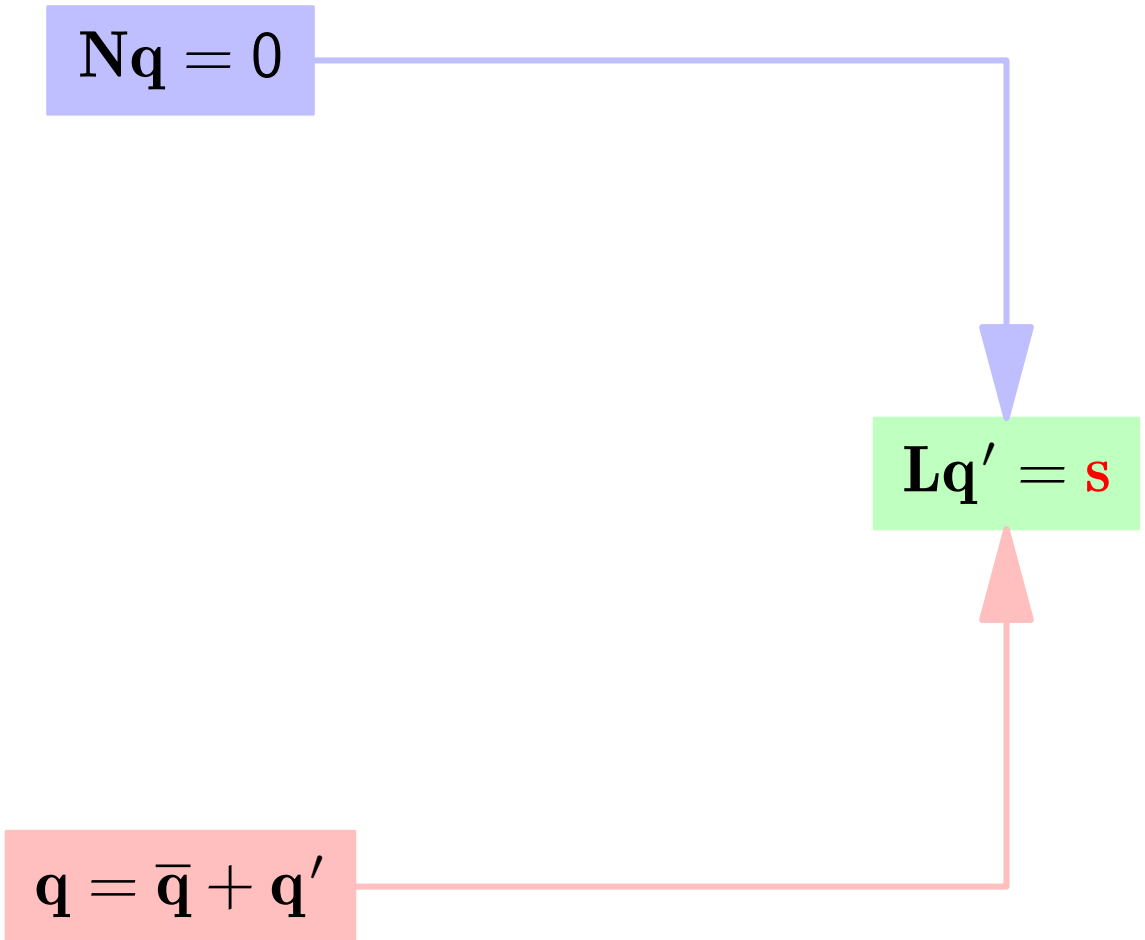
Methods

- Goldstein's theory
- Direct Numerical Simulation

Part I

Theory

Sources definition



Sources definition

Physical sound sources

$$f_i = -\frac{\partial}{\partial x_j}\left(\overline{\rho}\,\widetilde{v_i}\widetilde{v_j}\right)' \tag{1}$$

$$\widetilde{v_i} = \overline{\rho v_i}/\overline{\rho}$$

Flow decomposition

Space-time domain

$$\overline{\mathrm{q}} = w * \mathrm{q}$$

Wavenumber-frequency domain

$$\overline{\mathrm{Q}} = W \times \mathrm{Q}$$

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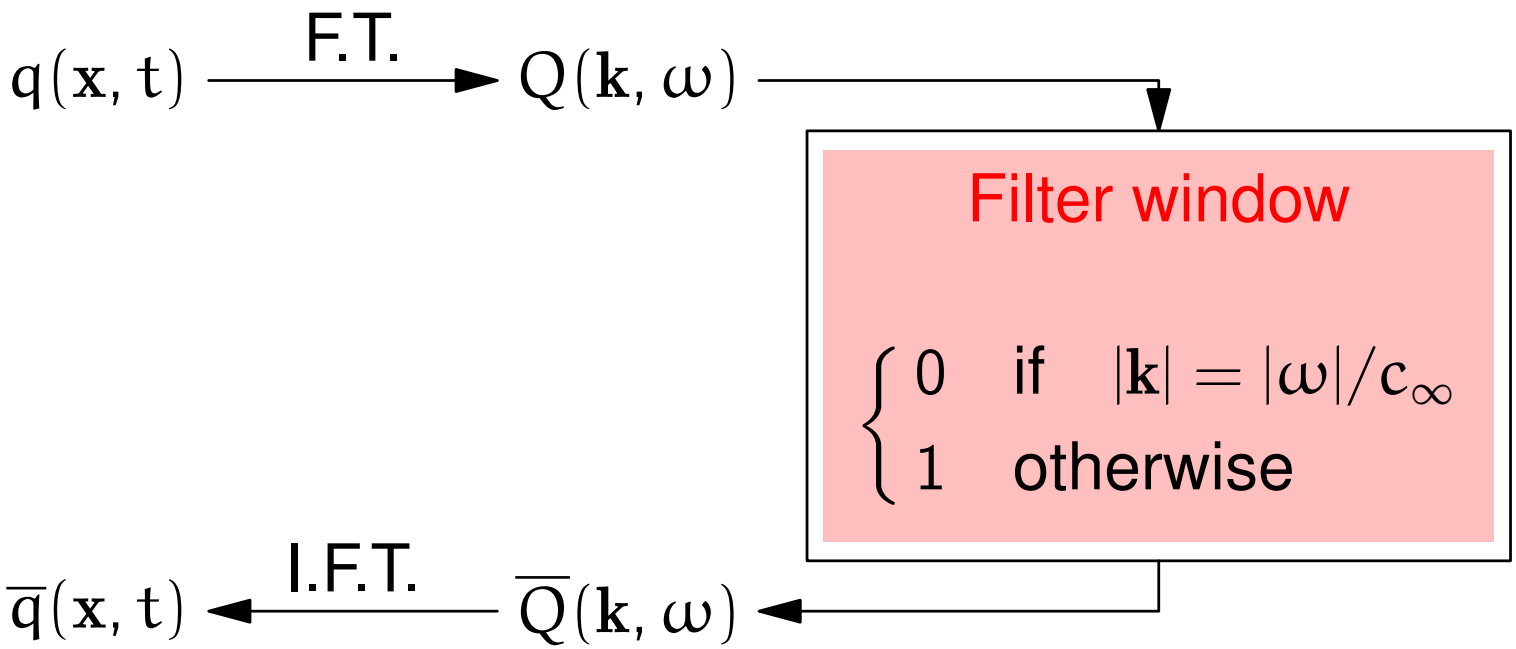
Wavenumber-frequency domain

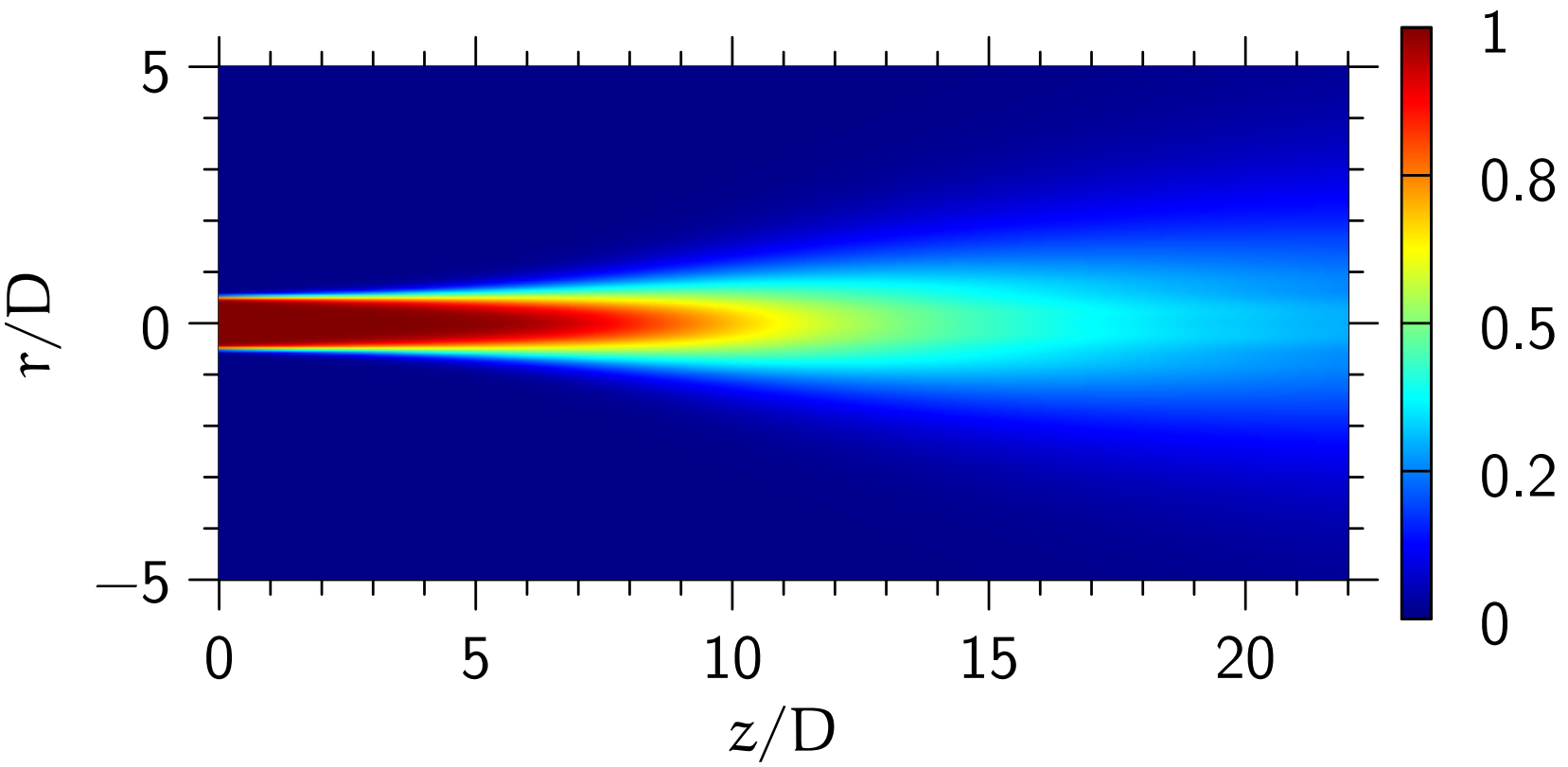
$$\overline{Q} = W \times Q$$



Part II

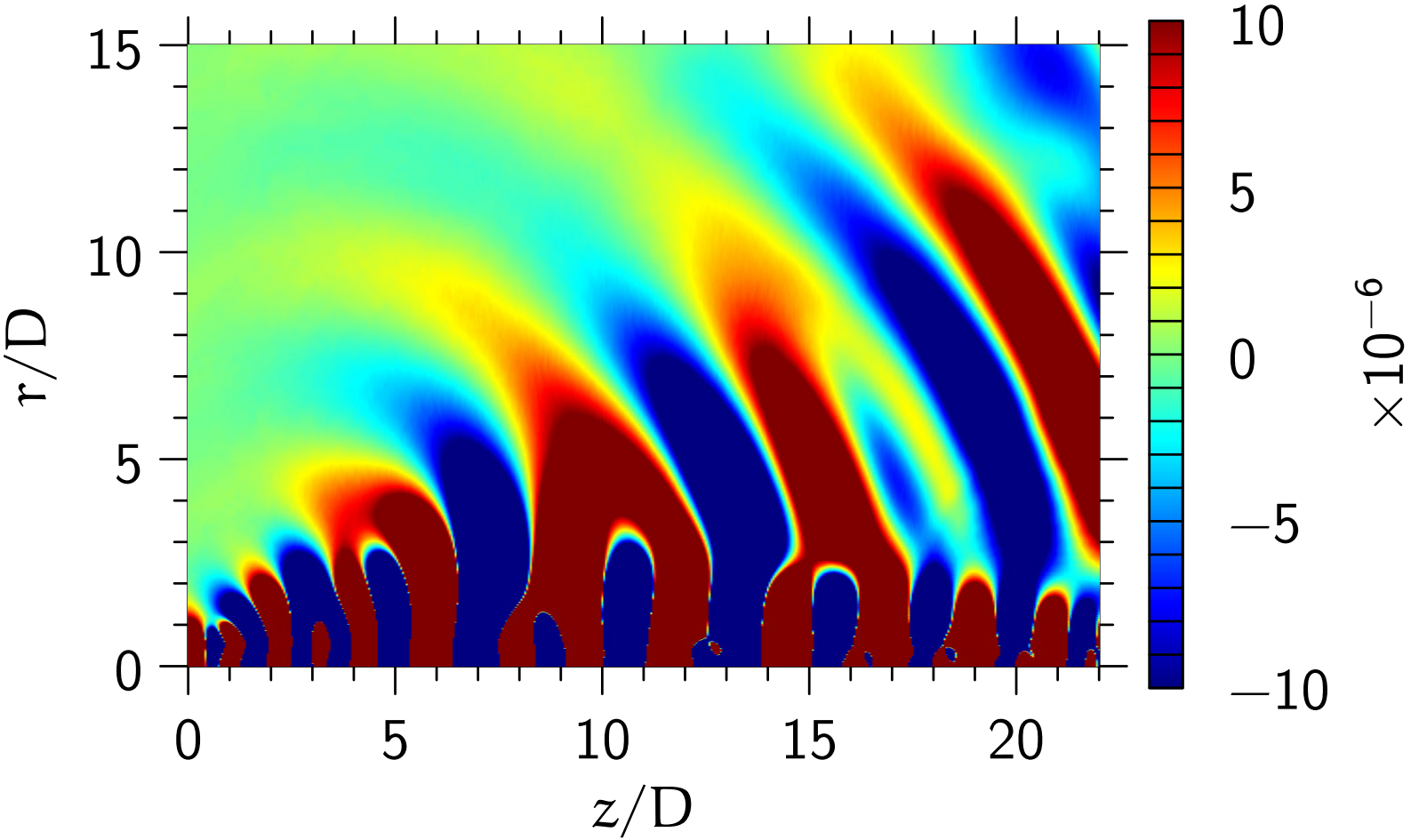
Numerical experiment

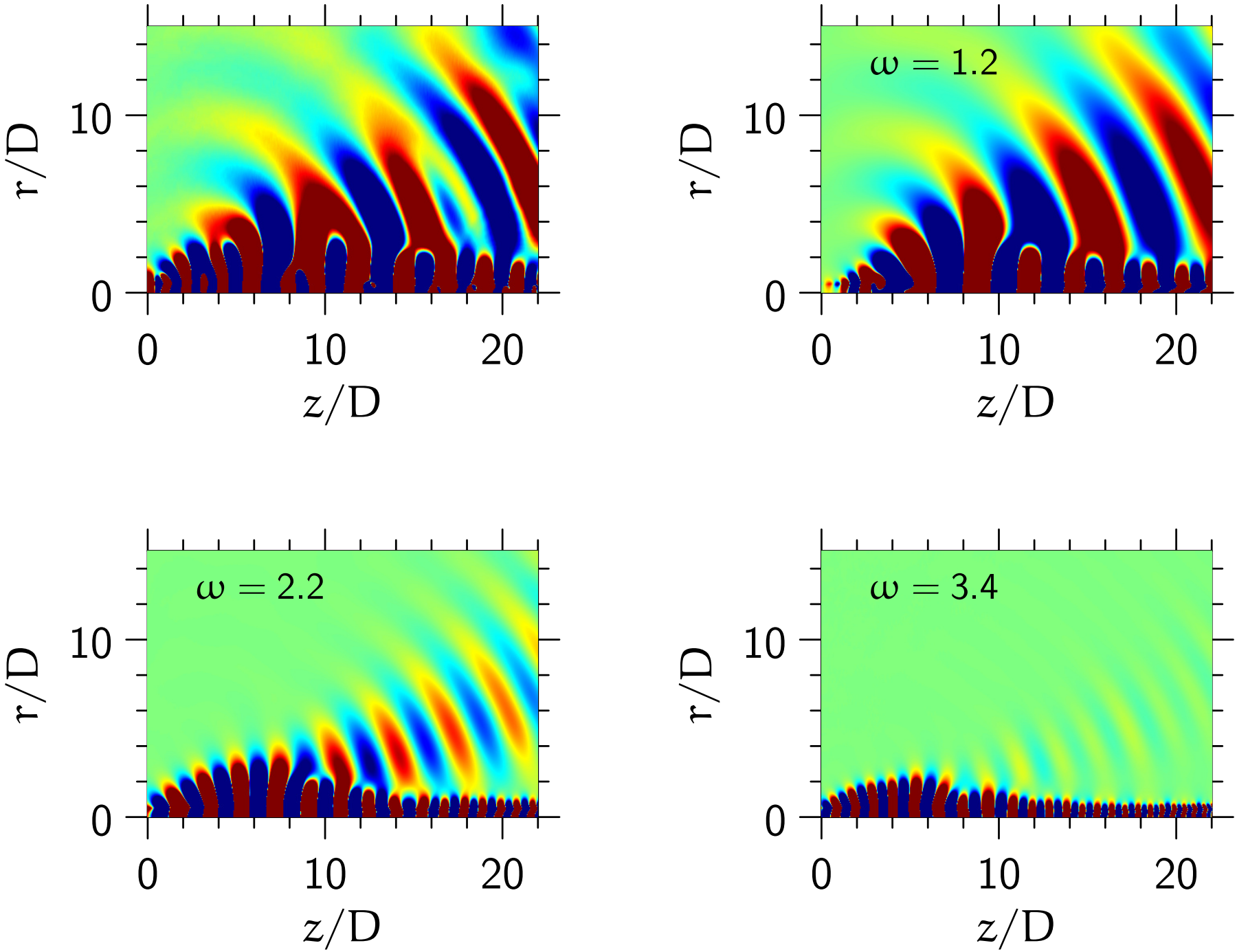
Mean flow



$\omega_1 = 2.2$ $\omega_2 = 3.4$

Pressure snapshot

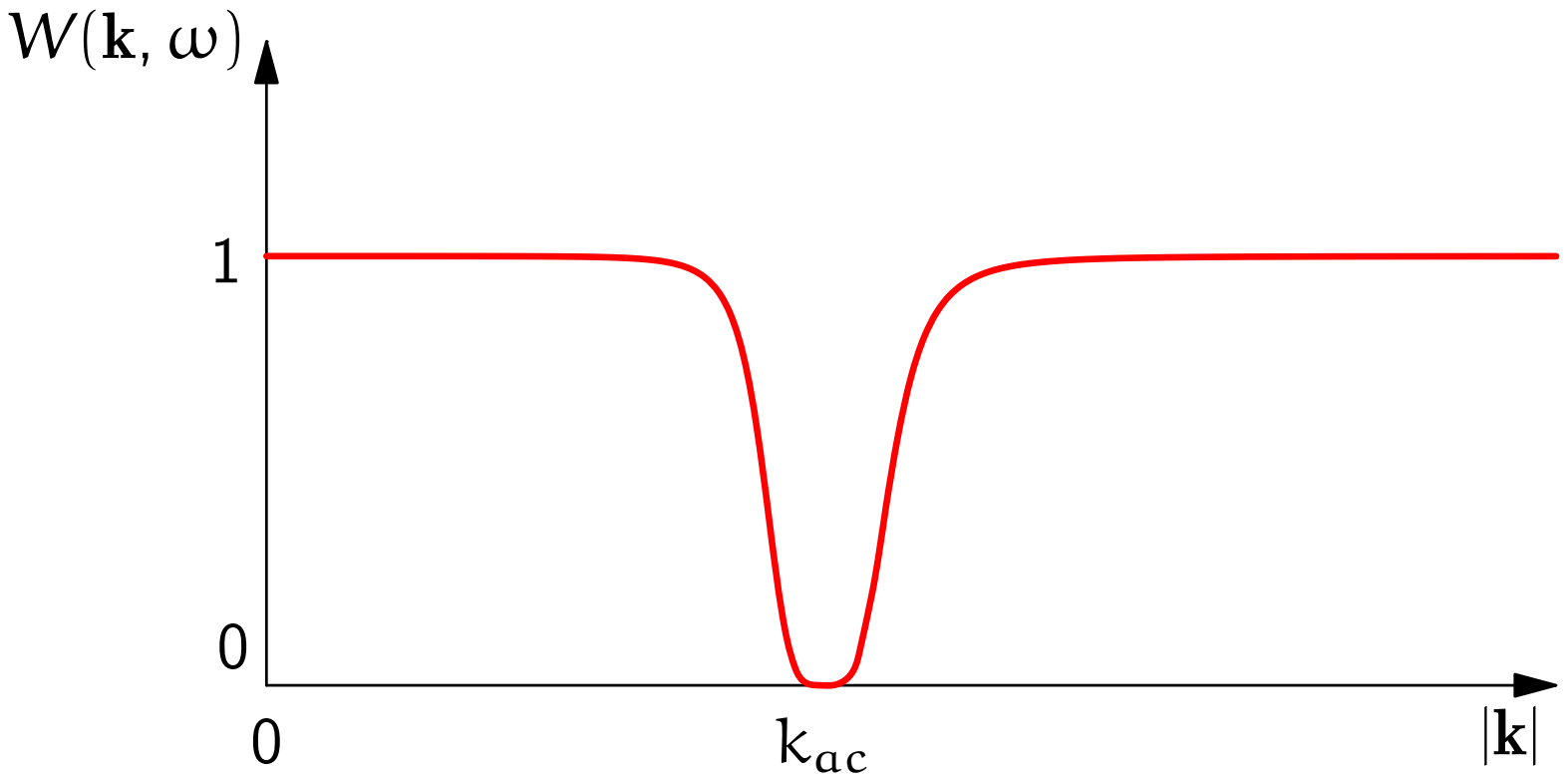



r/D
z/D
0
10
20
ω = 1.2
ω = 2.2
ω = 3.4

Flow decomposition

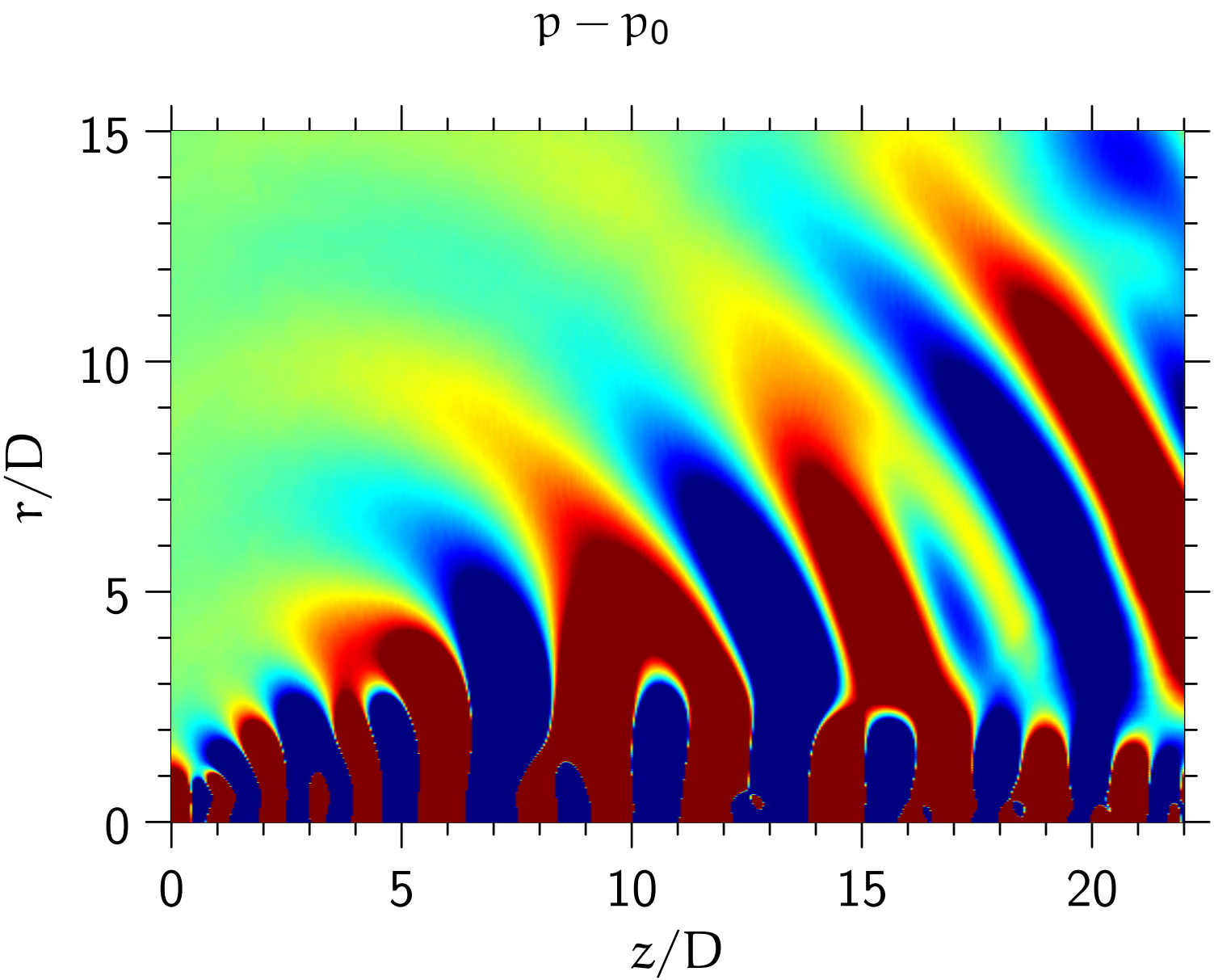
Filter definition

$$k_{ac} = \Delta\omega / c_\infty$$



Flow decomposition

Results



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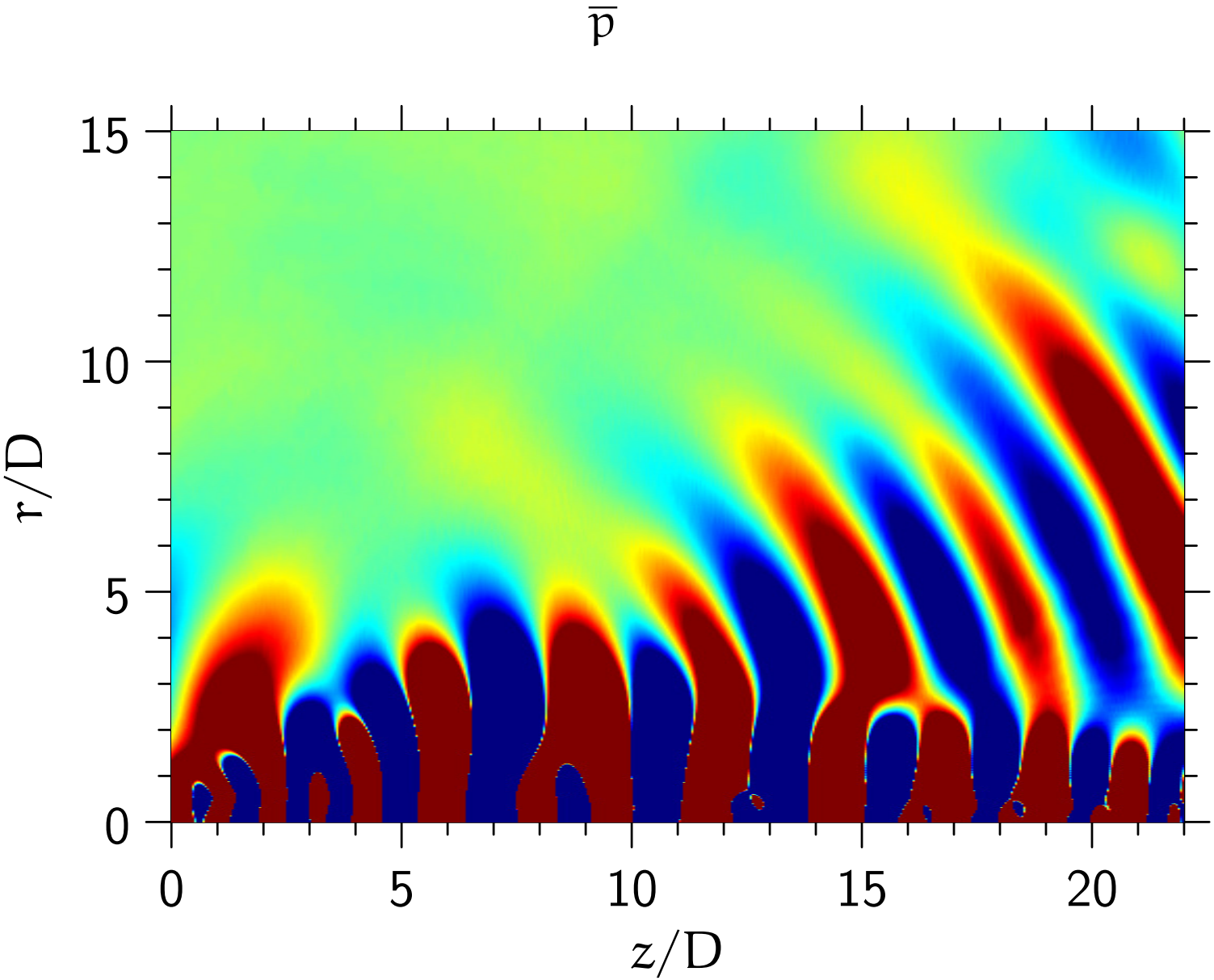

Flow decomposition

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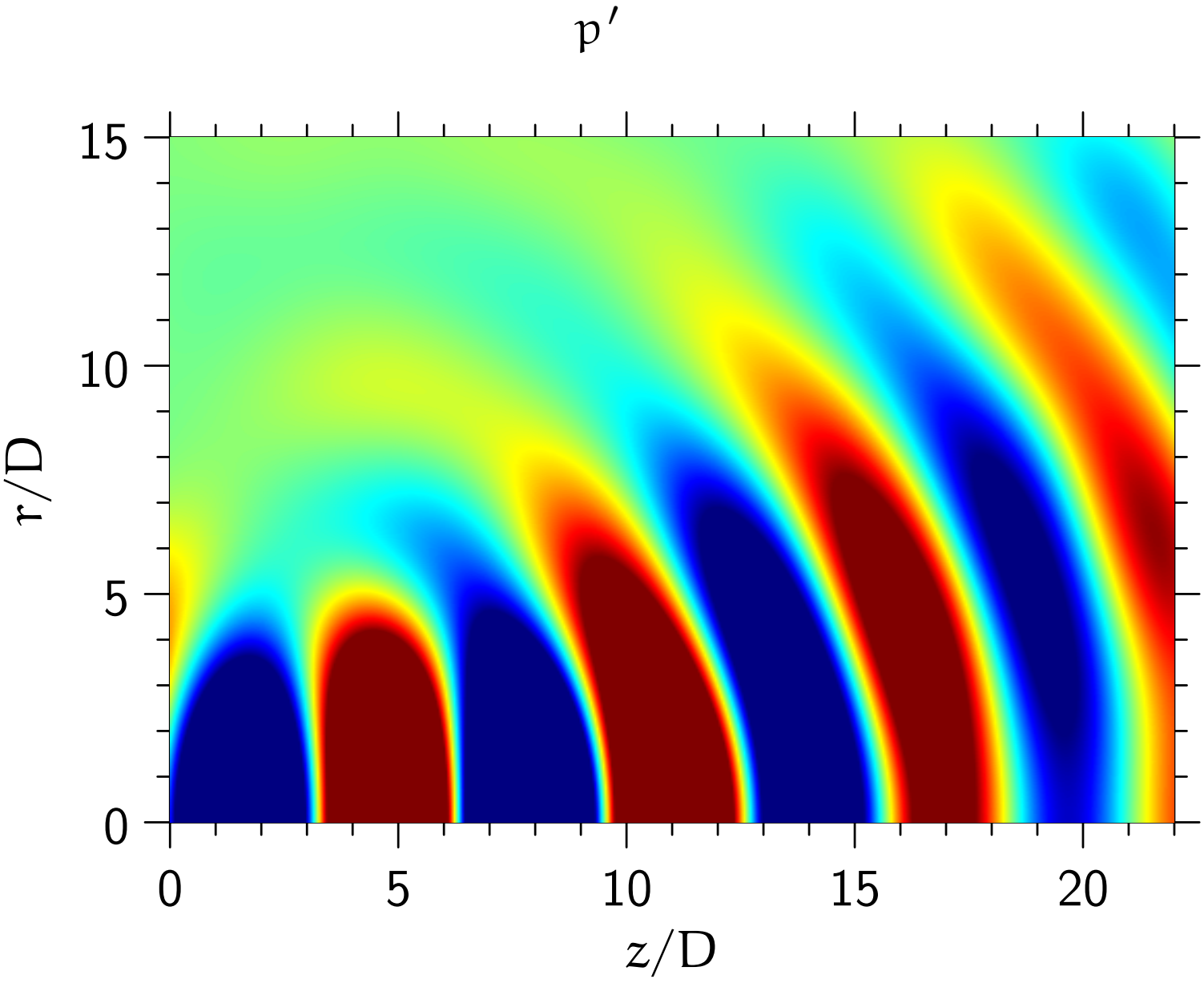
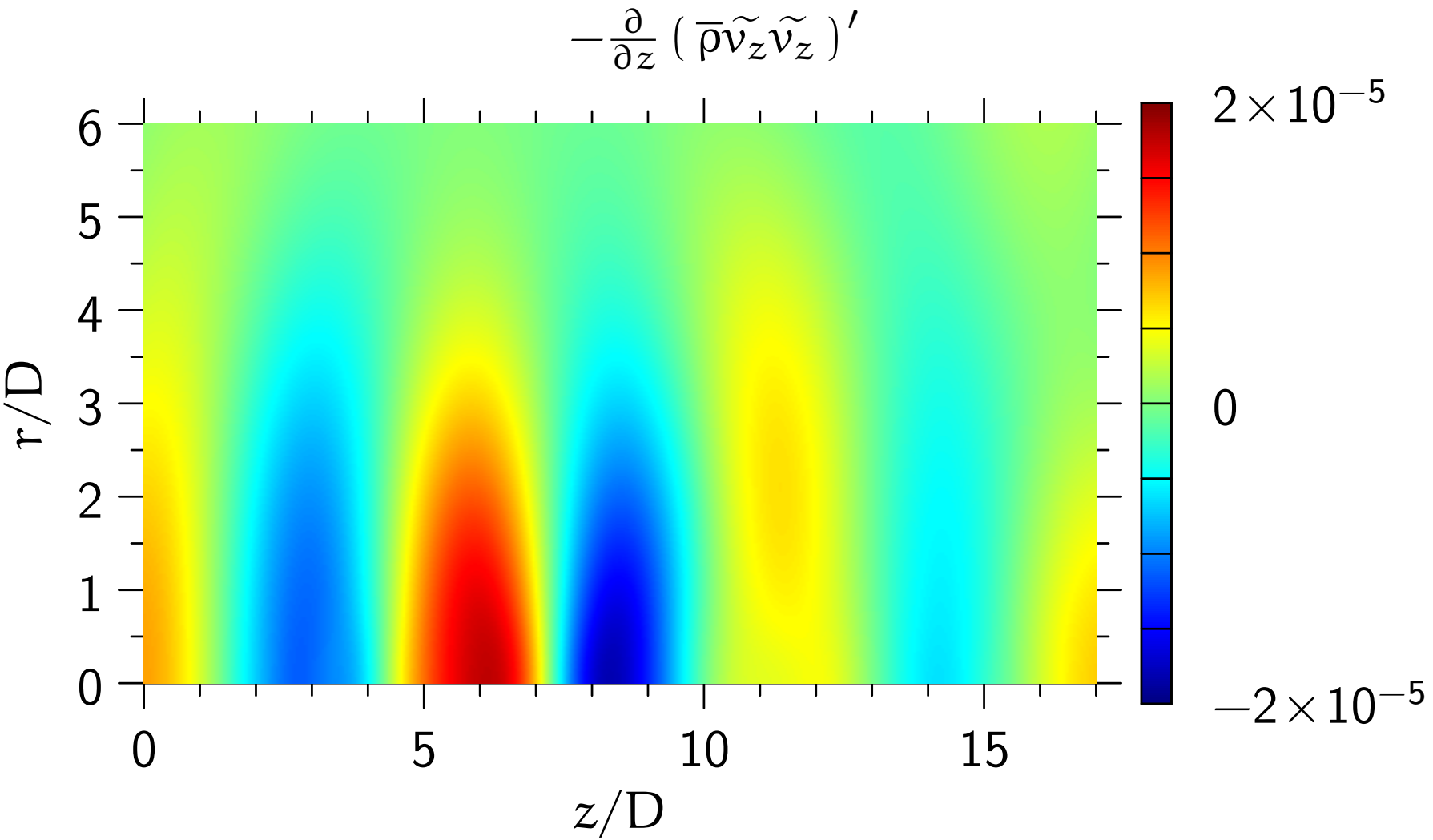


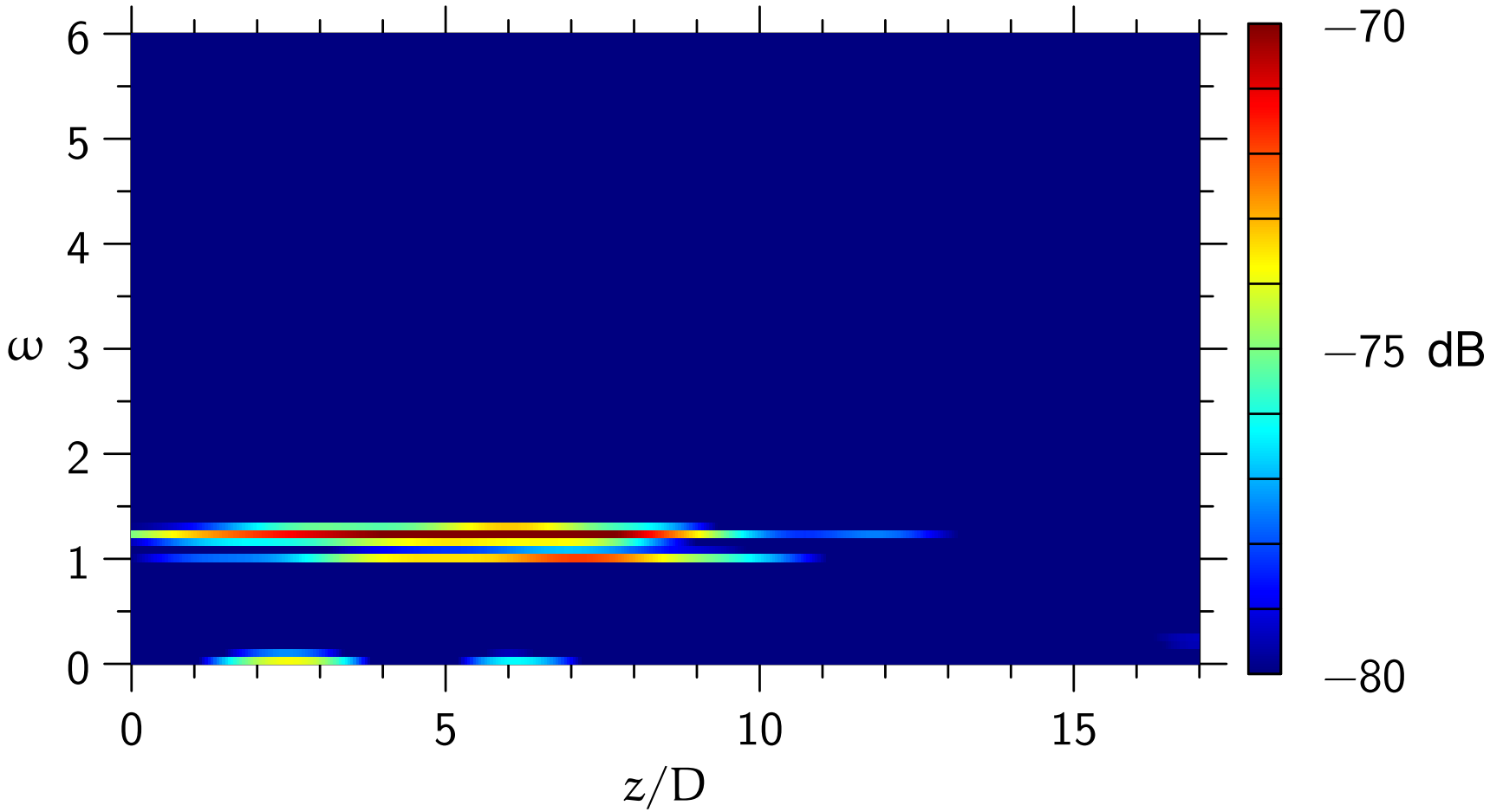
Sound sources

Snapshot

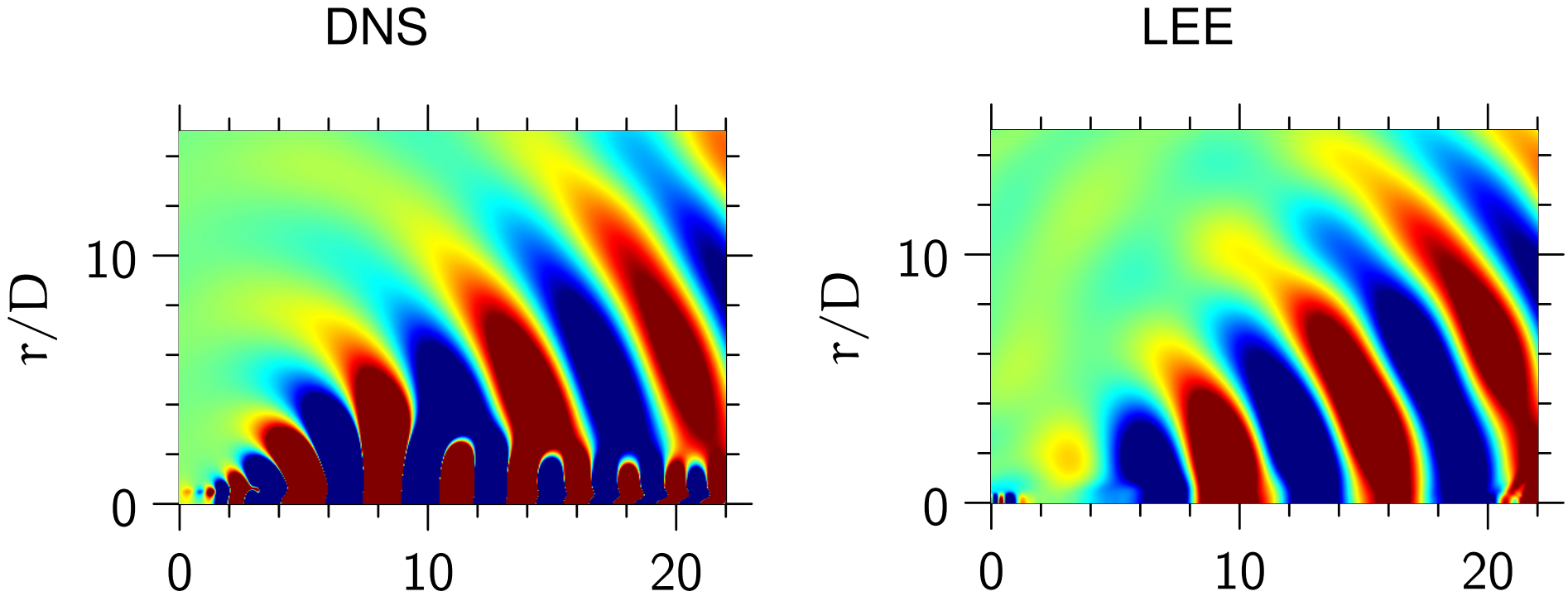


Sound sources

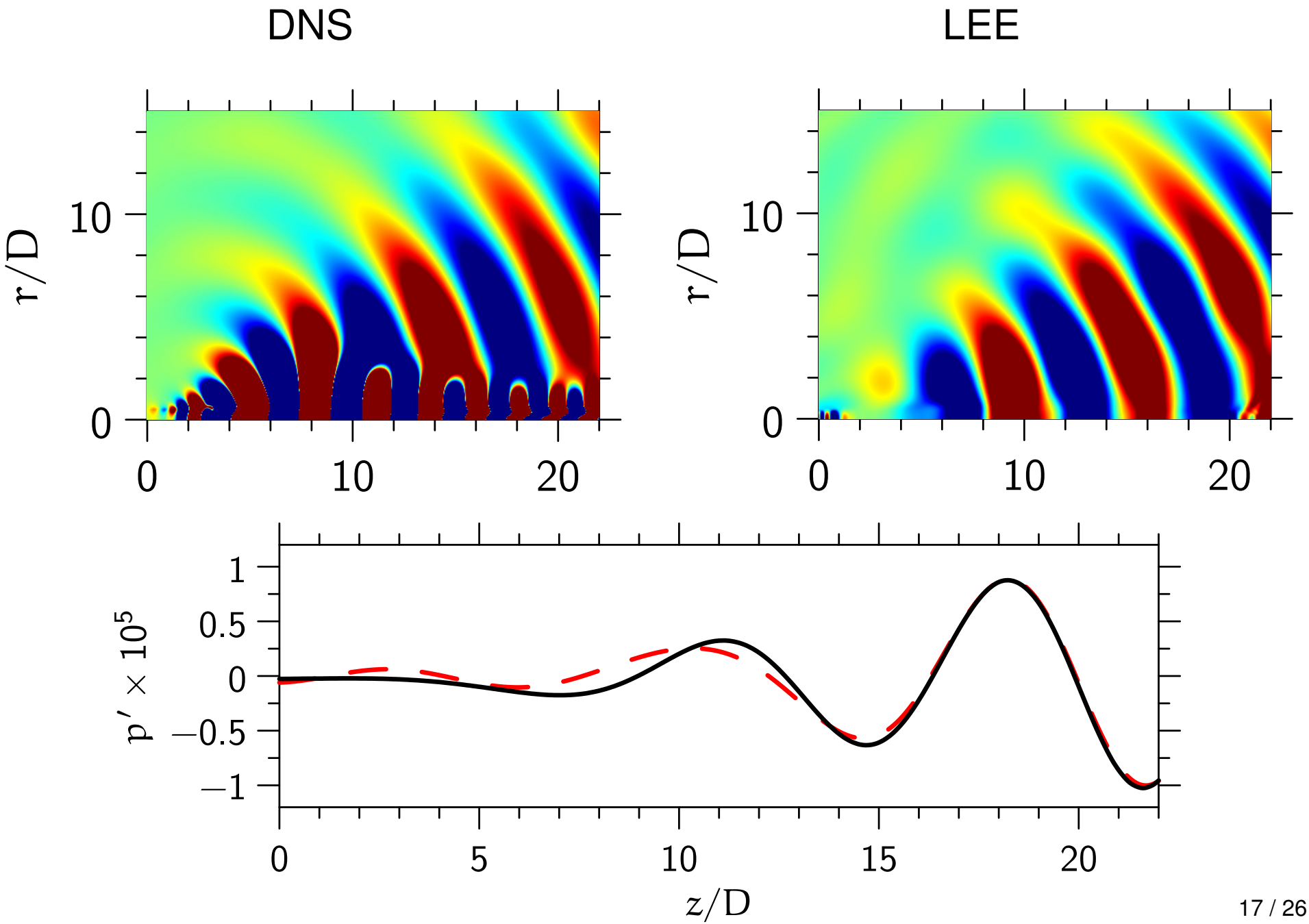
Power spectum density



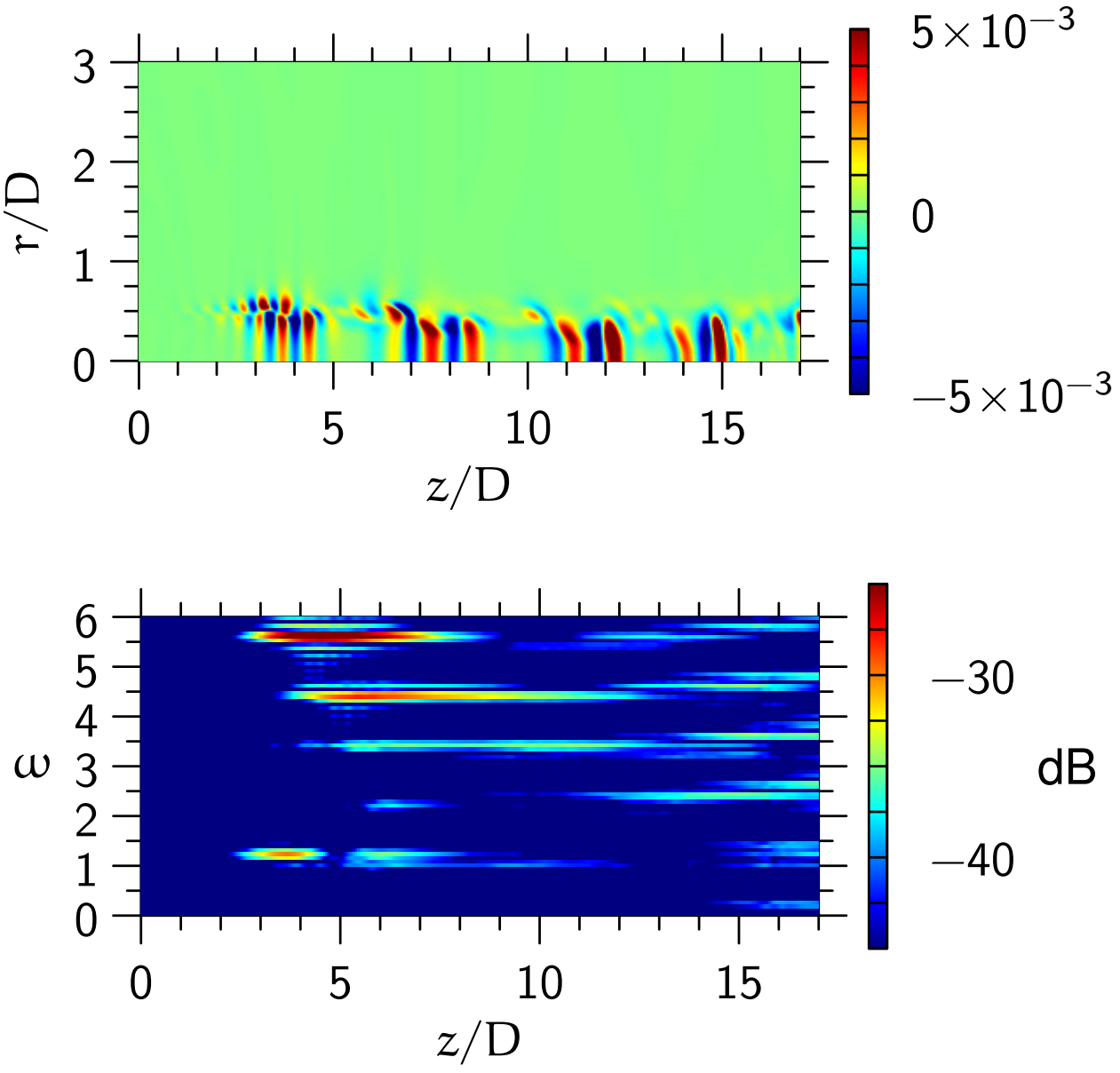
Validation



Validation



Acoustic analogy sources



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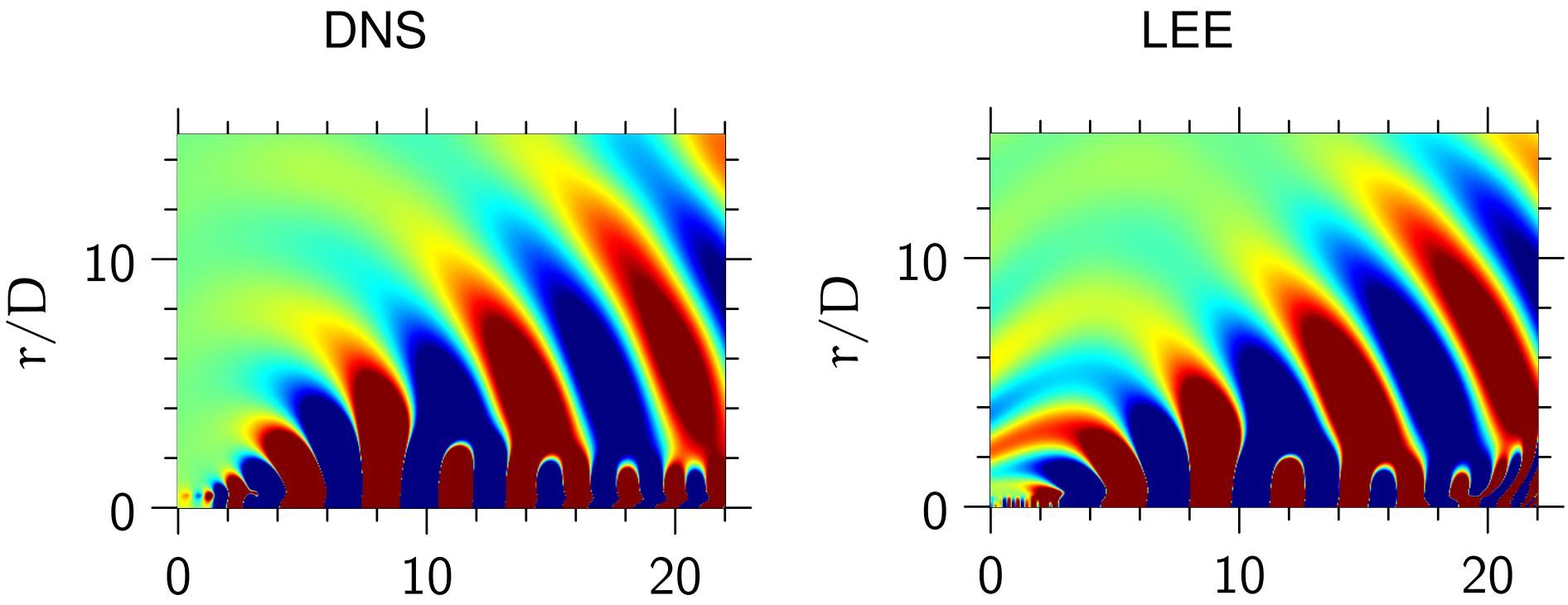

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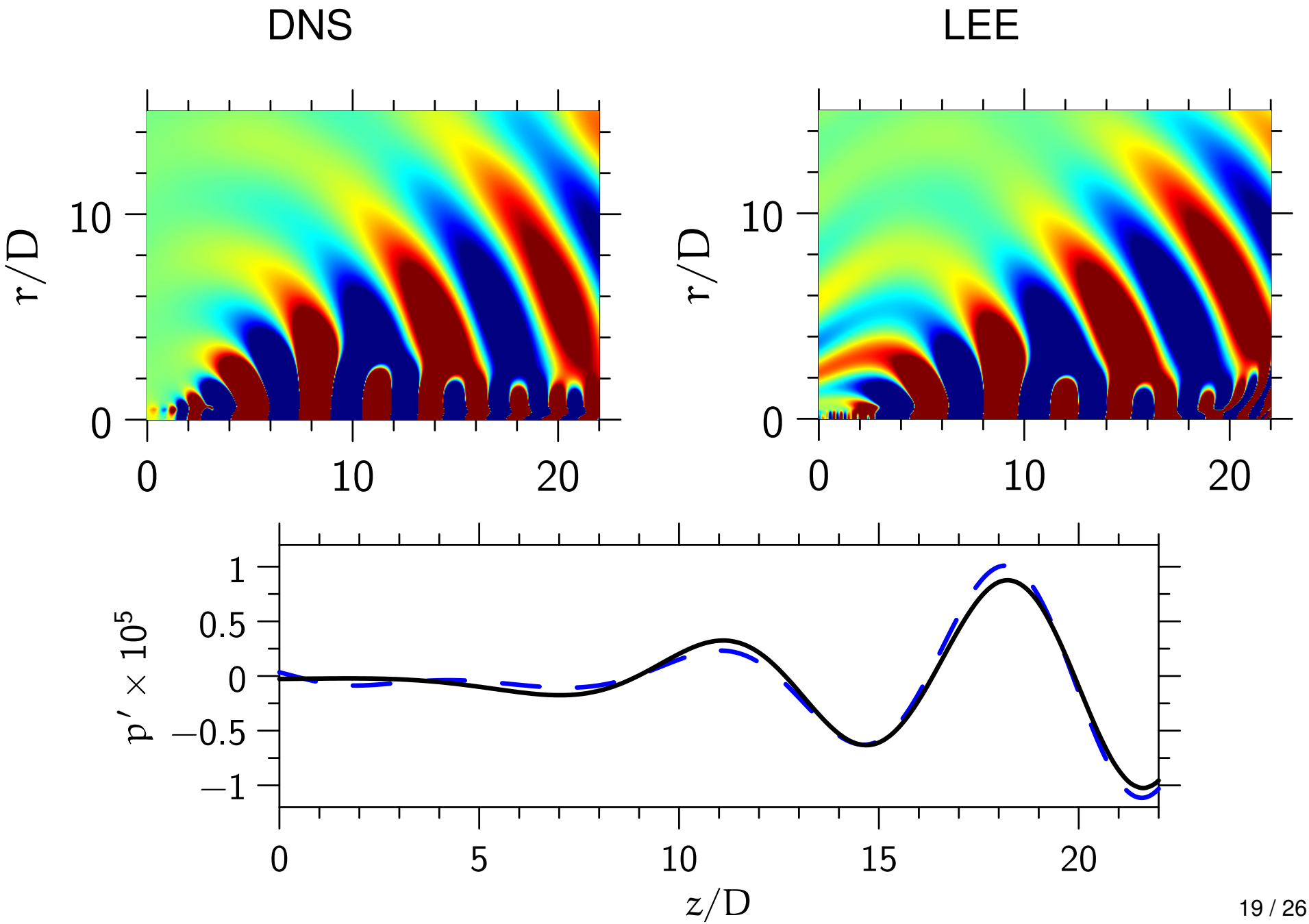

Conclusion

Results

- Use convolution filters
- Physical sound sources can be computed

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Future work

- Model the sound sources
- Understand the physical mechanisms

Acknowledgements

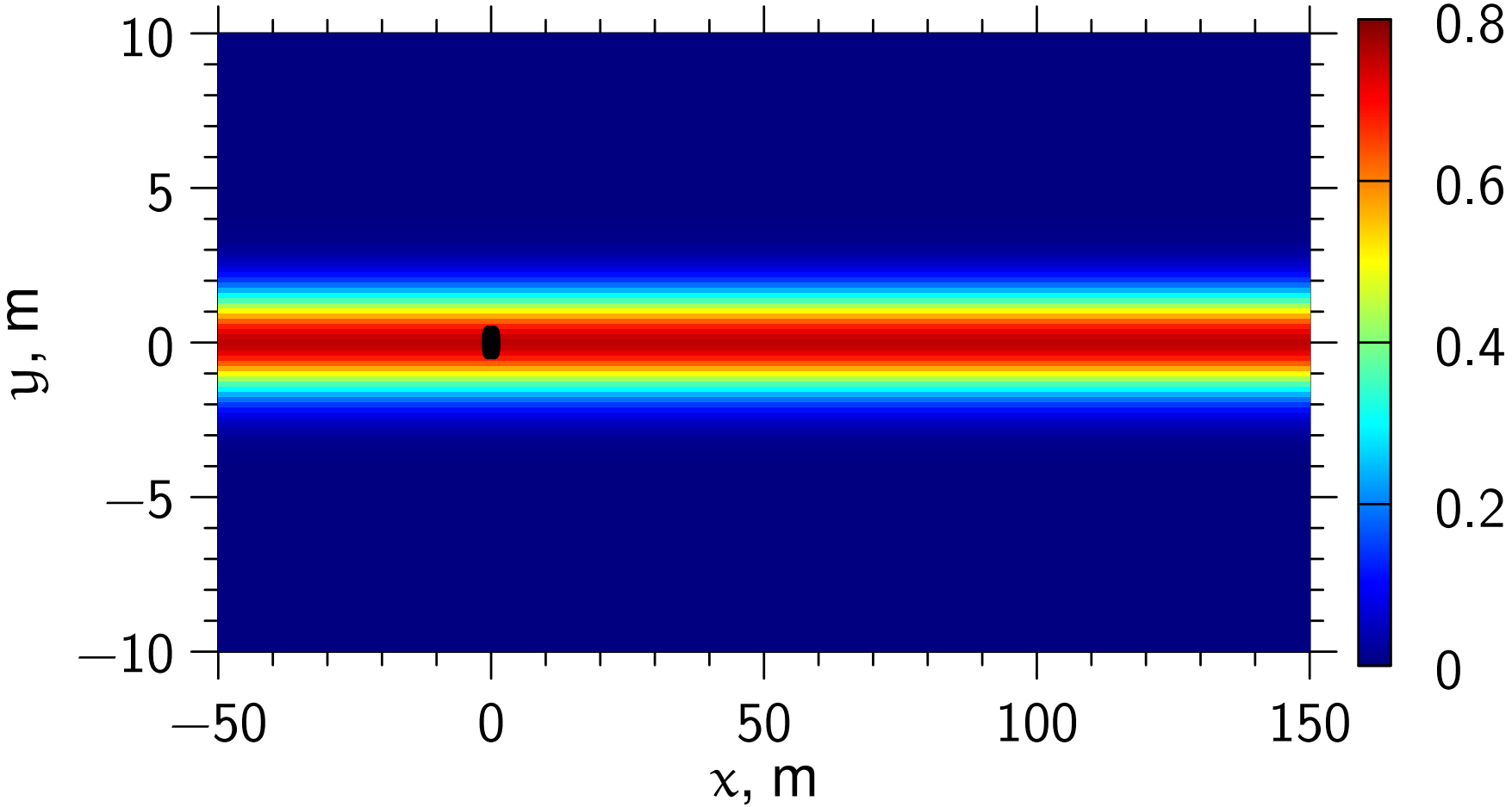
EPSRC
Engineering and Physical Sciences Research Council

ROLLS ROYCE
Rolls-Royce

Thank you!

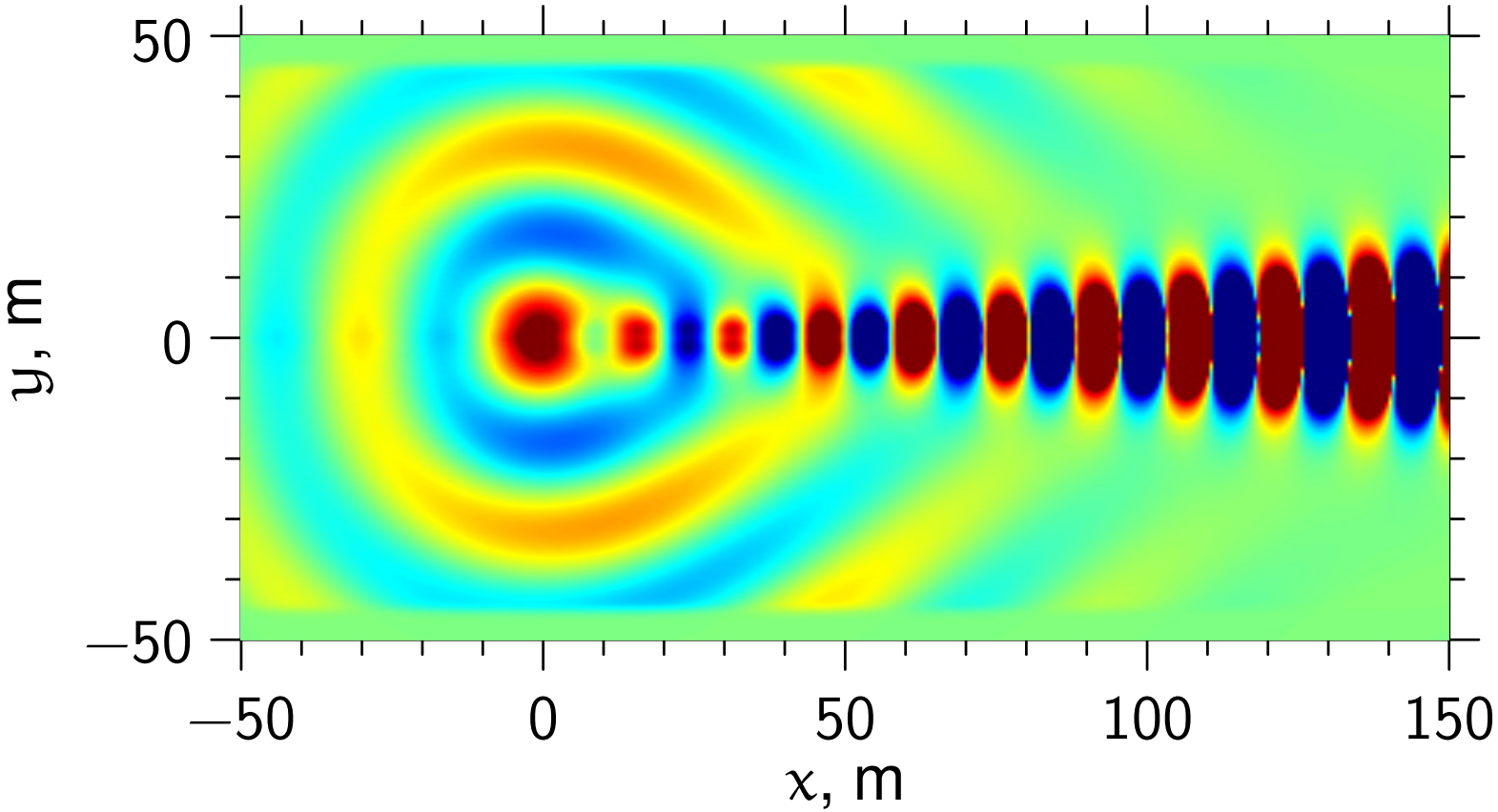
Filtering of a two-dimensional shear layer

Flow description



Filtering of a two-dimensional shear layer problem

Pressure field



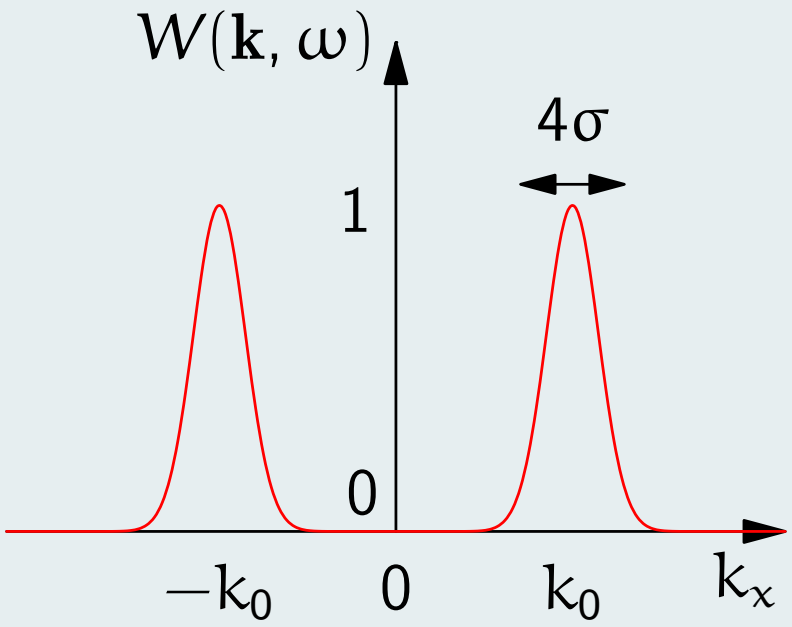
Filtering of a two-dimensional shear layer

Gaussian filter

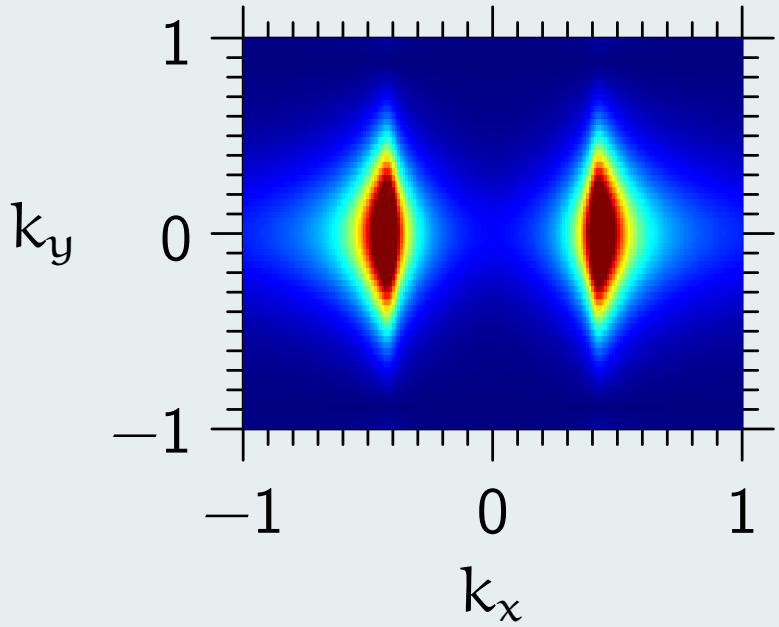
$$W(\mathbf{k},\omega) = \exp\left(-\frac{(k_x - k_0)^2}{2\sigma^2}\right) + \exp\left(-\frac{(k_x + k_0)^2}{2\sigma^2}\right)$$

$$k_0 = 0.41459, \quad \sigma = 0.1$$

Filter window



Fourier transform of pressure



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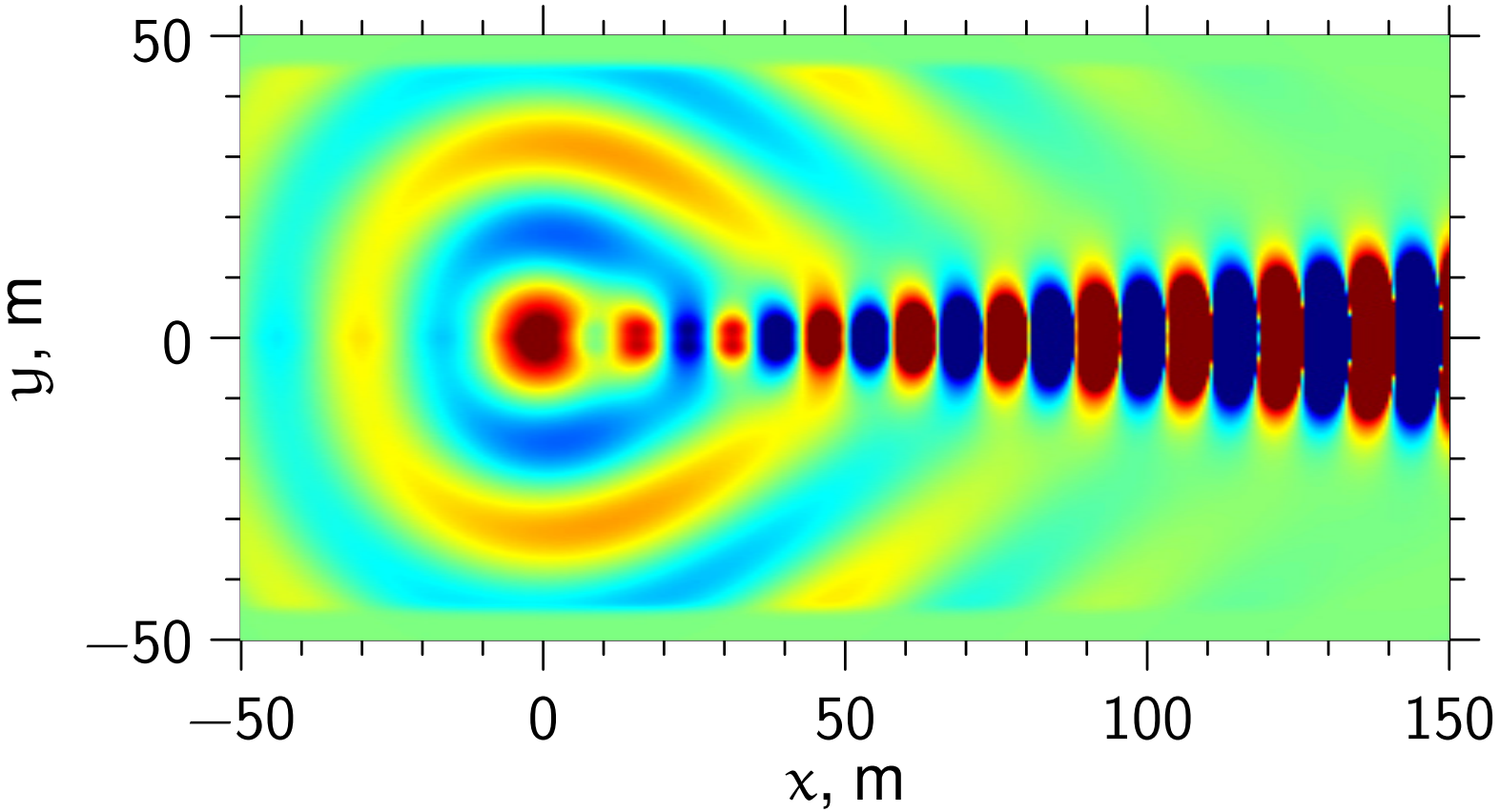

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