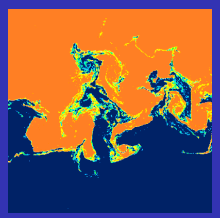


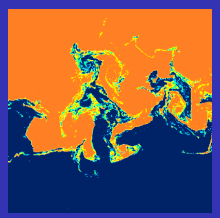
Travelling perturbations in sheared flows: sudden transition in frequency and phase speed asymptotics

Stefania Scarsoglio
Francesca De Santi Daniela Tordella

Philofluid Research Group (www.polito.it/philofluid)
Department of Mechanical and Aerospace Engineering
Politecnico di Torino, Torino, Italy

9th European Fluid Mechanics Conference
September 9-13, 2012, Rome, Italy

General aspects



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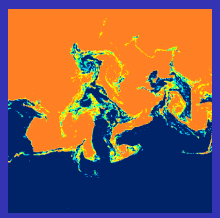

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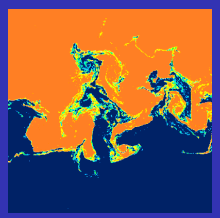

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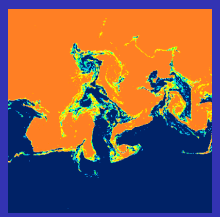

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  - High maxima of energy followed by asymptotic damping;

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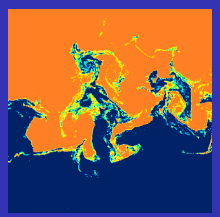

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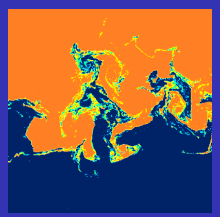

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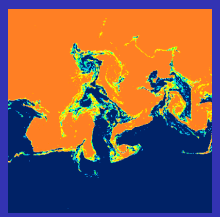

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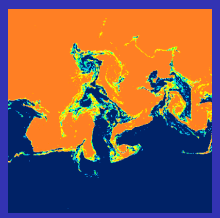
- Nonlinear terms limit the amplitude of the wave packet leaving unaffected its frequency (Delbende & Chomaz, 1998).

Perturbation scheme



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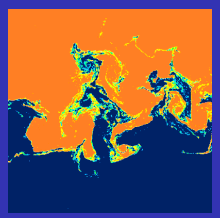

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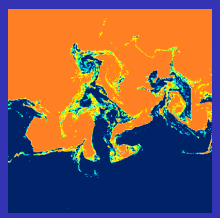

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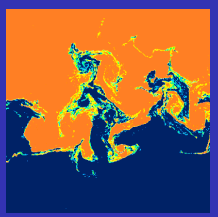

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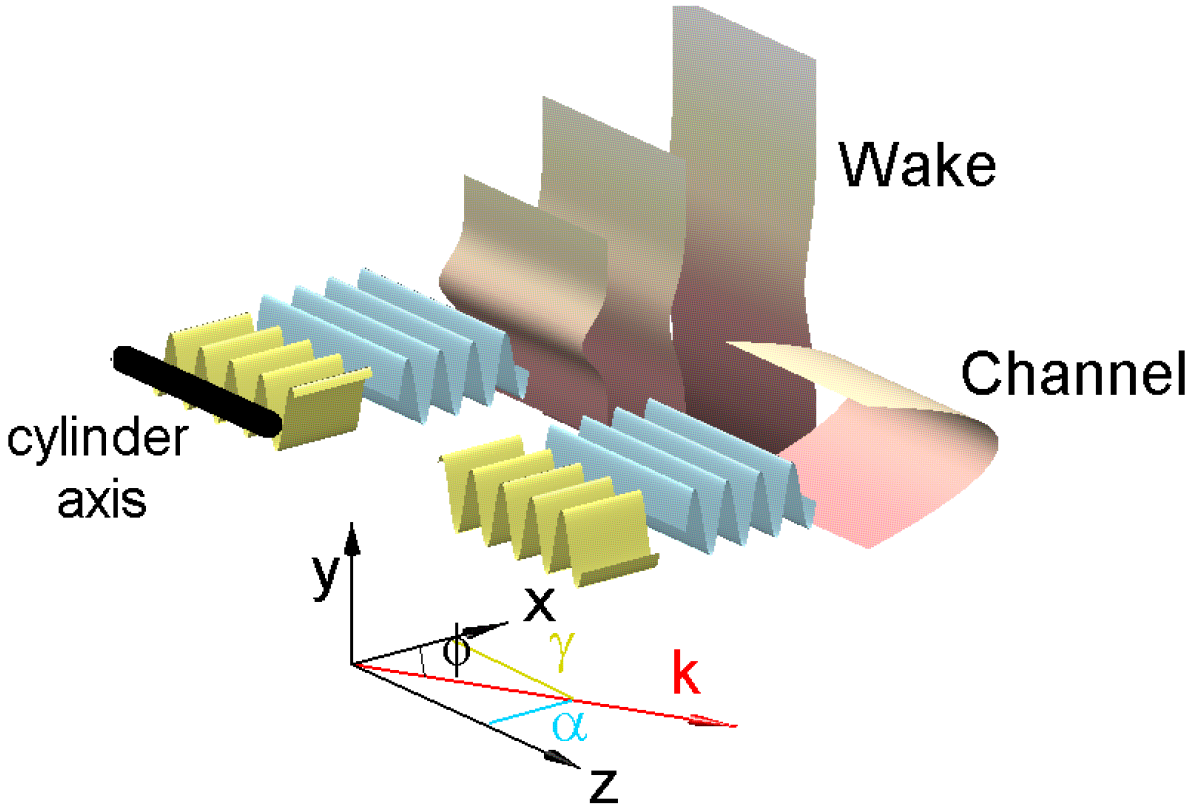
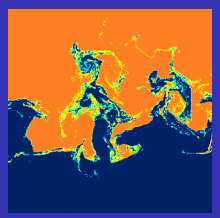


Measure of the growth



- Kinetic energy density e:

$$e(t;\alpha,\gamma) = \frac{1}{2}\int_{-y_d}^{+y_d}(|\hat{u}|^2+|\hat{v}|^2+|\hat{w}|^2)dy$$

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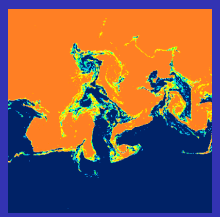

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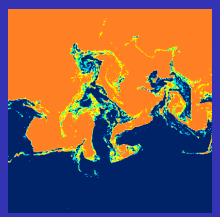

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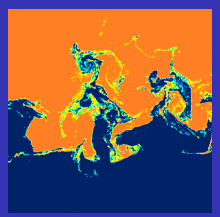
- Temporal growth rate r:

$$r(t;\alpha,\gamma) = \frac{log[e(t;\alpha,\gamma)]}{2t}$$

Characteristics of the perturbation



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$$\theta_w(y,t;\alpha,\gamma) = arg(\hat{v}(y,t;\alpha,\gamma))$$

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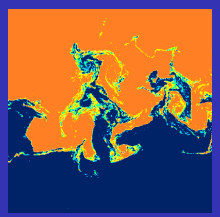

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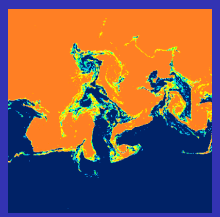

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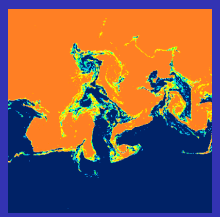
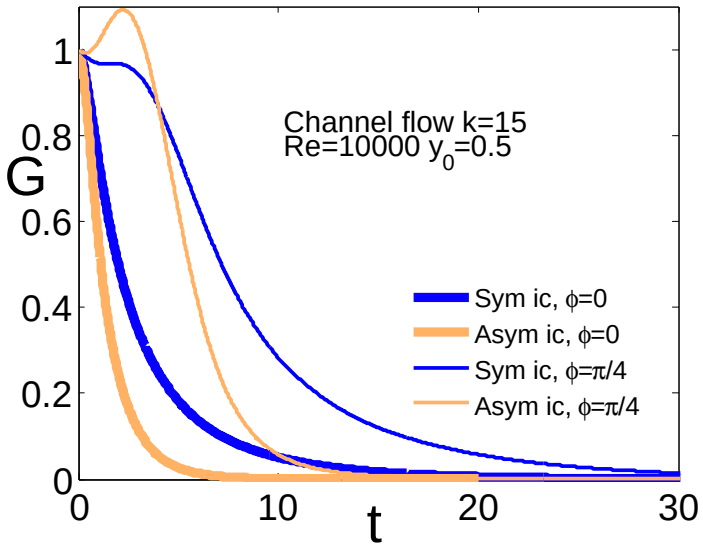
- Phase velocity $\mathbf{C}$:

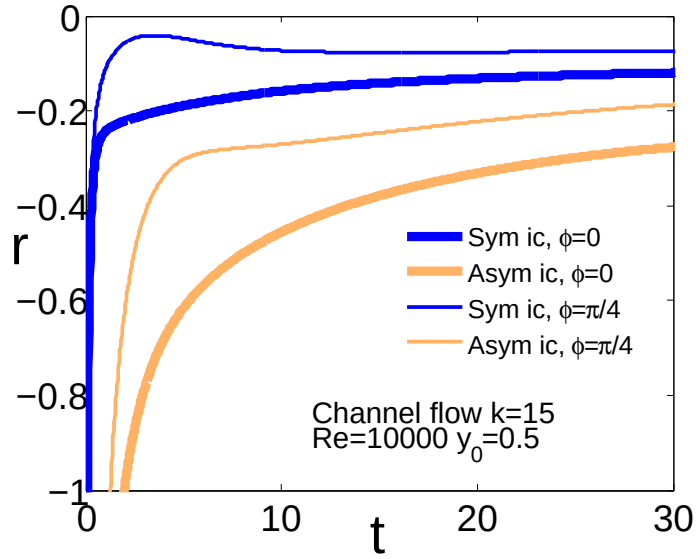
$$\mathbf{C} = (\omega/k)\hat{\mathbf{k}}$$

$\hat{\mathbf{k}} = (\cos(\phi), \sin(\phi))$ is the unitary vector in the k direction.

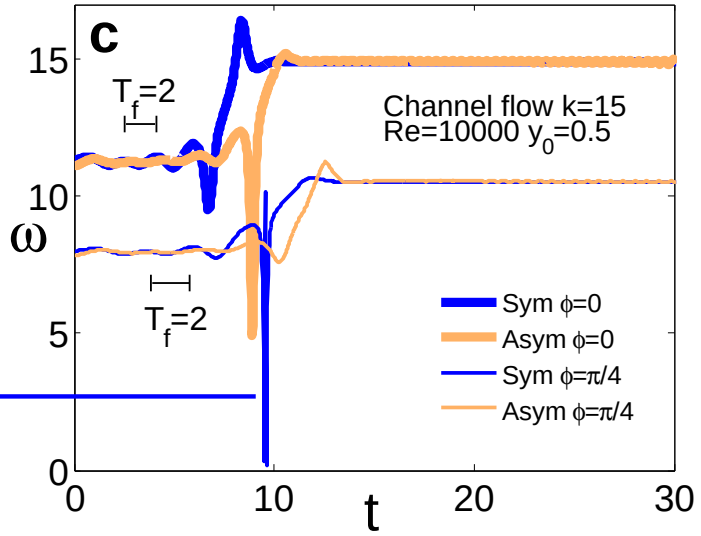
Channel flow ($Re = 10000$, $k = 15$, $y_0 = 0.5$)



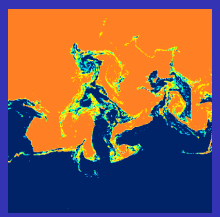


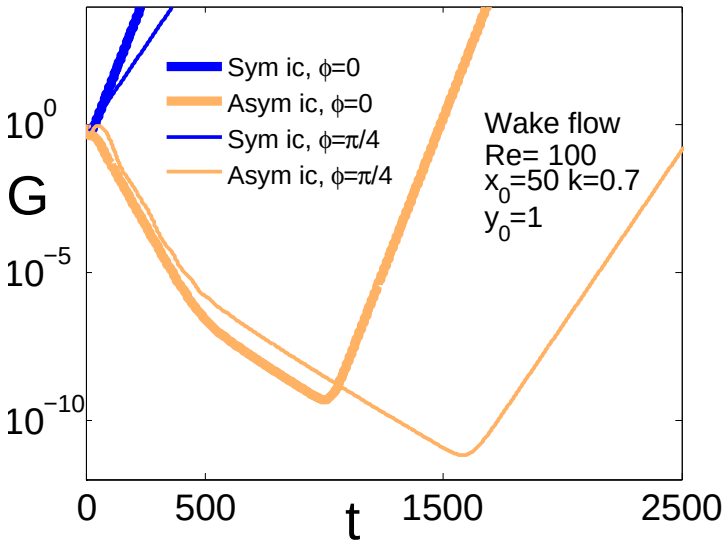


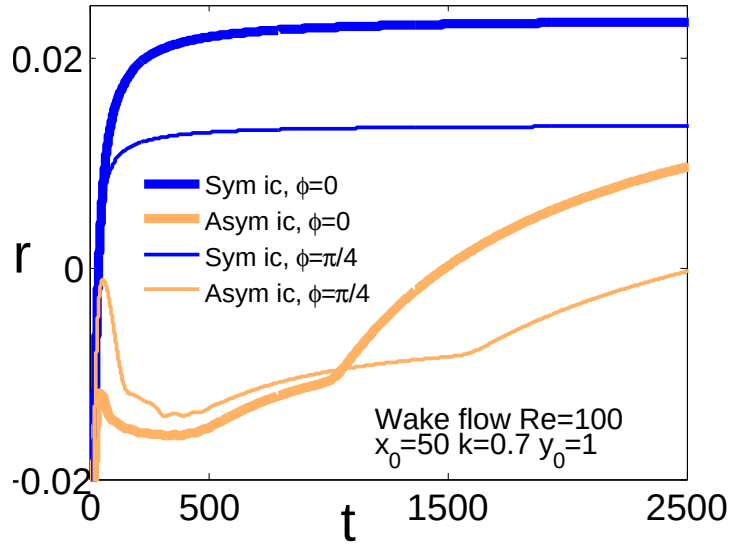
Movie



Wake flow ($Re = 100$, $k = 0.7$, $x_0 = 50$, $y_0 = 1$)







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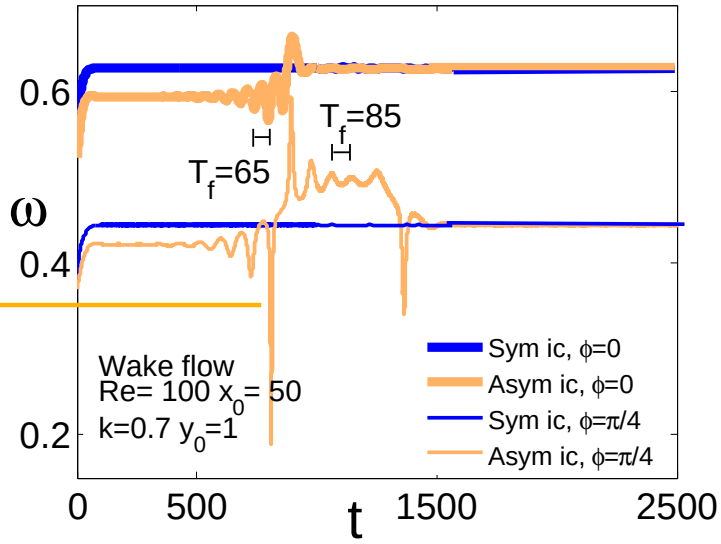
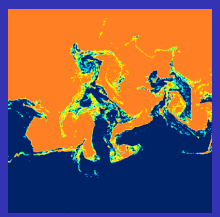
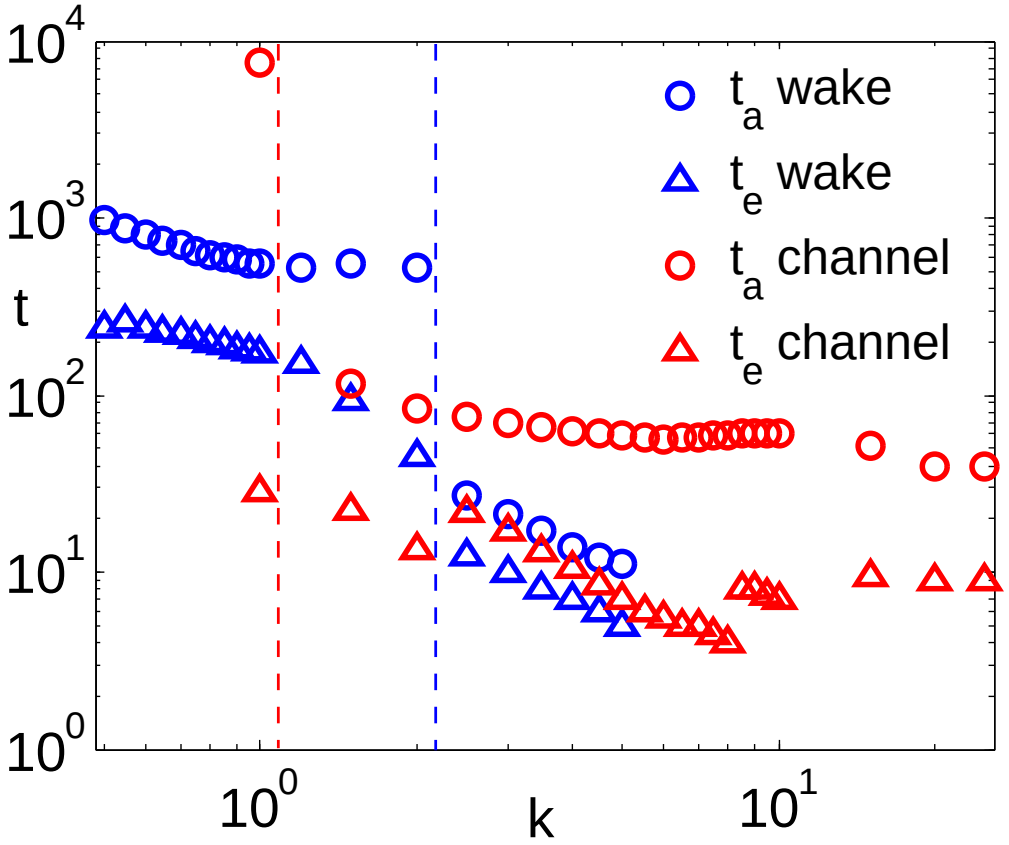


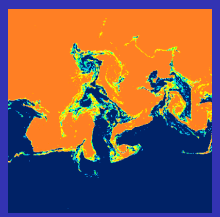
Typical transient time scales

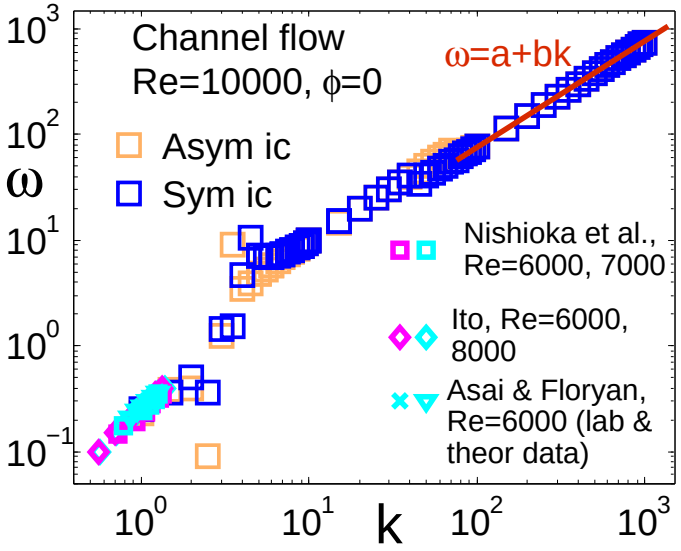


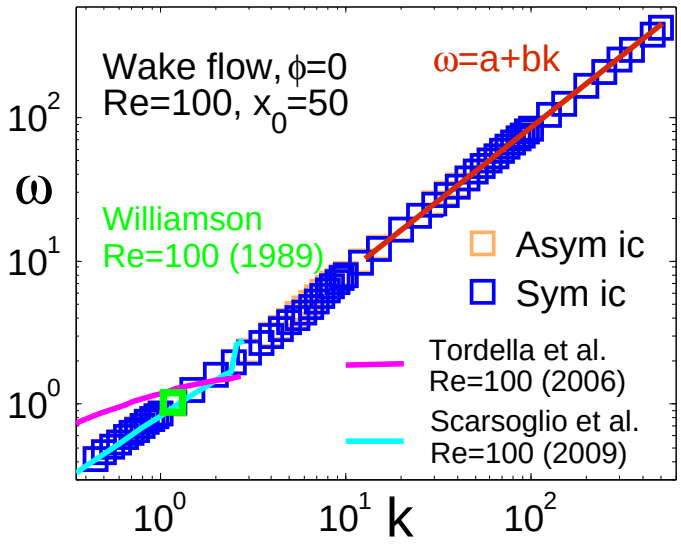


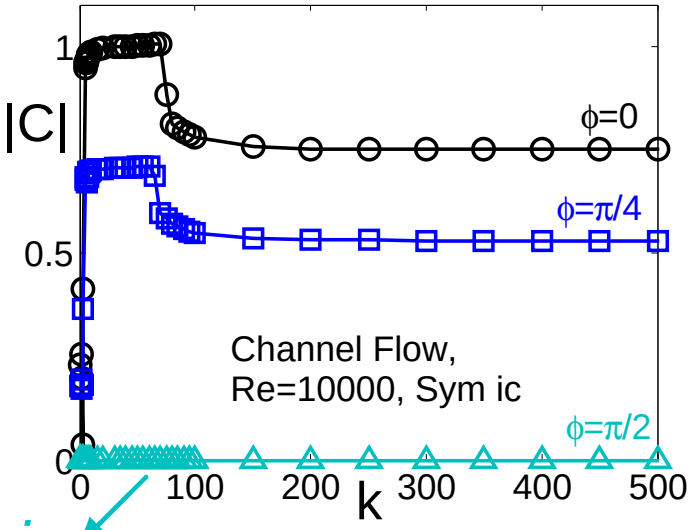
t_a ($\circ$): the asymptotic limit is reached. t_e ($\triangle$): the early transient ends and the frequency discontinuities occur. Blue symbols: wake flow, $Re = 100$, antisymmetric input, $\phi = \pi/4$, $x_0 = 10$, $y_0 = 1$. Red symbols: channel flow $Re = 10000$, symmetric input, $\phi = \pi/4$, $y_0 = 0.5$.

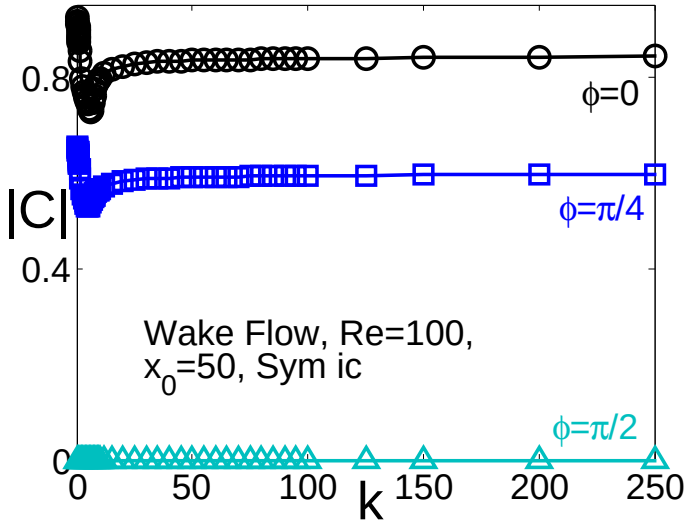
Spectra of the frequency and phase velocity





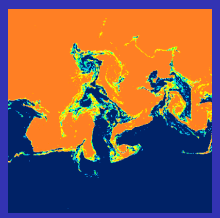






Movie

Concluding Remarks



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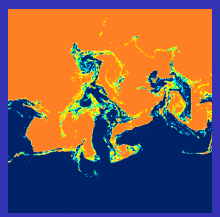

- Discontinuities in frequency never observed before (loss of information with the spectral analysis of signals);
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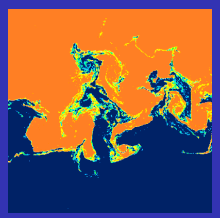

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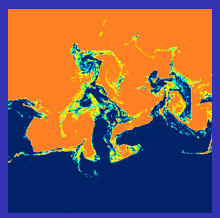

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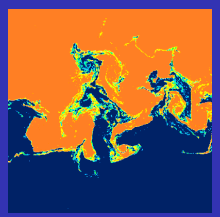

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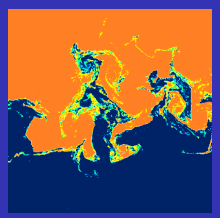
- Orthogonal standing waves $\Rightarrow$ How does a spot form?

Coming next...Spot formation



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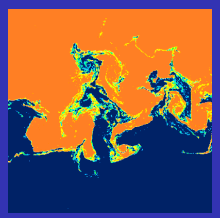

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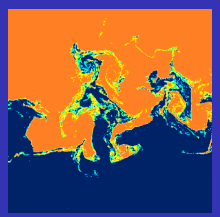

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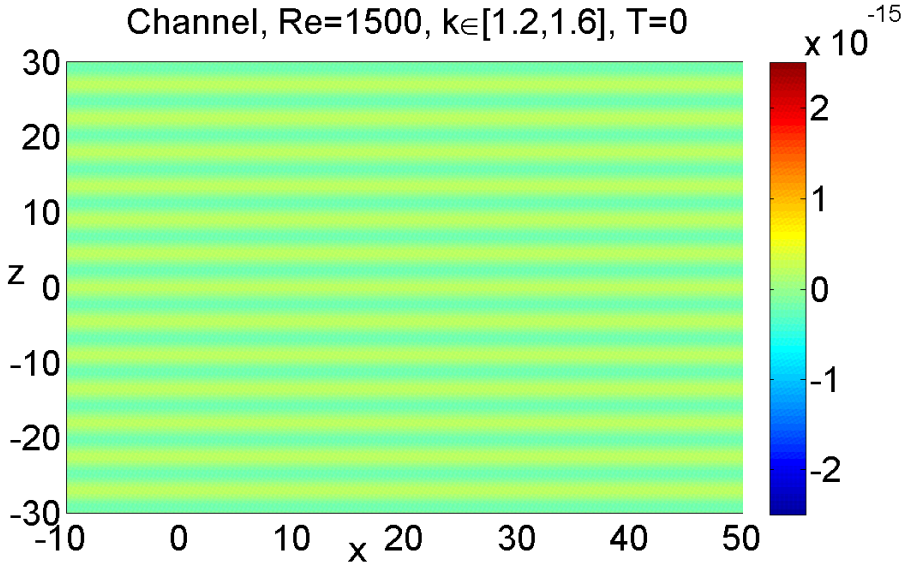
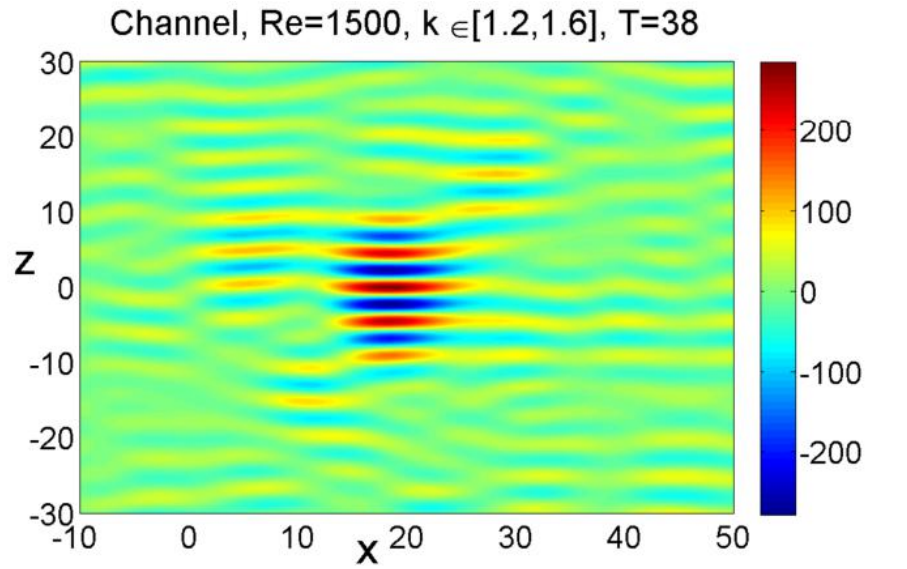
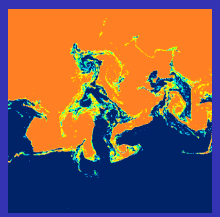
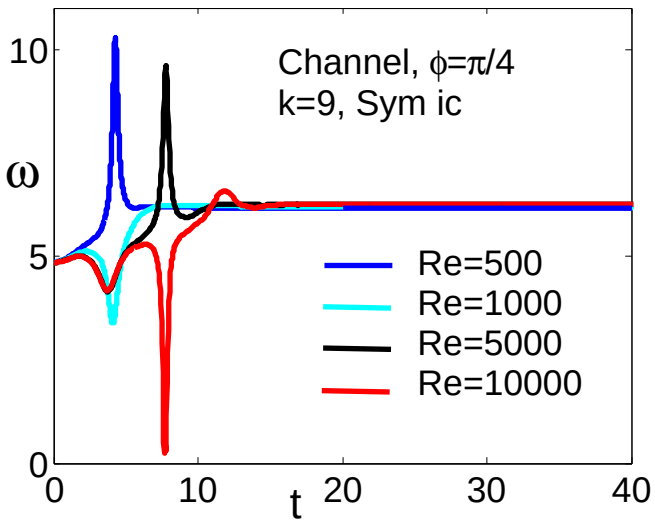
- Different wavelengths: $k \sim 10^{-1} - 10^{0}$;
- Wave packet: $k \sim 1.4$.

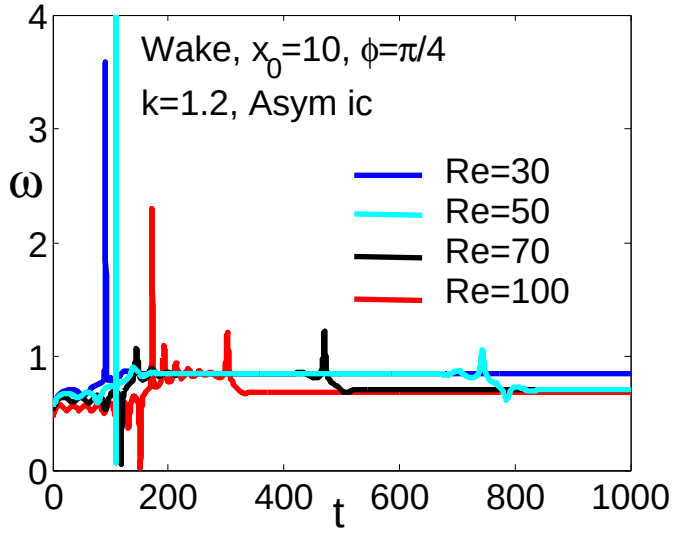




Influence of the Reynolds number







Different transversal observation points y_0