Studying wave dynamics in turbulent flows via space and time resolved spectra

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What, how, and why?

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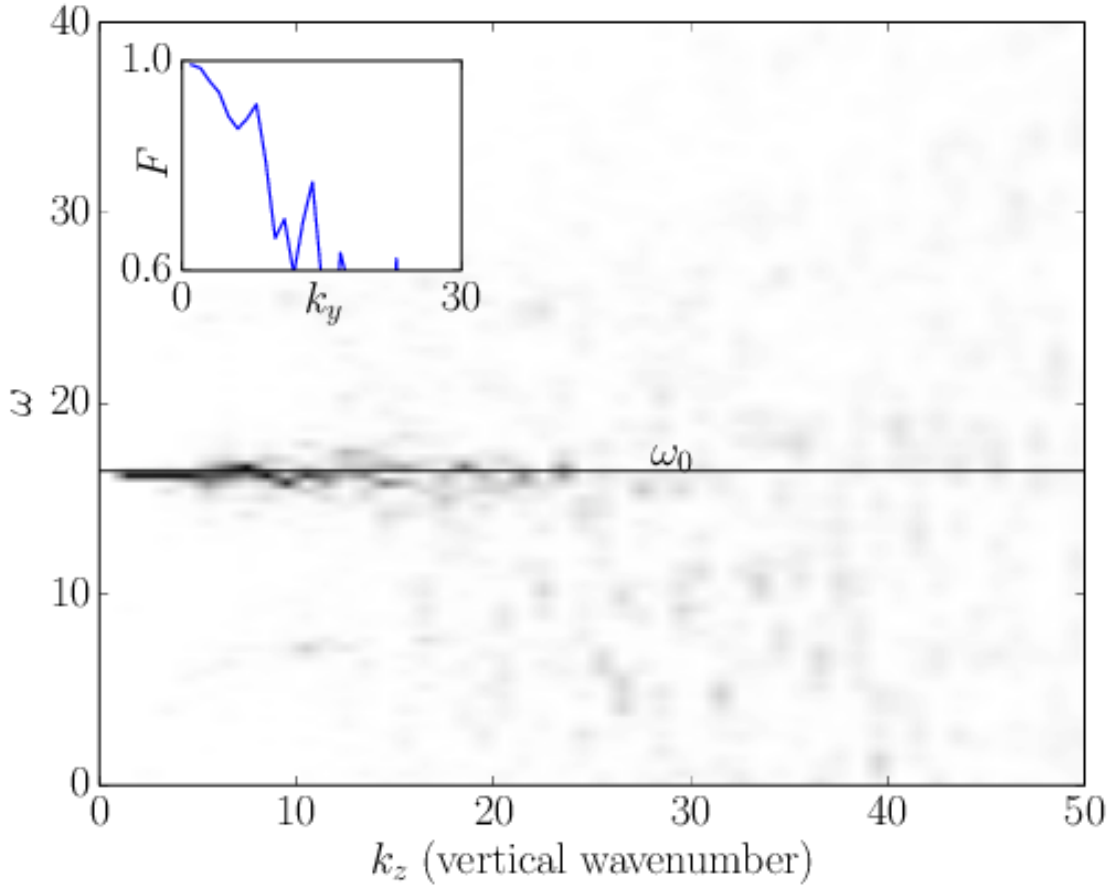
- Characterization of the effect of waves, and measurements of the amount of energy in wave modes has been done mostly indirectly.
- By calculating space and time resolved spectra from DNS we study directly the effect wave motions in turbulent flows.

Rotating flow (Navier Stokes in rotating frame)

$E(k, \omega)$

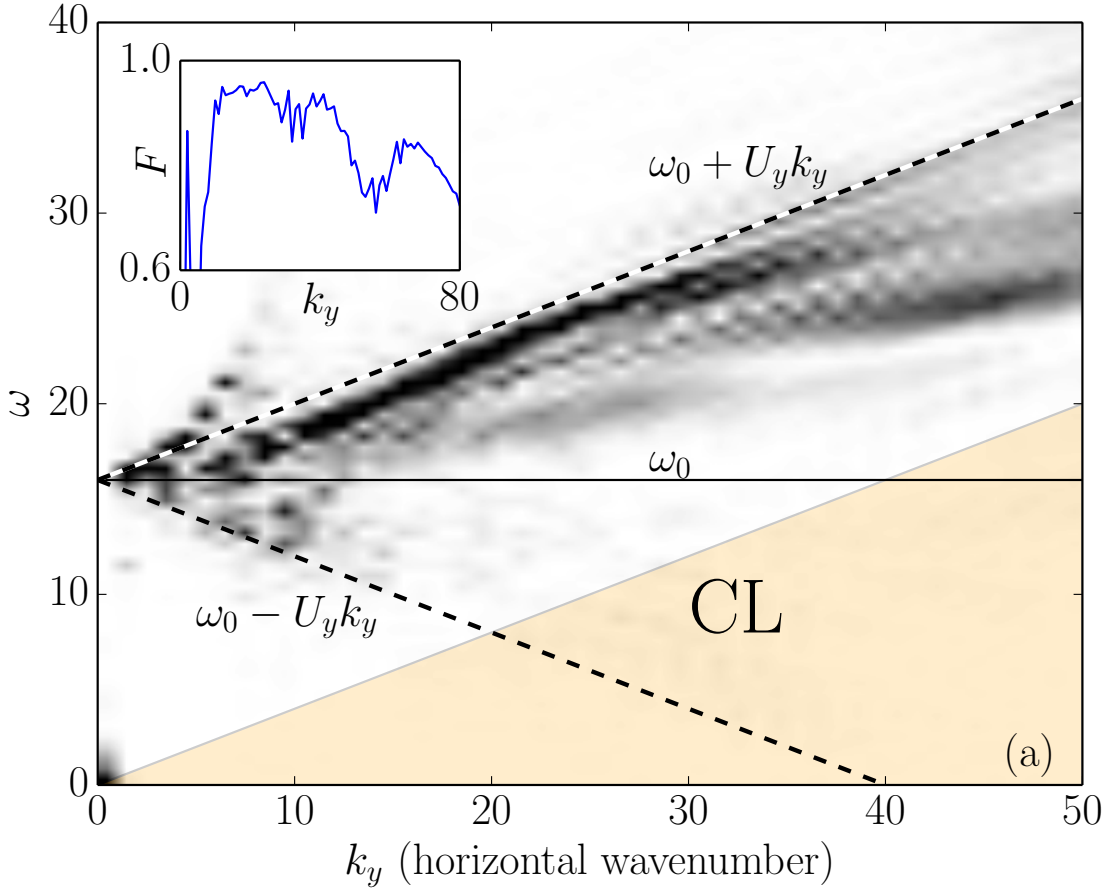
Only In the larger scales energy accumulates along modes satisfying the dispersion relation of intertial waves!



Clark di Leoni, Cobelli, Mininni, Dmitruk & Matthaeus, PoF (2014)

Stratified flow (Boussinesq model with no rotation)

$E(k, \omega)$



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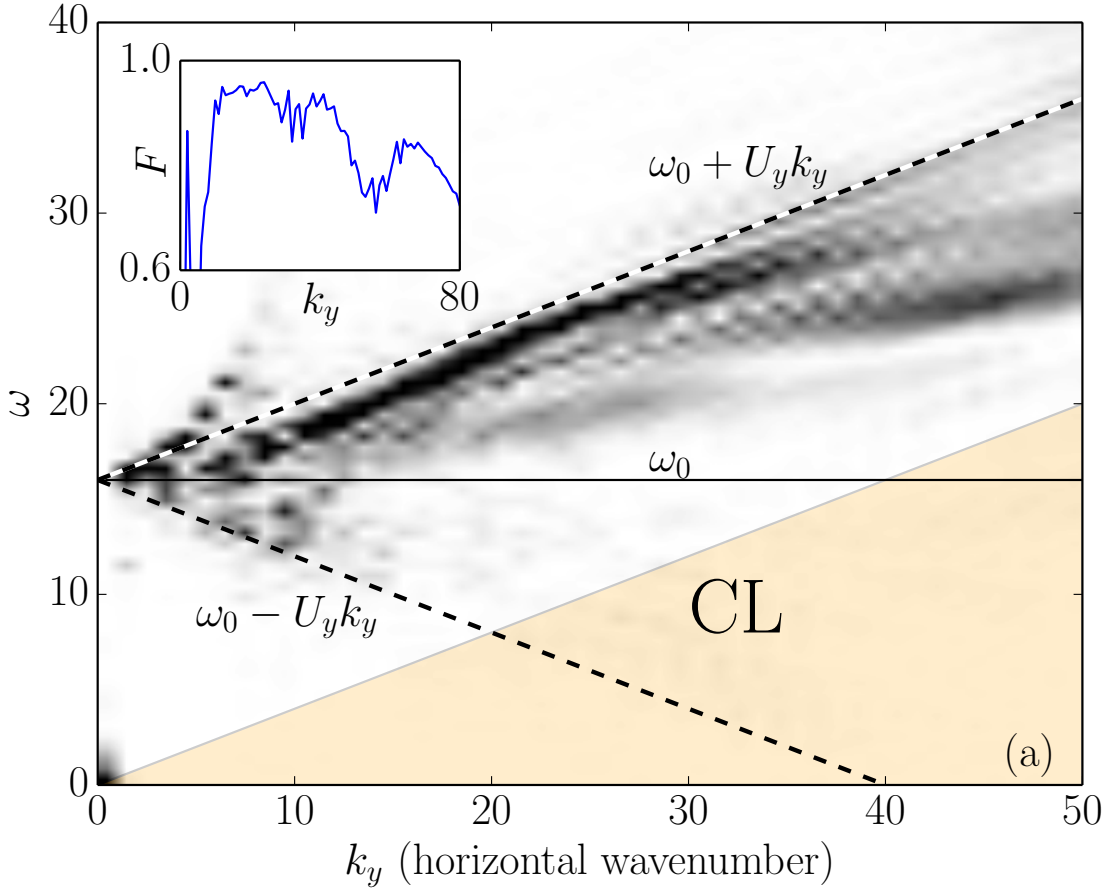


Doppler shifting and Critical Layer absorption appear! This indicates a nonlocal transfer of energy from the small to the large scales. *Clark di Leoni and Mininni, PRE (in press)*

Superfluid turbulence (Gross-Pitaevskii equation)

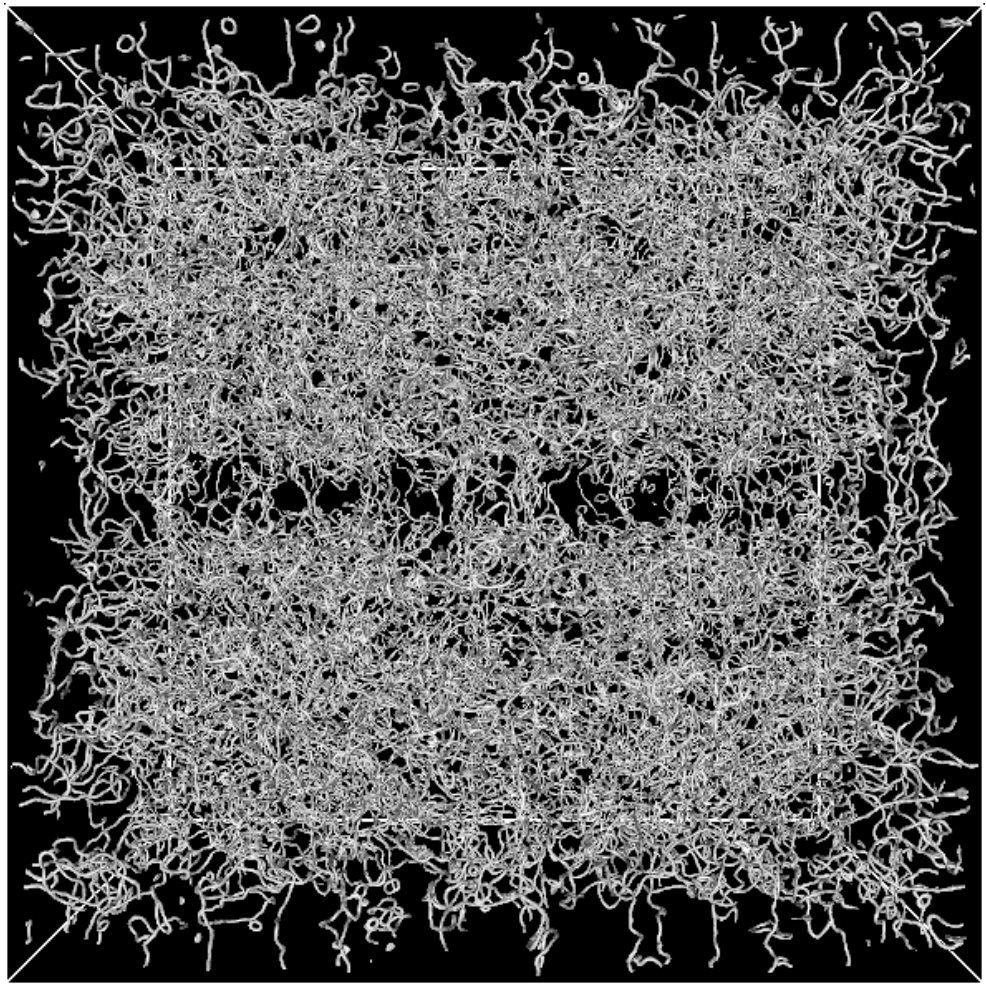
Nonlinear PDE describing a Bose Einstein condensate for wavefunction ψ

$$\psi(\mathbf{r}, t) = \sqrt{\frac{\rho(\mathbf{r}, t)}{m}}\, e^{i\frac{m}{\hbar}\phi(\mathbf{r},t)}$$

Vorticity is quantized and concentrated along lines with $\rho = 0$

Superfluid turbulence (Gross-Pitaevskii equation)

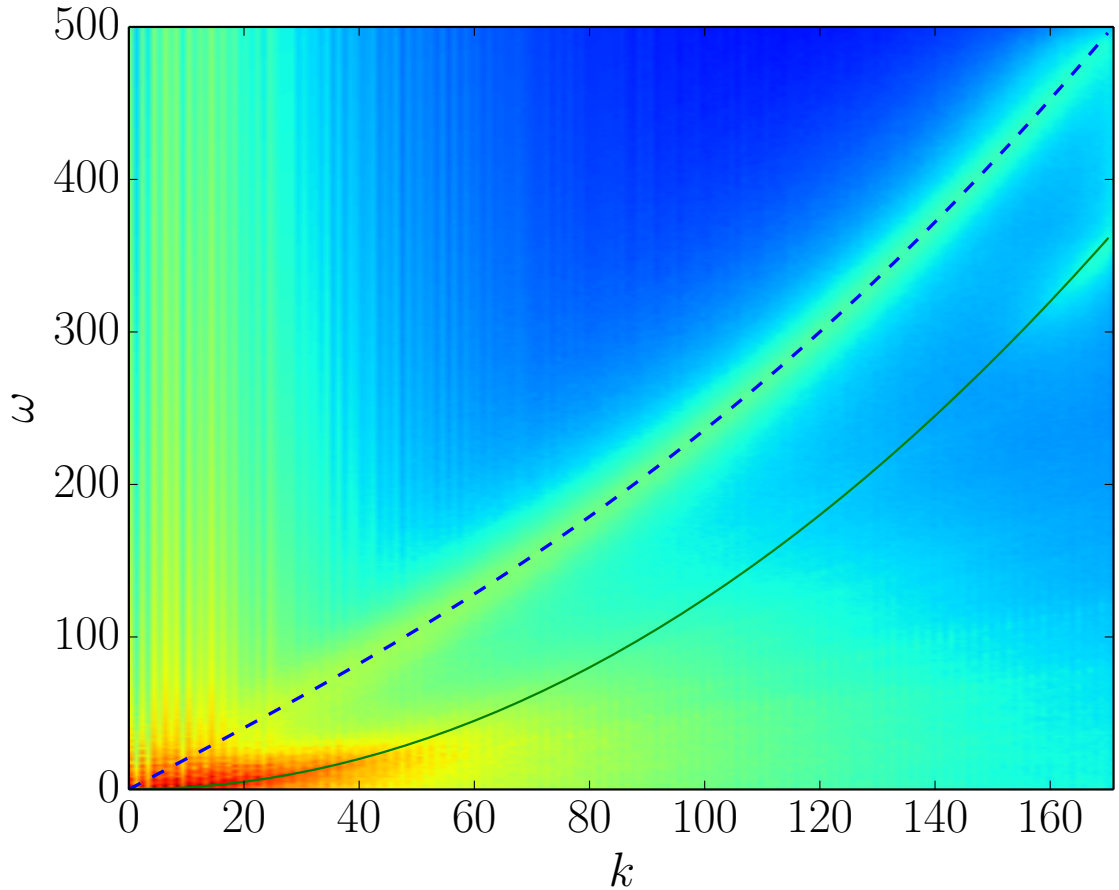
$\rho(\mathbf{r})$



Superfluid turbulence (Gross-Pitaevskii equation)

$\rho(k, \omega)$

Sound and kelvin waves!



In collaboration with Marc Brachet

Superfluid turbulence (Gross-Pitaevskii equation)

$\rho(k, \omega)$