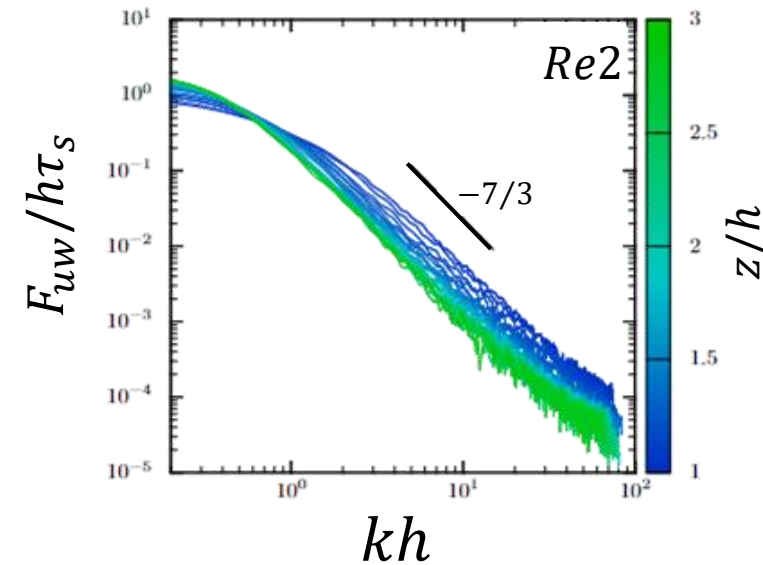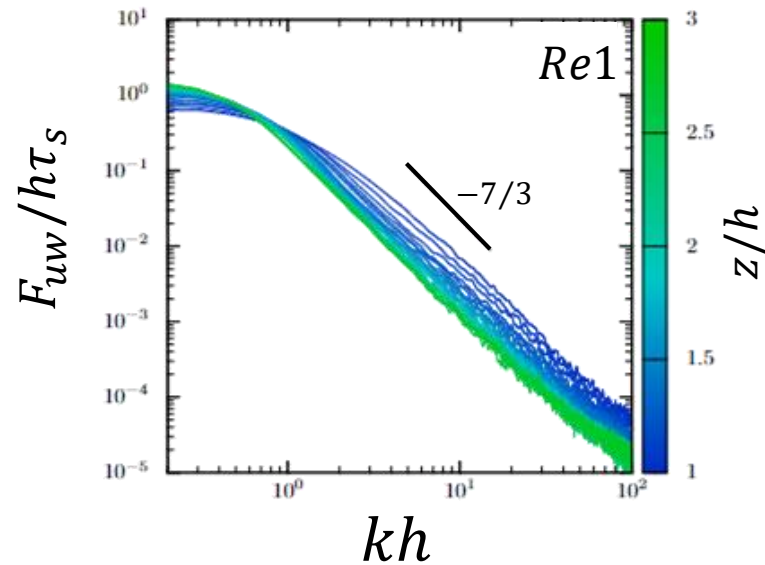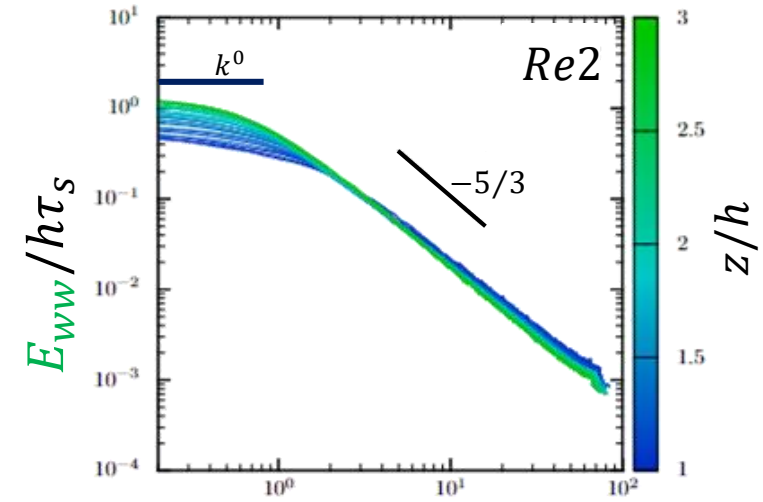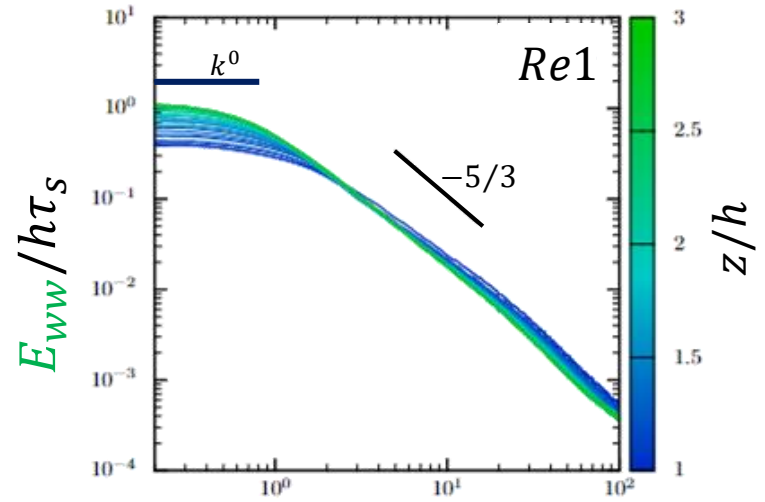# Perturbed Roughness Sublayer Affecting the Law Of The Wall Modeled by a "Co-spectral Link"

Y.Bohbot-Raviv, V. Babin and G. G. katul

❑ Measured vertical energy spectra and co-spectrum at two Reynolds number
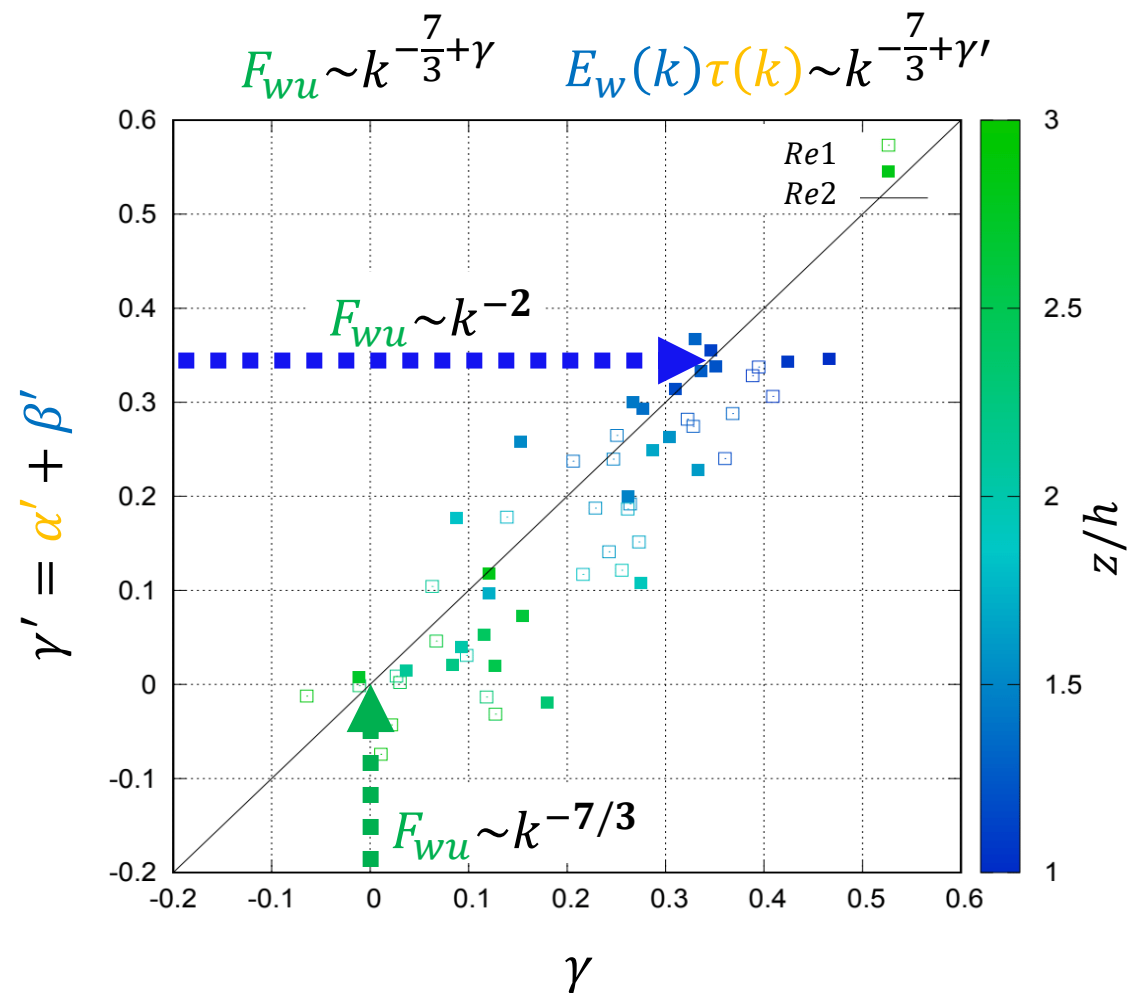
Perturbed Roughness Sublayer Affecting the Law Of The Wall Modeled by a "Co-spectral Link"

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❑ Deviation from idealized co-spectrum power law – estimation and measurements

$$\Phi_{\gamma'} = k_v \left[\frac{4}{7} \left(\int_0^1 d\hat{k} + \int_1^\infty \hat{k}^{-\frac{7}{3}+\gamma'} \, d\hat{k} \right) \right]^{3/4}$$

$$\Phi_{\gamma'} = \kappa_v \left[\frac{1 - 3\gamma'/7}{1 - 3\gamma'/4} \right]^{3/4}$$

$$\Phi_{\gamma'} > \kappa_v$$

$$\Phi_{1/3} \to 0.406 > \kappa_v = 0.367$$

$$F_{wu} \sim k^{-\frac{7}{3}+\gamma} \qquad E_w(k)\tau(k) \sim k^{-\frac{7}{3}+\gamma'}$$

$$F_{wu} \sim k^{-2}$$

$$F_{wu} \sim k^{-7/3}$$

$$\gamma' = \alpha' + \beta'$$

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❑ Measured deviation from idealized slow relaxation of co-spectra
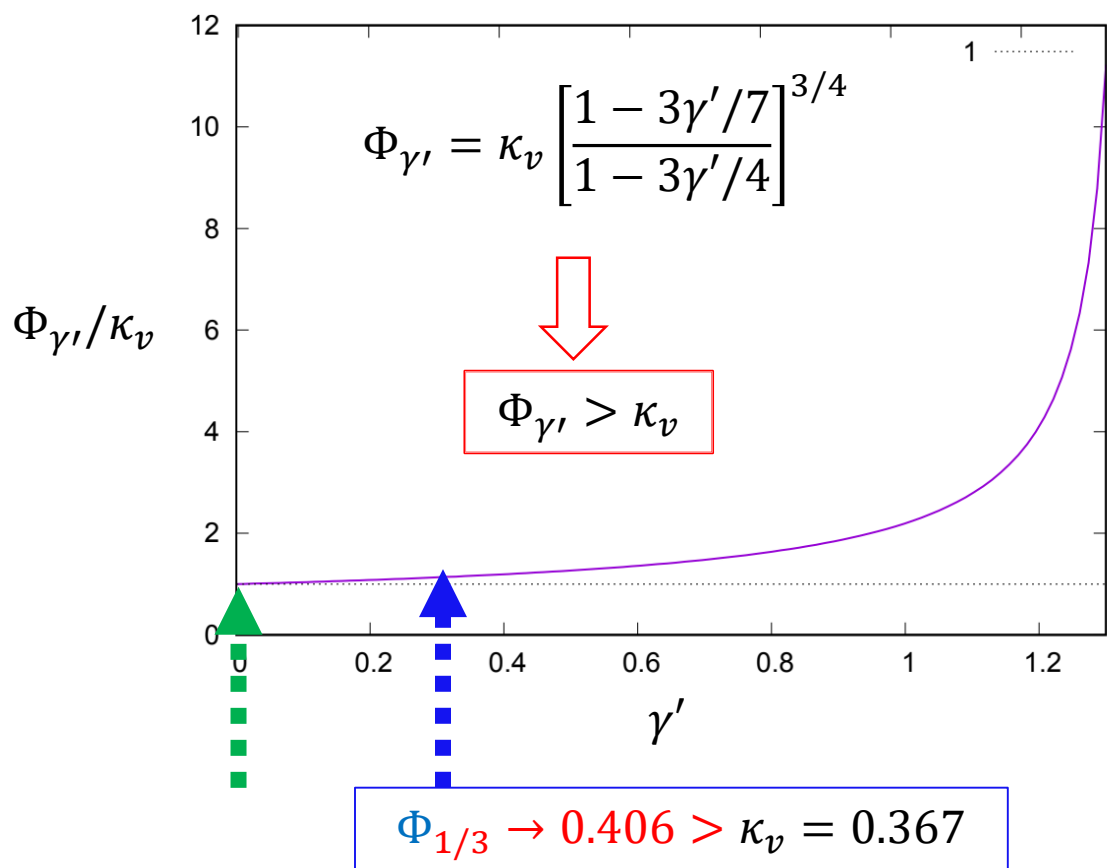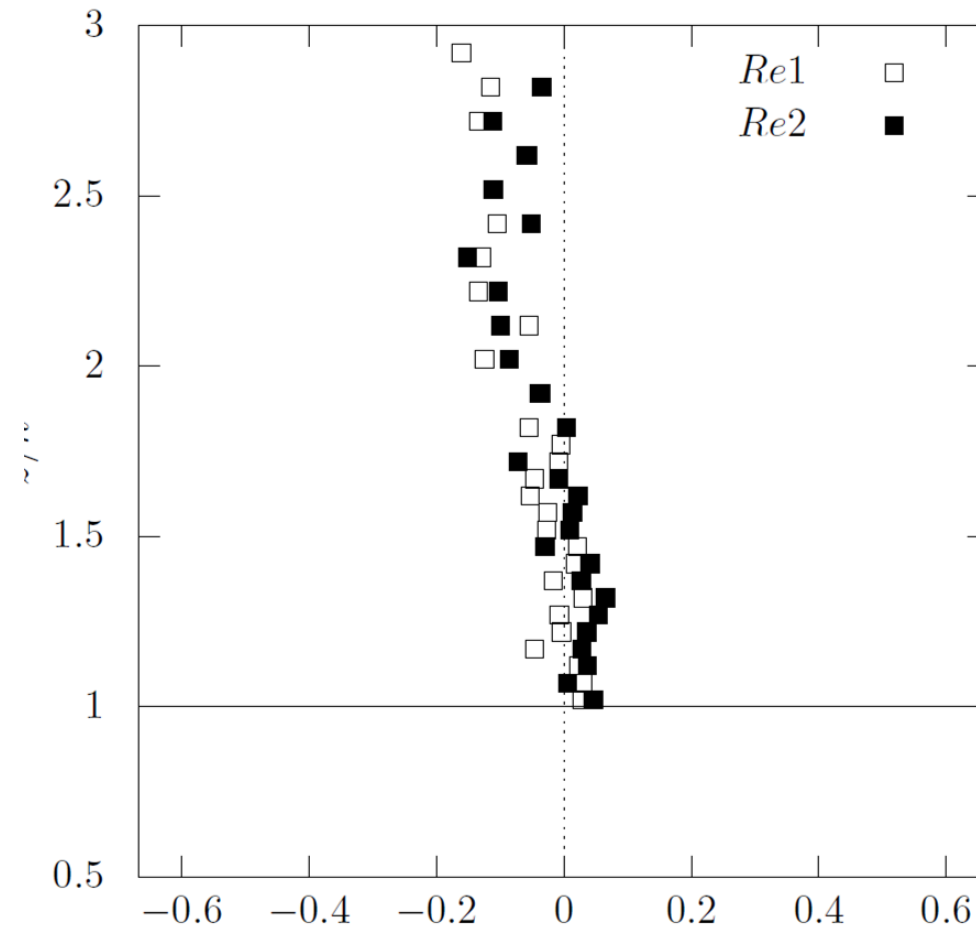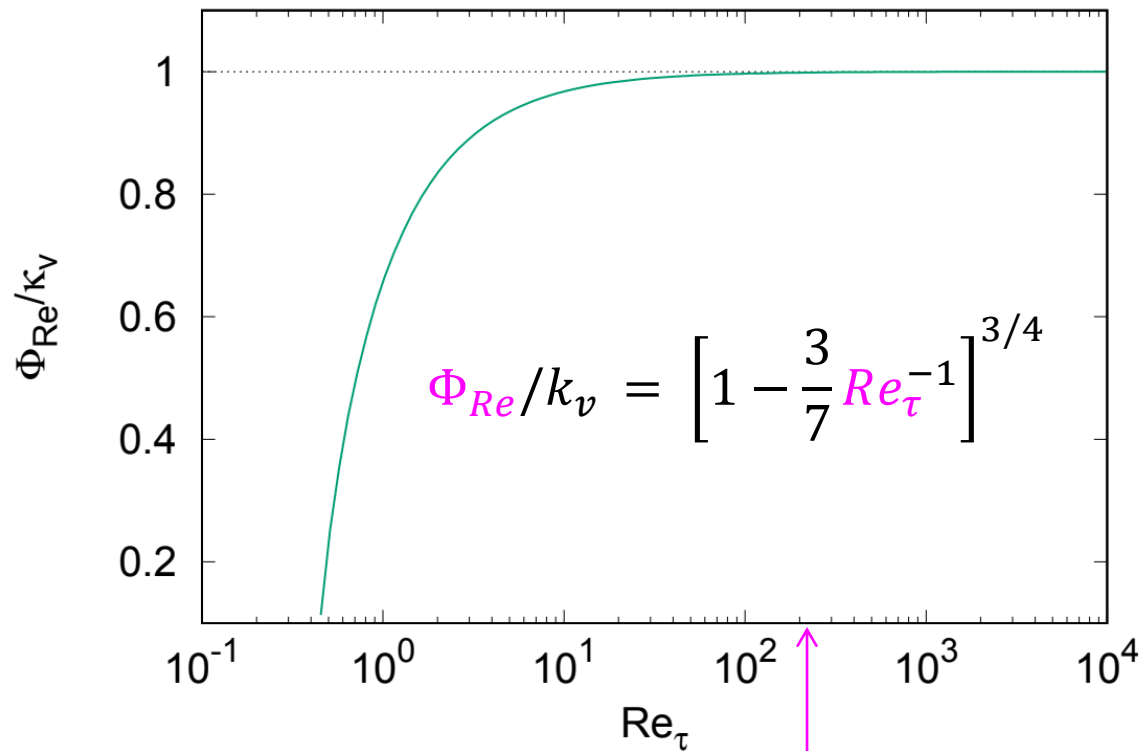
$$\tau(k) \sim k^{-\frac{7}{3}+\gamma'}$$

Perturbed Roughness Sublayer Affecting the Law Of The Wall Modeled by a "Co-spectral Link"
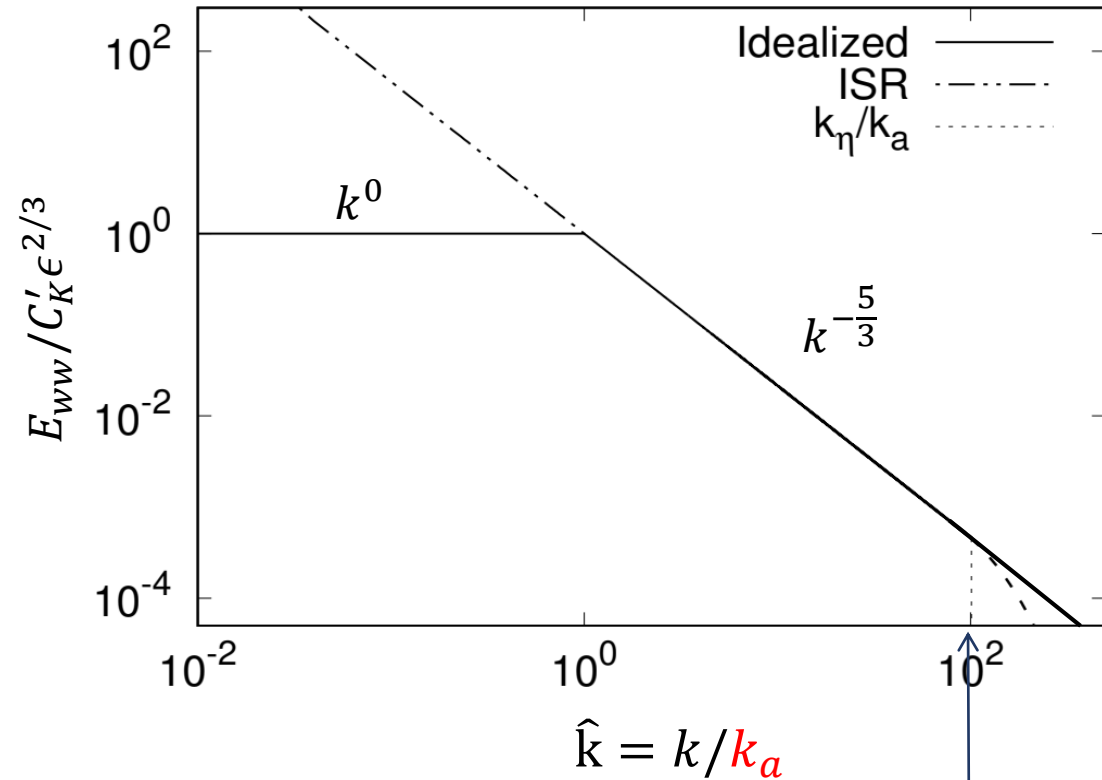
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❑ Deviation from idealized co-spectrum due to finite Re number – estimation and measurement

$$\Phi_{Re} = k_v \left[\frac{4}{7} \left(\int_0^1 d\hat{k} + \int_1^{Re_\tau} \hat{k}^{-\frac{7}{3}} \, d\hat{k} \right) \right]^{3/4}$$

$$\Phi_{Re}/k_v = \left[1 - \frac{3}{7} Re_\tau^{-1} \right]^{3/4}$$

$$Re_{\tau 1}(h) = 2200$$

$\hat{k} = k/k_a$

k_η/k_a

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❑ Deviation from idealized co-spectrum due to Intermittency

$$E_{ww}(k) = C'_K \epsilon^{2/3} k^{-5/3} (kL)^\alpha$$

	$L = z$	$L = \delta$	
VKC	$\Phi_z = \kappa_v \left[\dfrac{1 - 3\alpha/7}{1 - 3\alpha/4}\right]^{3/4}$	$\Phi_\delta = \kappa_v \left[\dfrac{1 - 3\alpha/7}{1 - 3\alpha/4}\right]^{3/4} (k_a\delta)^{3\alpha/4}$	$L =$ length scale; $\alpha \approx -0.1$
$\alpha \approx -0.1$	→ slight decrease VKC	→ slight decrease VKC	
Law of the wall	$\dfrac{dU}{dz} \sim \Phi_z^{-1} \dfrac{u_*}{z}$	$\dfrac{dU}{dz} \sim \Phi_z^{-1} \dfrac{u_*}{z} \left(\dfrac{z}{\delta}\right)^{3\alpha/4}$	
Velocity	$U \sim \log(z)$	$U \sim \log(z) + z^{f(\alpha)}$	