Statistics of Particle Concentration in Free-Surface Turbulence

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Outline

I. Experiment Description/Overview

II. Coarse-Graining Procedure

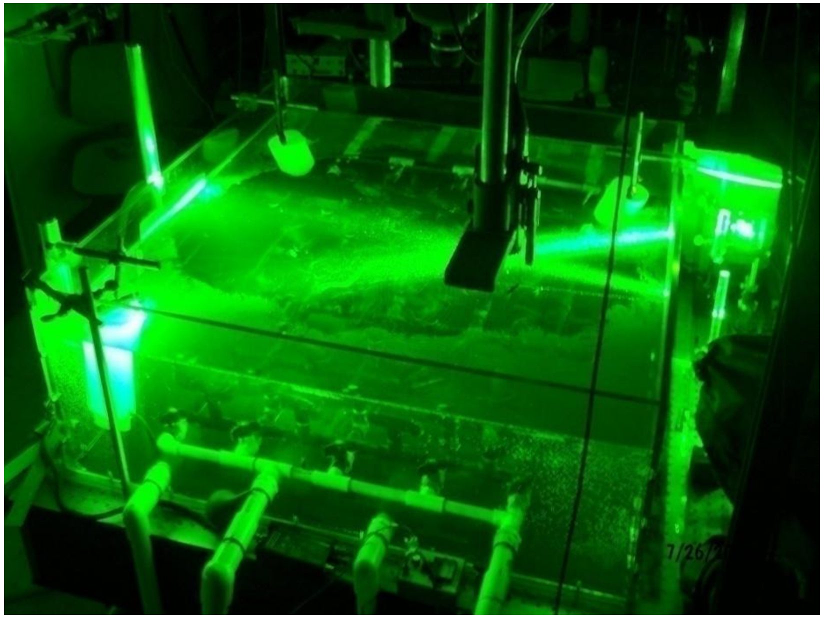
III. Scale-Free Behavior

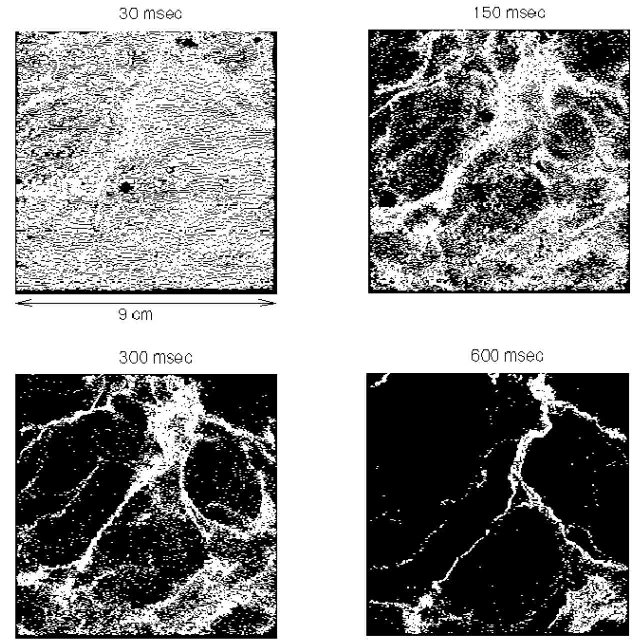
IV. Probability Distribution

V. Review

VI. Questions

I. Experiment Overview





- Tank: 1 m x 1 m x 0.3 m driven by 8 hp pump through "sprinkler" system.
- Real particles 50 micron size and highly bouyant (sg 0.25), low Stokes number $St \simeq 0.1$
- Want to study particle coagulation due to surface effect, not inertia.
- Instantaneous velocity fields measured by high-speed camera (9 cm field of view) used to evolve virtual particles.

$$\mathcal{C} = \frac{\langle (\nabla \cdot \mathrm{v})^2 \rangle}{\langle (\partial_x v_x)^2 + (\partial_x v_y)^2 + (\partial_y v_x)^2 + (\partial_y v_y)^2 \rangle} \simeq 0.5$$

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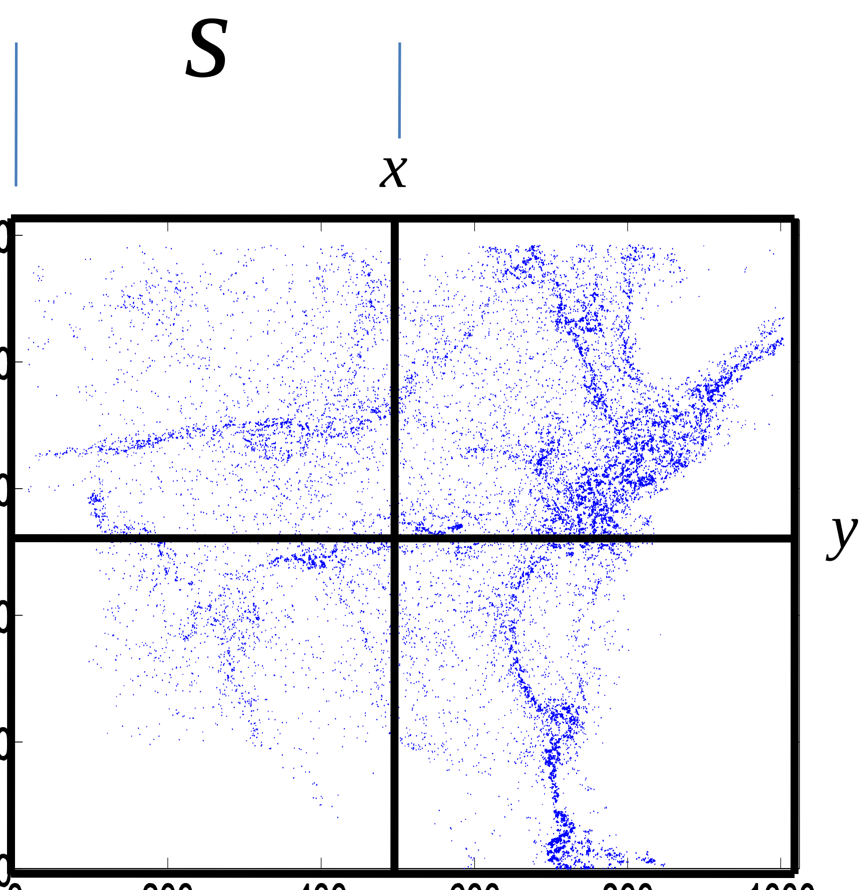
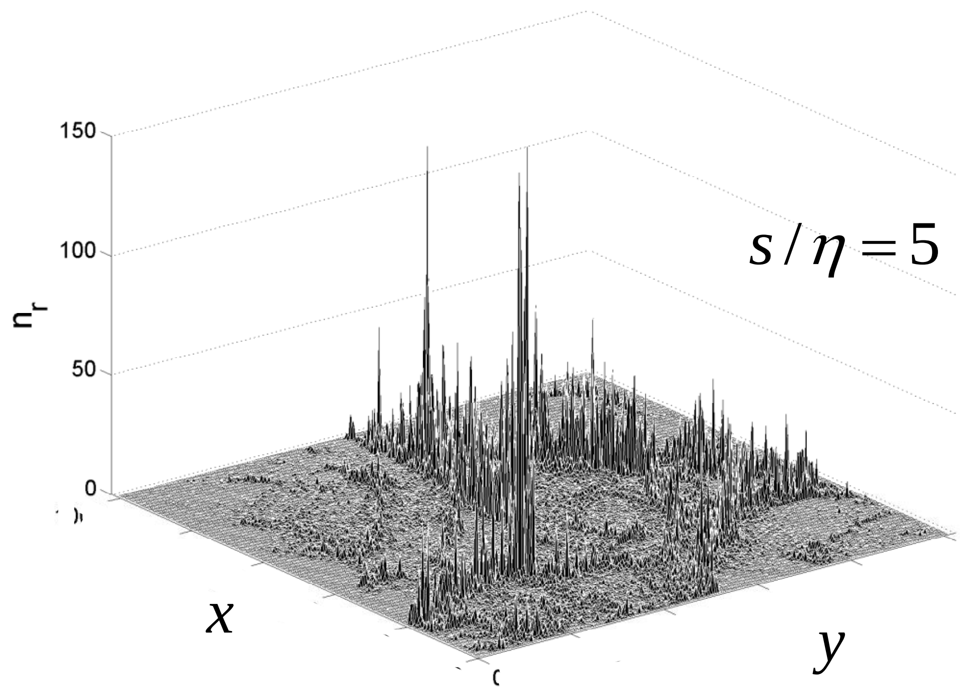
II. Coarse-Graining Procedure

Coarse-Grained Concentration: $$n_r = \frac{N_r}{\langle N_r \rangle}$$ $$\eta = \left(\frac{\nu^3}{\varepsilon}\right)^{1/4} = 0.02cm$$

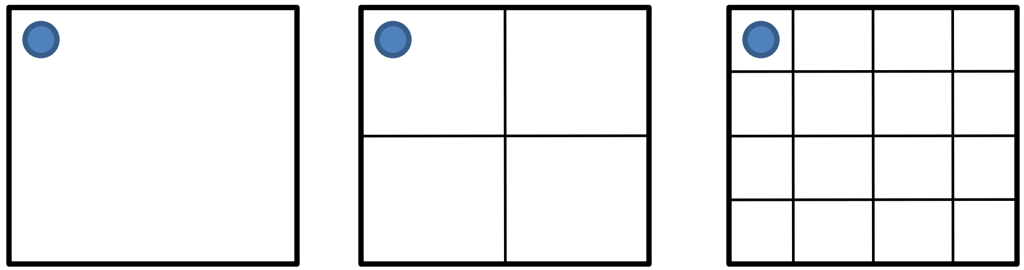
All analysis done in steady-state!

$$r = s/\eta$$ $$\langle n_r \rangle = \left\langle \frac{N_r}{\langle N_r \rangle} \right\rangle = 1$$





III. Scale-Free Distribution



$\langle n_r^{\,2} \rangle = 1$ $\quad \langle n_r^{\,2} \rangle = 4$ $\quad \langle n_r^{\,2} \rangle = 16$

$$\langle n_r^{\,2} \rangle \propto r^{-\alpha_2}$$

$\mathrm{Re}_\lambda = 169$

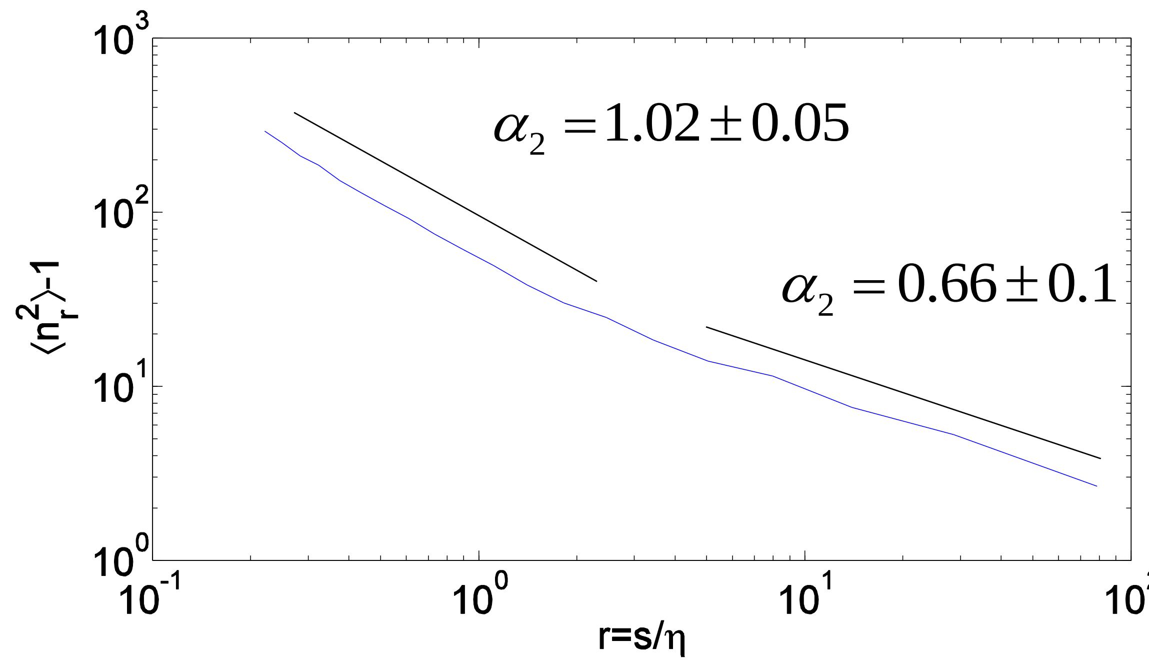
Point: $\alpha_2 = 2$

Line: $\alpha_2 = 1$

Surface: $\alpha_2 = 0$

-For fractal distributions:

$$\langle n_r^{\,m} \rangle \propto r^{-\alpha_m}$$



IV. Concentration PDF

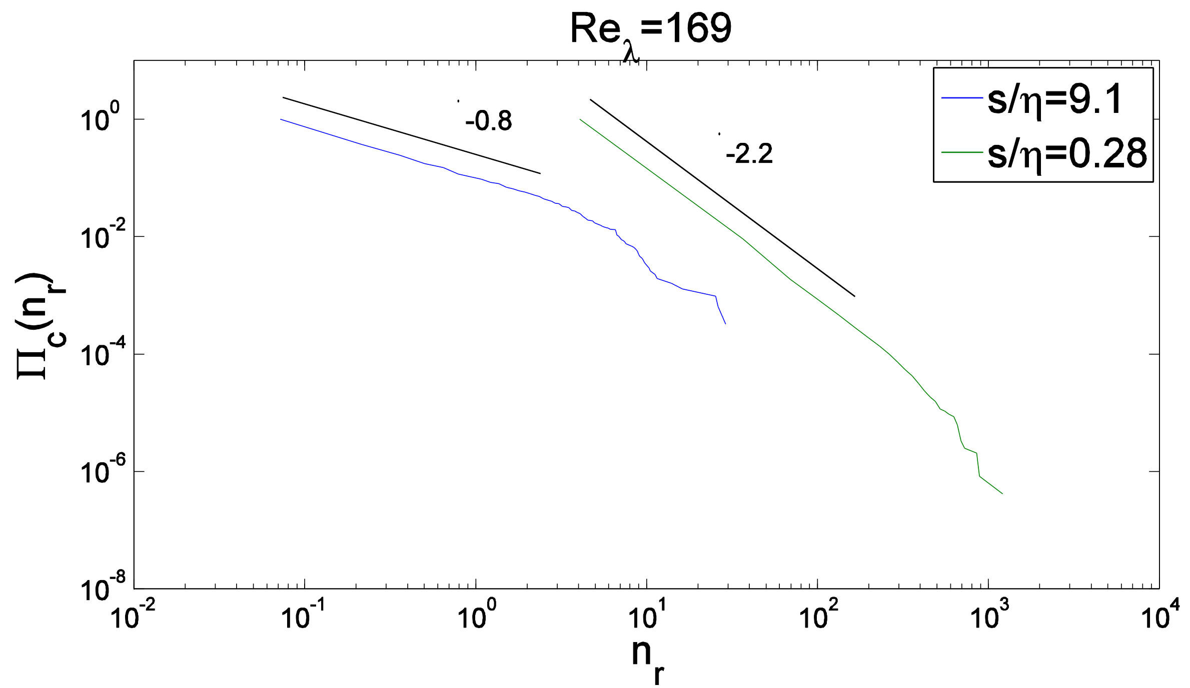
-For power-law distributions:

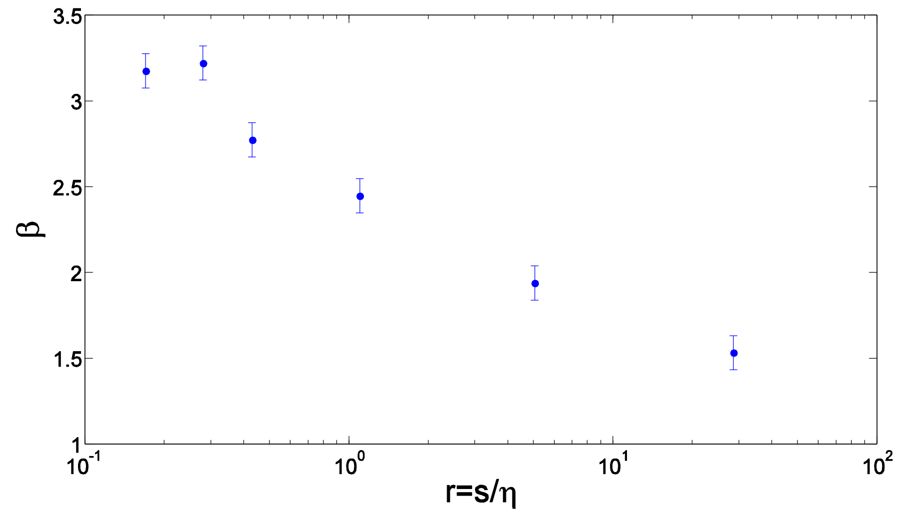
$$P(n_r) \propto n_r^{-\beta}$$

-Cumulative PDF:

$$\Pi_c(n_r) = \int_{n_r}^{\infty} P(n_r)\,dn_r \propto n_r^{-\beta+1}$$

Can this be explained by theory of compressible clustering?





V. Review

- Floaters coagulate into strings.
- Effect <u>not</u> due to surface waves or inertia.
- Distribution is scale dependent.

VI. Question?

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