I.A.C. 06 . A2 P.2.

Numerical study of the generation and dispersion of a bubble jet in microgravity

Pau Bitlloch [1]

Jordi Carrera [2]

Xavier Ruiz [3, 4]

Ricard González-Cinca [5]

Laureano Ramírez-Piscina [5, 4]

Jaume Casademunt [1, 4]

[1] Universitat de Barcelona, [2] NTE, SA, [3] Universitat Rovira i Virgili,

[4] Institut d'Estudis Espacials de Catalunya, [5] Universitat Politècnica de Catalunya

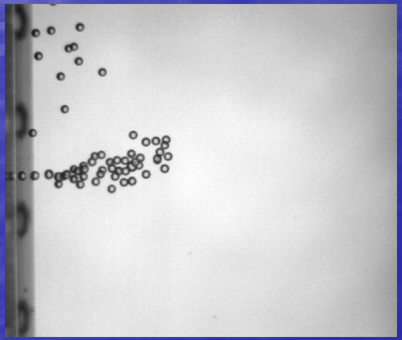
Previous experimental campaign

Recently, a first series of drop tower experiments was conducted, which proved the excellent performance of a new method of generation of monodisperse microbubble suspensions in microgravity

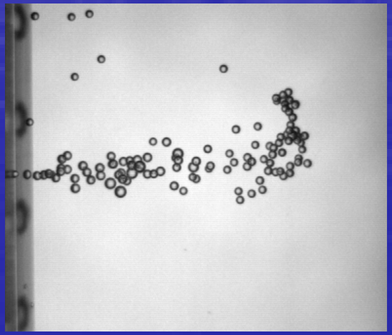
Results are relevant for a large variety of systems which may exploit the enhanced efficiency of biphase flows in space technology.

The experimental system allows also to address a number of basic questions concerning the collective dynamics of bubbles.

Normal Gravity



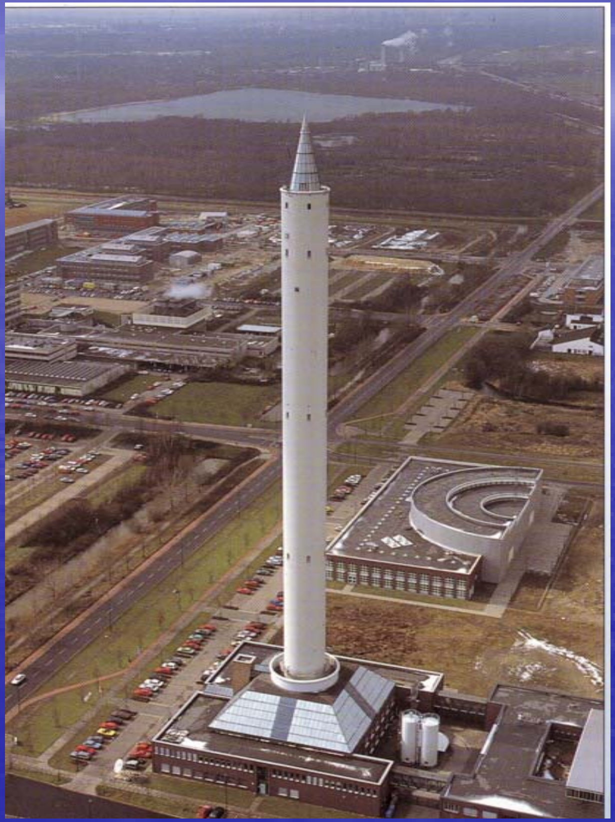
μg, t = 0.24 s



μg, t = 0.76 s

Drop number 1: Q_l = 0.69 ml / s, Q_g = 0.27 ml / s

Bremen Drop Tower



Dropping height =119 m

Compensated gravity time = 4.74 s

Residual accelerations = 10^{-5} to 10^{-6} g_E

Vacuum pressure < 10 Pa

Deceleration levels = 25 - 35 $g_\circ$ (200 ms)

Theoretical approach

We represent the turbulences using the standard k-ε model

The dispersion of bubbles are represented with a scalar magnitude *P* (the probability density of bubbles) wich is diffused within the jet by means of a diffusivity factor of the same magnitude than that of *k*

Standard k-ε model

$$\frac{\partial(\rho k)}{\partial t}+\nabla\cdot(\rho k\mathbf{U}) = \nabla\cdot\left[\left(\mu+\frac{\mu_t}{\sigma_k}\right)\nabla k\right]+2\mu_t E_{ij}\cdot E_{ij}-\rho\epsilon$$

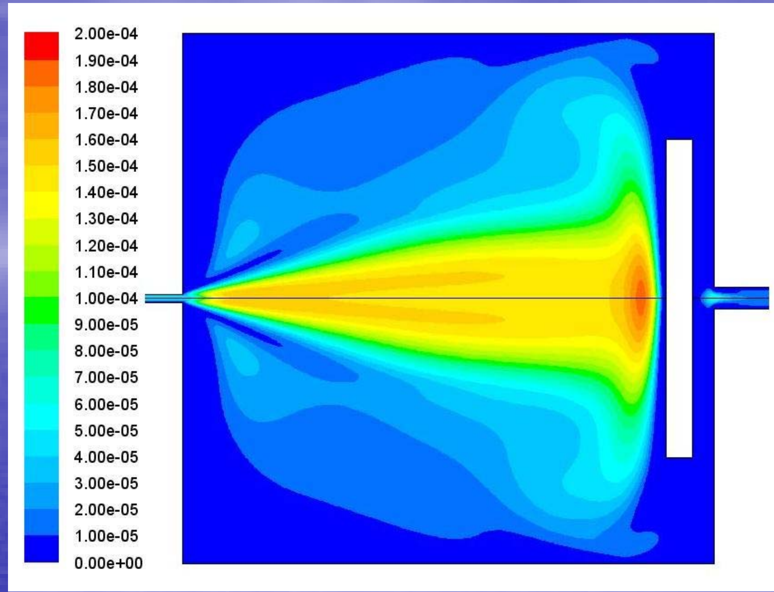
$$\frac{\partial(\rho\epsilon)}{\partial t}+\nabla\cdot(\rho\epsilon\mathbf{U}) = \nabla\cdot\left[\left(\mu+\frac{\mu_t}{\sigma_\epsilon}\right)\nabla\epsilon\right]+C_{1\epsilon}\frac{\epsilon}{k}2\mu_t E_{ij}\cdot E_{ij}-C_{2\epsilon}\rho\frac{\epsilon^2}{k}$$

$$\mu_t = \rho C_\mu \frac{k^2}{\epsilon}$$

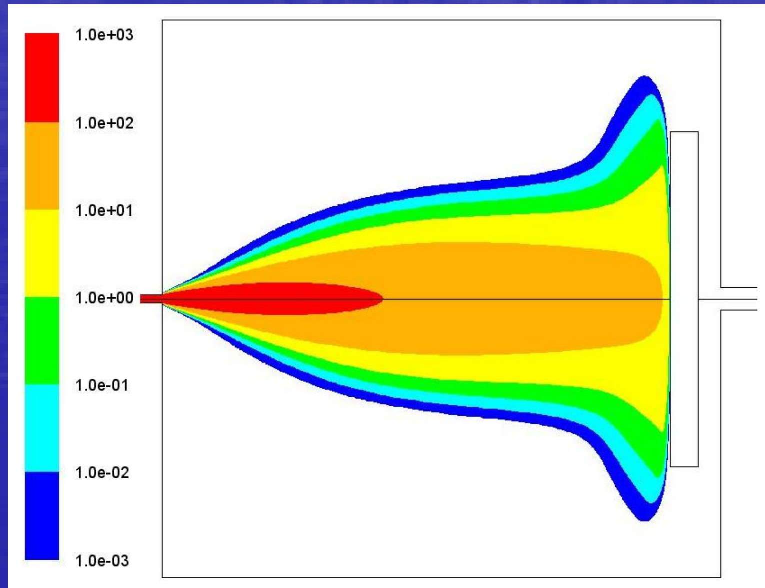
$$C_\mu = 0.09; \sigma_k = 1.00; \sigma_\epsilon = 1.30; C_{1\epsilon} = 1.44; C_{2\epsilon} = 1.92$$

Probability density P of bubbles

$$\frac{\partial P}{\partial t}+\nabla\cdot(\mathbf{U}P) = \nabla\cdot\left[\alpha\frac{k^2}{\epsilon}\nabla P\right]$$



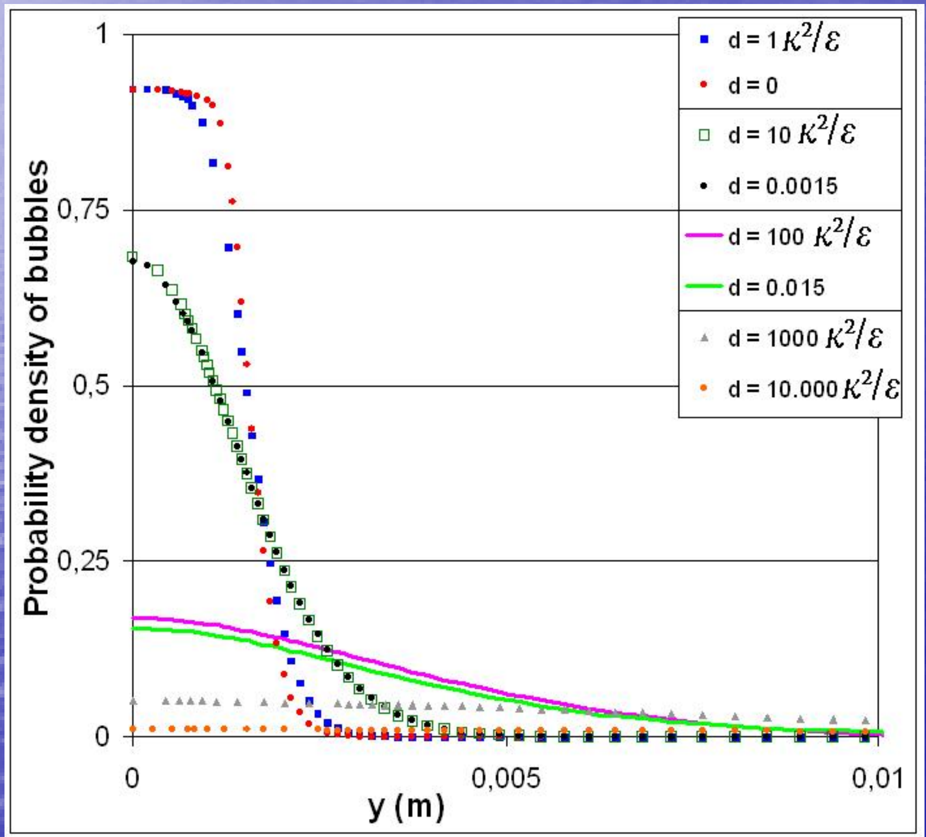
Contours levels of k^2/ε for the turbulent jet



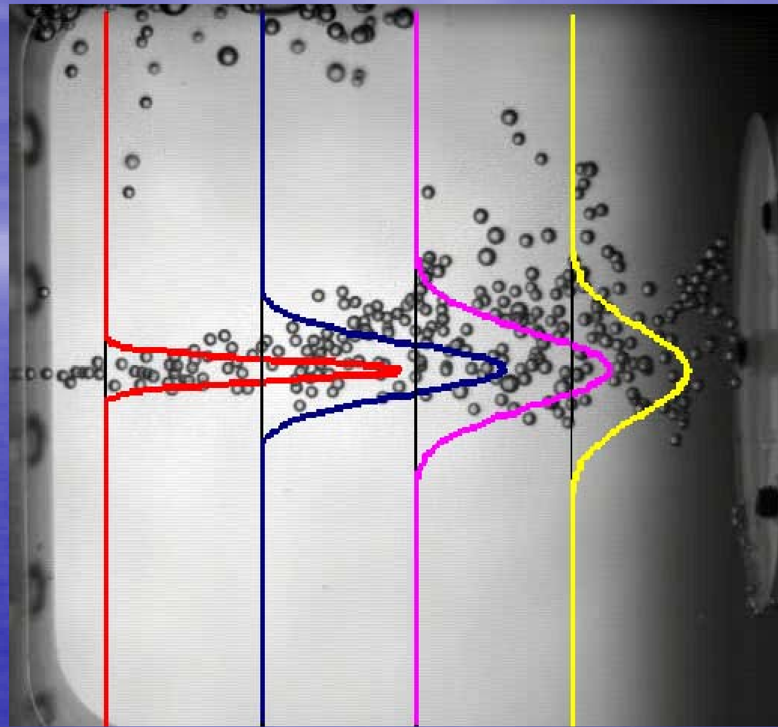
Contour levels of bubble probability density in logarithmic scale for a longitudinal section of the jet

Results and Conclusions

Good qualitative agreement with experimental results



Comparison of *P* for a vertical section at x=3cm with different treatment of the effective diffusion of bubbles, either homogeneous values or proportional to k^2/ε



Probability density of bubbles

Numerical results show that nonhomogeneous diffusivity is necessary to have realistic patterns of bubble dispersion.

We also find that the local diffusivity of bubbles is of the order of that of the kinetic energy of turbulences, which scales as k^2/ε **, and that diffusion and advection are quantitatively comparable.**

We conclude that the proposed stochastic model for bubble dispersion based on the k-ε **model of turbulence with local diffusivity is a proper description of experiments.**