A study of a monodisperse microbubble jet under microgravity conditions

J. Carrera[a,c], X. Ruiz[a,e], P. Bitlloch[a], L. Ramírez-Piscina[a,f], S. Arias[a,d], R. González-Cinca[d,f], M. Dreyer[g], J. Casademunt[a,b]

[a] *Institut d'Estudis Espacials de Catalunya (IEEC), Gran Capità, 2-4, 80034-Barcelona (Spain)*
[b] *Departament d'Estructura i Constituents de la Matèria, Facultat de Física, Diagonal 647, E-08028,, Universitat de Barcelona, Barcelona (Spain)*
[c] *NTE SA, Can Malé s/n, 08186 Lliçà d'Amunt, Barcelona (Spain)*
[d] *Escola Politécnica Superior de Castelldefels, Av. del Canal Olímpic, s/n, Campus Baix Llobregat, 08860, Castelledefels (Spain)*
[e] *Departament de Física Aplicada, Universitat Rovira i Virgili, Marcel i Domingo s/n, Campus Sant Pere Sescelades, E-43005 Tarragona (Spain)*
[f] *Departament de Física Aplicada, Universitat Politècnica de Catalunya, Jordi Girona 1-3, Campus Nord, Mòdul B4, E-08034, Barcelona (Spain)*
[g] *Center of Applied Space Technology and Microgravity (ZARM), Bremen, 28359 (Germany)*

The study of biphasic flows in microgravity environments constitutes an active area of research. In particular, the capability of generation and control of large numbers of microbubbles has promising applications in space technologies in which the contact area between phases has to be maximized in order to improve transport. In the present work a novel injector concept has been developed and characterized in which a slug flow is pre-generated in a capillary T-junction before injection [1]. The injector operating mode is dominated by capillary forces, so it is insensitive to gravity level. The performance of the injector system has been tested in a series of drops in the Zarm drop tower facility, which provides 4.74 s of microgravity conditions.

Experimental results show the generation of a virtually monodisperse jet of bubbles, of sizes of the order of employed capillary tubes, and indeed independent of gravity. Statistical data on bubble sizes, and on the dispersion of bubbles in a cavity, have been recorded. Events of coalescence of injected bubbles have been observed, but these appear to have small statistical relevance. An example of the biphasic injected jet is shown in Fig. 1. Additional ground experiments have been performed in order to completely characterize the slug flow generated at the T-junction. All these results are the basis for a coming new series of parabolic flight experiments.

An analytical approach to study the slug flow formation due to crossflow in a capillary T-junction has also been attempted [1]. Among the different forces acting on the detachment process, we show that capillary forces and drag are the relevant ones in this regime. Moreover, drag dominates when the forming bubble fills a large amount of the available cross section of the capillary, inducing then the detachment. We show that in this process the relevant parameter is the Weber number, *We*, of the liquid cross flow. We have calculated both the estimated bubble size and the size dispersion. Interestingly enough, the size dispersion scales with the Weber number, while the size only has a weak dependence on it. Therefore, and contrary to other common crossflow configurations, the optimum operating mode of the injector corresponds to the small Weber number limit [1]. In addition, a theoretical study of the dispersion of bubbles in the cavity has been made showing that a qualitative description of the bubble jet which is consistent with experimental observations requires that bubbles differ from being just passive tracers. We introduce a stochastic model for the bubble dispersion in which bubbles are advected passively and, at the same time, dispersed with an effective diffusion coefficient related to the local properties of the turbulent flow, which is modelled by using the RANS k-epsilon model. The probability density of finding a bubble in this stochastic model is governed by a Fokker-Plank type equation [2]. Numerical results seem to show good agreement with experiments (see Fig. 1). These results appear as highly relevant for the planning and analysis of further experiments.

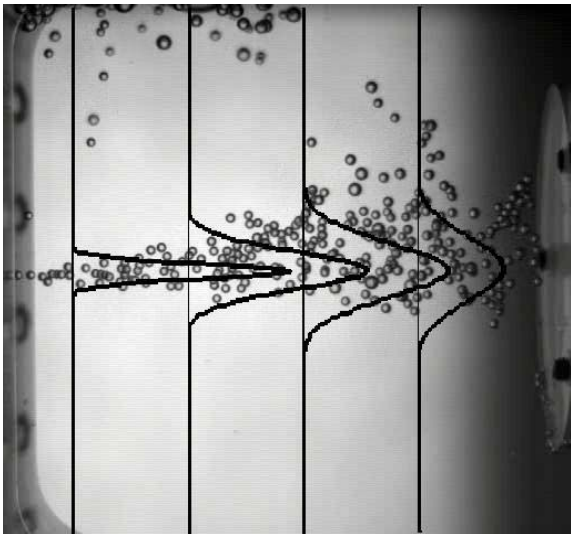

Figure 1. Microbubble jet generated in microgravity conditions. The linear size of the cavity is 10 cm. Predictions on projected bubble density at different distances are shown.

[1].- J. Carrera, X. Ruiz, L. Ramírez-Piscina, J. Casademunt, M. Dreyer, *Generation of a Monodisperse Microbubble Jet in Microgravity*, AIAA Journal, Submitted (2007).

[2].- P. Bitlloch, J. Carrera, X. Ruiz, R. González-Cinca, L. Ramírez-Piscina, J. Casademunt, *Numerical Study of the Generation and Dispersion of a Bubble Jet in Microgravity,* 57th International Astronautical Congress, Valencia, September 2006. (IAC-06-A2.P.2 Paper).