Experimental characterisation of the interaction between a vortex ring and a single bubble

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The interplay between bubbles and vortical structures comprises a yet to be understood complex and three-dimensional problem[1,2]. To investigate this phenomenon, we performed experiments on the interaction of a single, freely-rising bubble with a vortex ring. 3D measurements of the fluid and bubble motions were obtained by using time-resolved 4D-PTV and shadowgraphy. This technique allowed us to extract information about the vortex size and motion, as well as the bubble position, size and deformation. A global reconstruction of the bubble was performed thanks to a tomographic system including 6 high-speed cameras which provided a wide, three-dimensional field of view. The evolution of the flow was derived by using the Shake-The-Box (STB) technique[3].

We observed different interaction regimes, such as weak interaction, bubble break-up or weakening of the vortex ring, among others. These behaviours were found to depend on the Reynolds number, $Re = \Gamma/\nu$, the Weber number, $We = \rho(\Gamma/2\pi R_0)^2/(\sigma/R_b)$, the vortex-to-bubble size ratio, R_0/R_b, and the vortex thickness a/R_0, with Γ the vortex circulation, R_0 its radius, a its core size, and R_b the bubble radius. As shown in figure 1, the vortex may trap the bubble, drag it downstream, break it into 2 or more daughter bubbles and then release them. Different scenarios may happen for varying combinations of the governing parameters, impacting the vortex trajectory, the kinetic energy or the azimuthal vorticity depending on the vortex-bubble interaction. We also observed that, whenever trapped into the vortex core, the bubble tends to elongate along the ring radius with its minor axis occupying the full height of the vortex core before break-up or release.

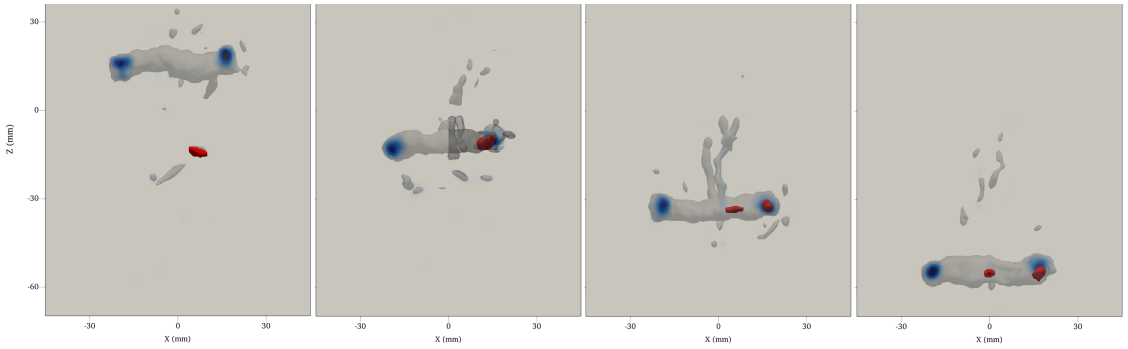

Figure 1: Sequence of frames showing a bubble-vortex ring interaction leading to bubble capture and break-up. $Re \approx 22600$, $We \approx 2.9$, $R_0/R_b \approx 3.3$, $a/R_0 \approx 0.26$. The bubble is shown in red, the vortex core in blue.

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