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## INTERACTION DAMAGE OF TWO CAPSULES IN SHEAR FLOW: EFFECT OF MEMBRANE PROPERTIES DIFFERENCES

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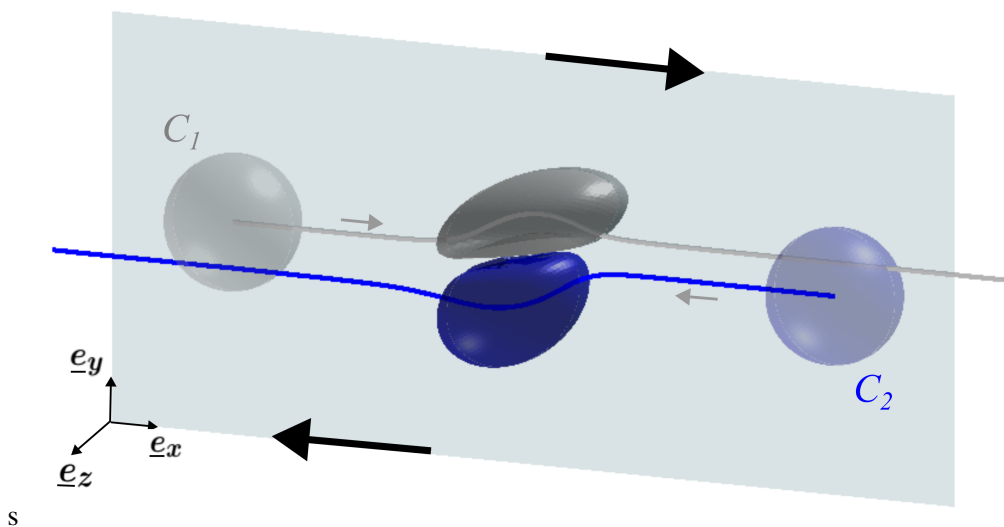
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Capsules are widely used in industry to protect an internal fluid against the external environment and control its release. Due to processing problems, suspensions of artificial capsules (or of cells) are rarely uniform. It is thus important to analyze the pair interaction of capsules with different physical properties in order to evaluate the stress levels in the membranes and predict potential mechanical damage that would alter the integrity of the particles.

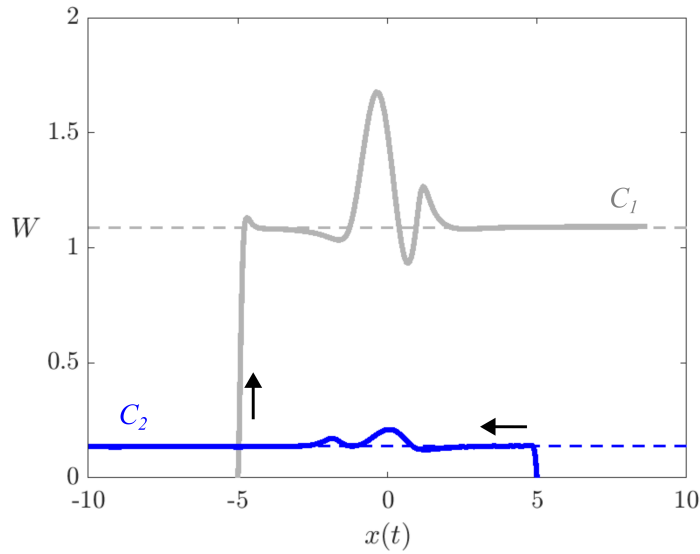
We consider two spherical capsules  $C_1$  and  $C_2$ , filled with the same liquid and enclosed by a very thin Neo-Hookean membrane. They have the same radius but their membranes have different surface shear modulus ( $G_{s1}$  and  $G_{s2}$ ). They are freely suspended in a simple shear flow under inertialess conditions. The capsule motion is computed by means of a fluid structure interaction model based on the boundary integral method to solve for the flow, coupled to a finite element method to compute the capsule wall deformation [1, 4].



**Figure 1.** Trajectories and deformation of two initially spherical capsules subjected to a simple shear. The grey arrows indicate the direction of motion for each capsule and the black arrows show the flow direction. In this case  $G_{s1} = 4G_{s2}$ .

The two capsules are initially positioned in the same shear plane but on different streamlines (Fig 1). The initial distance along the flow direction is large: the capsules thus first reach the steady deformation that they would have if they were alone in the flow. Then they come closer and pass each other (Fig 1) doing a leap-frog motion in the shear plane [2, 3, 4]. They continue their path and are eventually far enough to recover the single capsule profile that they had previously. However, an irreversible trajectory shift of their center of mass is observed, leading to self diffusion effects in the suspension.

The numerical model allows us to monitor the mechanical stress level in the capsule membranes during the whole interaction process. Specifically, during the close interaction phase, the capsules undergo a peak in



**Figure 2.** Evolution of the membrane energy  $W$  as a function of the centroid position along  $e_x$  for both capsules ( $G_{s1} = 4G_{s2}$ ). The value of the membrane energy when the capsule is alone in the flow at the same flow strength is represented by the dashed line. The arrows indicate the direction of time evolution.

membrane deformation energy, as shown in Fig 2. It is thus possible that at least one of the capsules exceeds the damage threshold [5]. For a given flow strength, a capsule may therefore be damaged because of the interaction whereas it would not have been damaged if it had been alone in the flow.

We will present phase diagrams that will show how the interaction damage depends on the capsule specific properties and on the flow strength. This information is useful to adjust the flow conditions to prevent damage to the weakest particles in a suspension, or to eliminate particles with properties that are below a given threshold.

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