Movie Captions

• Movie 1: Side-by-side comparison of simulation and experimental video of a quasi-spherical vesicle of reduced volume $\nu = 0.88$. The vesicle is deformed in the pulsating regime at $Ca = 10.9$, $De = 18.2$, and $\lambda = 1.00$. Experimental movie speed is 2X.

• Movie 2: Side-by-side comparison of simulation and experimental video of a quasi-spherical vesicle of reduced volume $\nu = 0.88$. The vesicle is deformed in the reorienting regime at $Ca = 10.9$, $De = 4.5$, and $\lambda = 1.00$. Experimental movie speed is 2X.

• Movie 3: Side-by-side comparison of simulation and experimental video of a quasi-spherical vesicle of reduced volume $\nu = 0.88$. The vesicle is deformed in the symmetrical regime at $Ca = 10.9$, $De = 3$, and $\lambda = 1.00$. Experimental movie speed is 2X.

• Movie 4: Side-by-side comparison of simulation and experimental video of a tubular vesicle of reduced volume $\nu = 0.64$. Experimental uncertainty of ± 0.02 for reduced volume measurement. The vesicle is deformed at $Ca = 21.3$, $De = 17.7$, and $\lambda = 1.00$ and displays pulsating like dynamics with wrinkling. Buckling of vesicle membrane is clearly visible during the compression phase of the flow. Experimental movie speed is 2X.

• Movie 5: Side-by-side comparison of simulation and experimental video of a tubular vesicle of reduced volume $\nu = 0.64$. Experimental uncertainty of ± 0.02 for reduced volume measurement. The vesicle is deformed at $Ca = 21.3$, $De = 8.9$, and $\lambda = 1.00$ with reorienting/pulsating like dynamics with wrinkling. In the experiments, change in 2D shape of the vesicle can be seen over repeated LAOE cycles. Experimental movie speed is 2X.

• Movie 6: Side-by-side comparison of simulation and experimental video of a tubular vesicle of reduced volume $\nu = 0.64$. Experimental uncertainty of ± 0.02 for reduced volume measurement. The vesicle is deformed at $Ca = 21.3$, $De = 4.7$, and $\lambda = 1.00$ and displays symmetrical/reorienting like dynamics. In the experiments, change in 2D shape of the vesicle can be seen over repeated LAOE cycles. Experimental movie speed is 2X.

• Movie 7: A quasi-spherical vesicle simulation of reduced volume $\nu = 0.80$ shown in the pulsating, reorienting, and symmetrical regimes at $= [2.0, 3.0, 4.0]$, $= 1.00$, and $\lambda = 1.00$.

• Movie 8: A prolate vesicle that starts aligned with the z-axis of $\nu = 0.80$, $= 3.00$, $= 1.00$, and $\lambda = 1.00$. Deforms symmetrically.

• Movie 9: A prolate vesicle that starts aligned 70 degrees rotated in the y-axis from the original x-axis orientation, such that is it is 30 degrees offset from the z-axis. Dynamics observed are equivalent to those seen in the symmetrical regime at other

starting orientations, parameters of $\nu = 0.80$, $= 6.00$, $= 1.00$, and $\lambda = 1.00$.

- Movie 10: A prolate vesicle that starts aligned 70 degrees rotated in the y-axis from the original x-axis orientation, such that is it is 30 degrees offset from the z-axis. Maintains off flow axis orientation, parameters of $\nu = 0.80$, $= 3.00$, $= 1.00$, and $\lambda = 1.00$.