5.3.3 Harmonic deformations

As a simple explicit example, consider harmonic deformations of the two arms, with identical frequencies ω and a mismatch in phases,

$$u_1(t) = d_1 \cos(\omega t + \varphi_1), \tag{5.33}$$
$$u_2(t) = d_2 \cos(\omega t + \varphi_2). \tag{5.34}$$

The average swimming velocity from Eq. (5.31) reads

$$\overline{V_0} = \frac{K}{2}\, d_1 d_2 \omega \sin(\varphi_1 - \varphi_2). \tag{5.35}$$

This result shows that the maximum velocity is obtained when the phase difference is $\pi/2$, which supports the picture of maximizing the area covered by the trajectory of the swimming cycle in the parameter space of the deformations. A phase difference of 0 or π, for example, will create closed trajectories with zero area, or just lines.