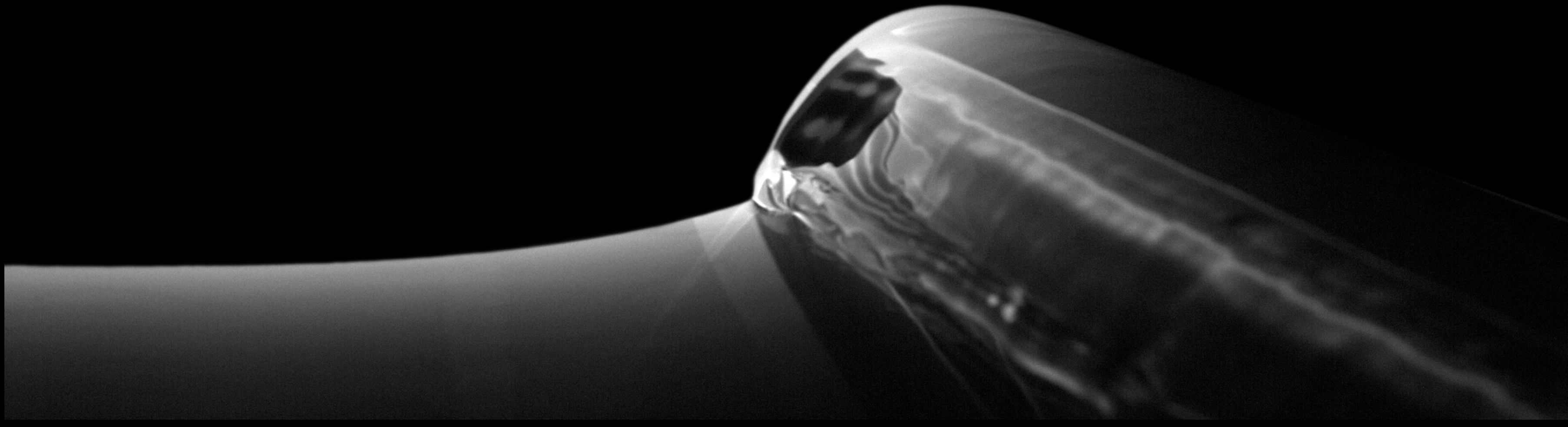# Effects of Ambient Surfactants on a Plunging Breaker

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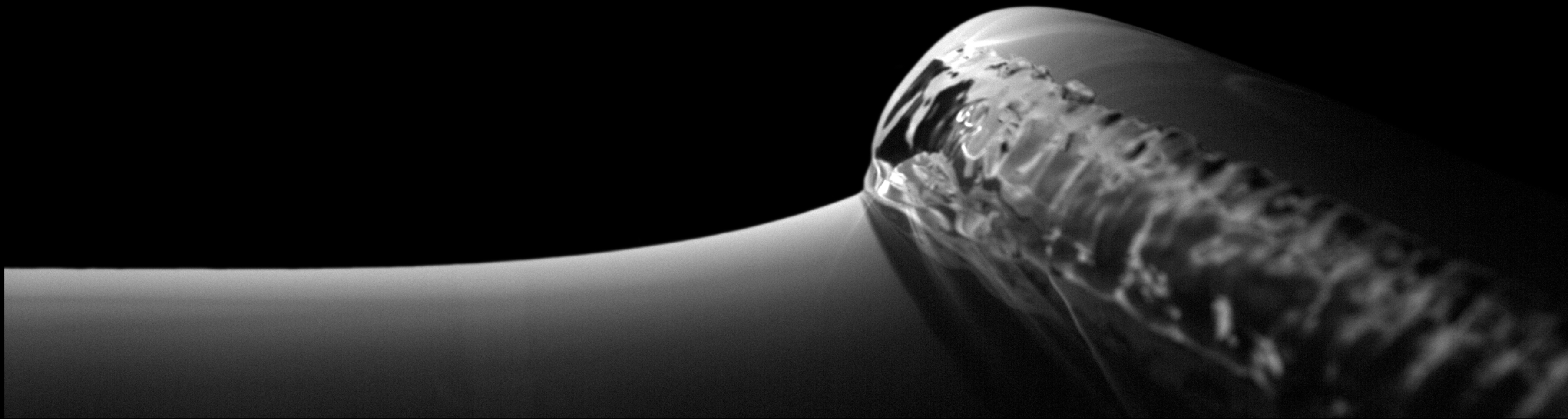
[1]University of Maryland, [2]Princeton University, [3]University of Oxford, [4]High Meadows Environmental Institute, Princeton University
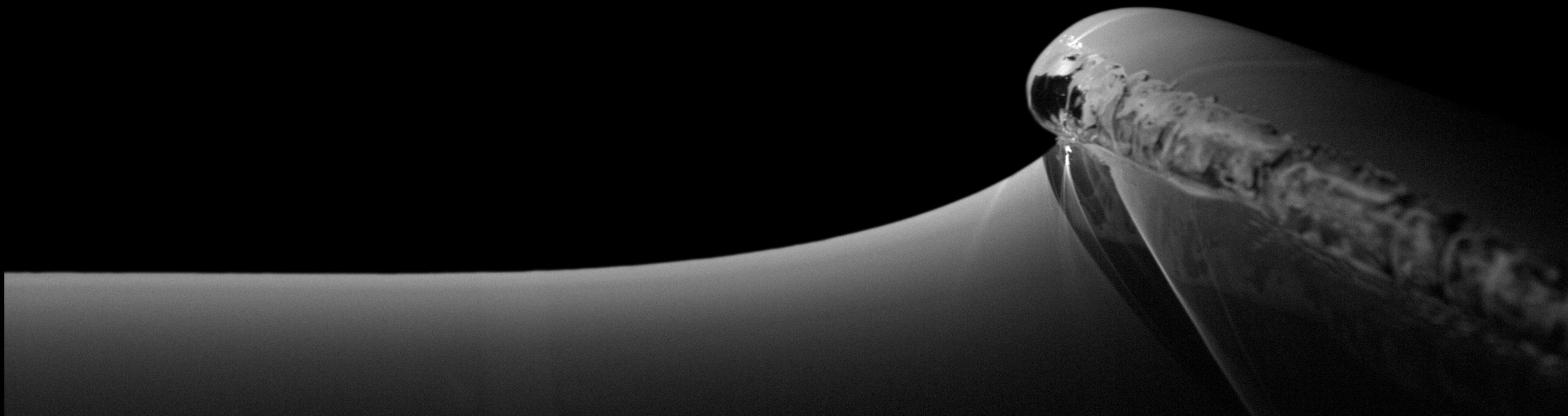
wait time
15 min

2 hrs

6 hrs

21 hrs

LIF images of four realizations of a plunging breaker at the moment of jet impact are shown. Breakers are generated via dispersively focused wave packets ($\overline{\lambda} \approx 1.2 \text{ m}$) created by identical wave maker motions in a wave tank filled with highly filtered tap water. The only difference between the breaker realizations is the amount of time allowed between the moment that the tank's filtration/skimmer system is turned off and the time that the breaker is generated (called the wait time). As seen in the images, the plunging jet and entrained air tube at jet impact are smooth at 15 minutes wait time. As the wait time increases, and the jet curls closer to the crest and instabilities grow to create an irregularly shaped jet and air cavity.

It was found that the surface profile changes are consistent with changes in the water surface dynamic properties due to surfactants. In this scenario, though the tank water was highly filtered, a low level of soluble surfactant remains in the bulk. Over time, surfactant molecules adsorb onto the water surface, changing its dynamic properties. Surprisingly, the surfactants do not change the ambient surface tension, which is close to that of clean water in all four conditions. Instead, the longer wait times increase the Gibbs elasticity, which can cause Marangoni stresses along the wave crest as the water surface compresses and dilates during the formation of the plunging jet. These results imply that Marangoni stresses, which are typically thought to act on small length scales, dramatically change the wave breaking process in the wave crest region for waves with $\lambda \sim \mathcal{O}(1 \text{ m})$. For a more complete physical explanation, see Erinin et. al (2023)[1].

[1]M. A. Erinin, C. Liu, X. Liu, W. Mostert, L. Deike, J. H. Duncan (2023). The effect of surfactants on plunging breakers. Journal of Fluid Mechanics