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Unsteady Sail Dynamics in Olympic Class Sailboats CHARLES WILLIAMSON, RILEY SCHUTT, Cornell University — Unsteady sailing techniques have evolved in competitive sailboat fleets, in cases where the relative weight of the sailor is sufficient to impart unsteady motions to the boat and sails. We will discuss three types of motion that are used by athletes to propel their boats on an Olympic race course faster than using the wind alone. In all of our cases, body weight movements induce unsteady sail motion, increasing driving force and speed through the water. In this research, we explore the dynamics of an Olympic class Laser sailboat equipped with a GPS, IMU, wind sensor, and a 6-GoPro camera array. We shall briefly discuss "sail flicking", whereby the helmsman periodically rolls the sail into the apparent wind, at an angle which is distinct from classical heave (in our case, the oscillations are not normal to the apparent flow). We also demonstrate "roll tacking", where there are considerable advantages to rolling the boat during such a maneuver, especially in light wind. In both of the above examples from on-the-water studies, corresponding experiments using a towing tank exhibit increases in the driving force, associated with the formation of strong vortex pairs into the flow. Finally, we focus on a technique known as "S-curving" in the case where the boat sails downwind. In contrast to the previous cases, it is drag force rather than lift force that the sailor is trying to maximise as the boat follows a zig-zag trajectory. The augmented apparent wind strength due to the oscillatory sail motion, and the growth of strong synchronised low-pressure wake vortices on the low-pressure side of the sail, contribute to the increase in driving force, and velocity-made-good downwind.

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