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Physics of Naval Flows[1]

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The flow past a ship operating in the ocean is one of our most challenging physics problems. Looking at a ship operating in waves, we see a fluid sheet separating off the bow, a multiphase contact line along the hull waterline, spray and bubbles from wave breaking, air wakes, and Kelvin ship waves. Below the waterline, we see turbulent boundary layers, 3-D flow separation and vortices, cavitation, and the rotational flow from the propeller. We also have the ocean itself adding a layer of complexity. A marine platform interacts with the world through environmental and hydrodynamic forcing. The environment (waves, wind, and buoyancy/gravity) acts on the platform, and it acts on the environment (propulsor, hull, and control surfaces). However, a naval platform's performance is characterized by more than just its performance as a ship, and in fact, it might be a submarine, planing craft, or amphibious vehicle, and the performance is also now characterized by its ability to perform military missions and survive. To the list of technical areas we have already mentioned, fluid dynamics and oceanography, we can now add acoustics, heat transfer, and meteorology. As we have noted the complexity of naval flows due to the range of physical phenomena (turbulence, waves, wave breaking, cavitation, boundary layers, etc.), we should also note the complexity due to the range of spatial and temporal time scales involved. For the phenomena already mentioned, we are interested in length scales ranging from Kolmogorov to Rossby.

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