Self-propulsion of floating ice blocks by melting

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The melting of icebergs floating on the ocean is often accompanied by buoyant convection flows [1], as temperature and salinity variations modify locally the water density. Significant gravity driven currents occur thus at the vicinity of iceberg below the water surface. As these currents carry momentum, they can participate to the drift of the iceberg, in addition to the more important contribution of the wind and oceanic currents. Previously, Dorbolo et al. related the spinning of floating ice disks to the convection flow driven by melting [2]. However due to the symmetric shape, no propulsion was reported. Then, Mercier et al. [3] showed the self-propulsion of a floating asymmetric solid with an embedded local heat source that generates thermal convection. Recently, we demonstrate that an inclined boat incorporating an inclined plate made of a solute material like salt and sugar can propel more rapidly due to the solutal convection flow driven by the dissolution [4]. Here, we investigate now, the propulsion of asymmetric floating ice blocks. For a water bath at a temperature of about $T_b = 20°$, we report typically propulsion velocity of order 5 mm/s for ice prisms of width about 10 cm with a rectangular triangle base of diagonal about 20 cm. We use a shadowgraph imaging setup to simultaneously track the motion, evaluate the melting rate and visualize the buoyancy convection flow (Fig. 1). A phenomenological model relating the melting rate to the transitional speed explains the magnitude of the reported propulsion velocities.

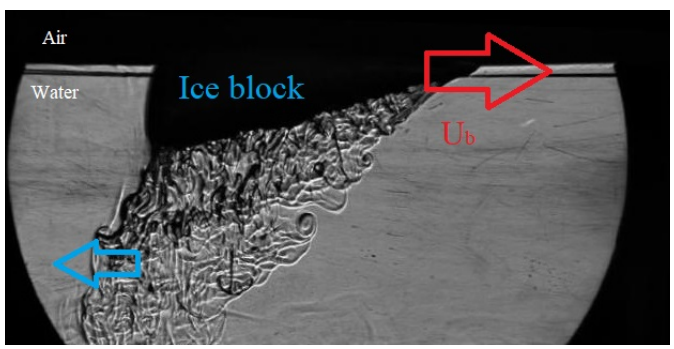

Figure 1. Shadowgraph imaging of a floating ice block (width 9 cm, diagonal 21 cm) during its melting in a bath at $T_b = 20°$. Due to the inclined melting surface, the convection flow is deviated on the left direction. Consequently, the block self-propel at a velocity of 4 mm/s (red arrow).

References

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