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First observations of shear-modified ship and ring waves

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We report experimental observations of ship waves and ring waves which are strongly and strikingly modified by the presence of sub-surface shear. These are canonical wave patterns, admired since the dawn of time and studied for two centuries, yet observations of their modification by shear have not previously been reported to our knowledge. Ship waves become narrower, broader or asymmetric in different directions of motion, and ring waves are seen to be visibly skewed and non-circular; none of this is possible on a depth-uniform current. The measured data match well the predictions from recent theory in all cases.

Observations were made in a recently built laboratory. A tailored shear current was created by two different means: by the insertion of a curved mesh at the inlet, and beneath a stagnant surface layer created by the Reynolds ridge phenomenon. Both the surface elevation and the shear profile were measured, the former with a synthetic schlieren method, the latter with particle image velocimetry. The dispersion relation in different directions was measured directly, and shows good agreement with that predicted based on the measured velocity profile.

Our observations lend strong support to recent theoretical predictions of strong shear effects in practical situations, and are striking examples of surface signatures of the sub-surface flow.