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Undulation–induced checkerboards in the 2-point function of 1D water flows

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In analogue models of curved spacetimes, white-hole horizons are as ubiquitous as black-hole horizons, these being time-reversed versions of each other. In a flowing medium (such as water in a flume), a white-hole horizon occurs where the flow crosses the speed of sound while decelerating. Considering surface waves on top of such a flow, incident hydrodynamical modes are blueshifted until a dispersive scale is reached, and the Hawking process at white-hole horizons is thus characterized by the emission of short wavelengths with close to zero frequency in the laboratory frame. This short-wavelength emission generates a growing “checkerboard” pattern in the two-point function of free surface deformations [1], the white-hole equivalent of the off-diagonal correlation profile characteristic of Hawking emission from black-hole horizons [2,3].

However, white-hole horizons are typically accompanied by stationary undulations in the flow profile, emitted in the same direction as the short-wavelength Hawking emission. Indeed, the growth of such an undulation can be viewed as a zero-frequency limit of the Hawking effect [4]. Its final amplitude being large compared with typical surface wave amplitudes, the undulation must be included in the background flow profile representing the effective spacetime, and its presence can significantly affect the surface wave scattering coefficients encoding the Hawking spectrum [5-7]. Moreover, slightly different realisations of the undulation will contaminate the two-point function, thus rendering the identification of the characteristic features of the Hawking effect rather delicate.

We will present experimental observations showing the presence of an undulation downstream from a white-hole horizon, as well as of a checkerboard pattern in the two-point correlation function of free surface deformations. While this pattern resembles that indicative of white-hole Hawking emission, analyses indicate that it can have a different origin. In particular, when the flow is not constrained by a gate at the downstream end of the flume, the checkerboard pattern stems from a degree of randomness in the position of the undulation. This is most clearly illustrated by the long timescales on which the checkerboard's temporal correlations vary, these being significantly longer than the typical propagation time associated with the passage of surface waves. Conversely, in flows constrained by a gate, we see no such clear separation of timescales. This is consistent with a greater degree of stability of the undulation and with the observed checkerboard pattern having its origin in the scattering of surface waves.

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