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Observed structure of an internal tide beam over the Mid-Atlantic Ridge

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Internal tides are key players in ocean dynamics above mid-ocean ridges. The generation and propagation of internal tides over the Mid-Atlantic Ridge (MAR) have been studied through theoretical and numerical models, as well as through moored, that is, one-dimensional, observations. Yet, observations remain sparse and often restricted to the vertical direction. Here we report on the first two-dimensional in situ observation of an internal tide beam sampled by a shipboard acoustic Doppler current profiler through a vertical section over the MAR. The beam is generated by the interaction of the barotropic tidal current with a supercritical abyssal hill that sits in the rift valley of the MAR. A vertical mode decomposition is carried out to characterize the spatio-temporal variability of the beam. Although the modal content of the velocity field is dominated by modes 1 to 3, higher modes display localized and not persistent bursts of energy. The use of an analytical theory for linear internal waves allows us to rationalize the observed velocity field and interpret it as the superposition of modal waves generated on the hill and propagating in the same direction. The observed beam is qualitatively reconstructed as the superposition of waves of modes 2 to 6. The velocity field was sampled seven times across the same section and displayed qualitatively different patterns, unveiling the complexity of the dynamics above the MAR. A ray tracing of modal waves shows that the refraction by mesoscale currents could explain the observed variability of the tidal beam.