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**Observations of out of plane arrivals for long range low frequency
transmission in shallow water**

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Two recent experiments have used long horizontal arrays to receive broad-band low frequency signals propagated over long ranges in shallow water. Both used m-sequence signals that resolve pulse arrivals in time with each arrival associated with a single acoustic mode of propagation. At moderate propagation ranges, out to 20 km. wave fronts for all modes are observed to be parallel, implying an orderly two dimensional propagation. At a much longer range, 80 km, a number of separable arrivals are observed but not necessarily with a one-to-one correspondence with modes. The paths appear to be stable and coherent in time implying that they are true Fermat paths, but their wavefront arrival angles differ suggesting the same mode is arriving from several directions, that is, by curved (out of plane paths). The paths could result from wedge effects from gentle slopes perpendicular to the propagation path or possibly from chaotic interaction with random facets of the bottom. In any case, the ultimate limitation for horizontal spatial coherence and array resolution may be the multipath interference of bundles of out of plane arrivals.