THE WAVEGUIDE INVARIANT FOR MID-FREQUENCY ACTIVE SONAR

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In the paper "Interference of wide-band sound in shallow water" [J. Sound Vib. (1972)], Weston and Stevens report results from acoustic transmission experiments made in the Bristol Channel. By towing a broadband source, they were able to construct maps of acoustic intensity as a function of range to the receiver and frequency. The maps can be interpreted as the constructive and destructive interference between the propagating acoustic modes that are supported by the shallow water waveguide. The work is a natural extension of Weston's earlier papers analyzing the interference patterns observed in laboratory tank experiments [J. Acoust. Soc. Am. (1960), (1968)]. Russian scientists appreciated the importance of Weston's fundamental research on interference patterns. Chuprov (1982) developed the waveguide invariant, a simple scalar that related the trajectories of the striations evident in interference patterns to the acoustic frequency and the range to the source. The waveguide invariant became a standard technique for Russian scientists to analyze low-frequency passive sonar problems. Of contemporary interest is extending the waveguide invariant method to mid-frequency active sonar. This extension is made complicated by multiple factors. First, as noted by Weston, the number of propagating modes scales linearly with frequency. Consequently, there are many more modes in the mid-frequency (1-10 kHz) band yielding a more detailed interference pattern. Second, as shown in the present work, acoustic mode coupling cannot be ignored at mid-frequencies. Energy gets redistributed between the modes by internal waves, a gradual propagation effect that can be described using transport theory. Energy also gets redistributed by the target, an abrupt scattering process that can be described using a T-matrix. Following Weston's example, the interchange of energy between acoustic modes and its effect on the waveguide invariant is demonstrated using data collected both in the field and in the laboratory. [Work supported by ONR.]