mode expansion and is limited to range independent and weakly range dependent environments. A different approach is introduced that describes the interfering components in terms of their travel times. This leads to a very simple derivation of basic results that apply equally well to range dependent environments and to situations, such as Lloyd's Mirror, in which the normal mode representation is inconvenient. Beta can be expressed in terms of the local phase velocities and the difference in travel times for the interfering components. The travel time differences involve integration over the entire path trajectories from the source to the point where the interference pattern is observed. Numerical examples using ray theory will be presented.

4:00

4pUW12. Evidence of three-dimensional waveguide propagation in SWARM 95 data. Scott Frank, William L. Siegmann (Rensselaer Polytechnic Inst., 110 8th St., Troy, NY 12180), and Mohsen Badiey (Univ. of Delaware, Newark, DE 19716)

During a period of the SWARM95 experiment, strong nonlinear internal waves passed across two tracks that had airgun pulses propagating along them. Environmental data for this period indicate that the angles between the tracks and the internal wave-fronts, which were roughly planar, were very different—one angle being close to zero, and the other approximately 42 deg. Two-dimensional PE simulations for these waveguides show dramatically different results for depth-averaged, pulse-integrated energy variations. Specifically, the observed levels can be reproduced for the waveguide with the large incidence angle, but not for the one with the small incidence angle. For the latter case, data show significant variations in pulse shapes and in the integrated energy (≈ 5 dB), while simulations show very small changes in both of these characteristics. Results from several recent computational and theoretical studies suggest that the cause may be three-dimensional effects from horizontal refraction and modal interference due to the nonlinear internal waves. The adiabatic mode parabolic equation [Collins, J. Acoust. Soc. Am. **94** (1993)] is used to quantify the three-dimensional influence of the internal waves on the integrated energy variations. The results demonstrate experimental evidence of three-dimensional effects from strong nonlinear internal waves. [Work supported by ONR.]

4:15

4pUW13. Computing the two-point correlation function directly from the transport equation using split-step Padé solutions. Chen-Fen Huang, Philippe Roux, and W. A. Kuperman (Scripps Inst. of Oceanogr., La Jolla, CA 92093-0238, chenfen@mpl.ucsd.edu)

The two-point correlation function that describes the correlation between an acoustic field at two depths as a function of range obeys a transport equation. Without making a frequency or narrow angle approximation, this equation can be solved by parabolic equation methods. The solution algorithm is split into two depth-steps using the alternating direction implicit (ADI) method to advance one range-step. Then, at each depth substep, the split-step Padé solution [M. D. Collins, J. Acoust. Soc. Am. **96**, 382–385 (1994)] is used. Computations are confirmed against intensities computed from the indirect method that constructs the two-point function by an outer product of pressure vectors. Examples of the propagation of the vertical correlation for deep, shallow, and stochastic environments are presented.

4:30

4pUW14. A study on simplification of the Biot–Stoll model in water-saturated porous medium. Keunhwa Lee and Woojae Seong (Dept. of Ocean Eng., Seoul Natl. Univ., Seoul 151-742, Korea)

A practical approximate method based on the Biot–Stoll model to represent acoustic waves in the ocean in the presence of porous sediment is presented. The ocean sediment can be described individually by four models; visco-fluid, visco-elastic, equivalent fluid, and water-saturated porous medium. The first two models are approximate forms of the Biot–Stoll model. The equivalent fluid model of Zhang and Tindle [J. Acoust. Soc. Am. **98**, 3391–3396 (1995)] derived for the fluid/solid interface is extended to the fluid/porous-medium interface for analytical derivation of the reflection coefficient. Then, the reflection characteristics as functions of frame stiffness (Kb/Kr) and frequency region (f/fc) are discussed for all four models. In weak stiffness and high-frequency region, the equivalent fluid and visco-fluid bottom models describe ocean bottom better than the visco-elastic bottom model. Two-phase property is dominant in strong (high) stiffness or high-frequency region. This demonstrates that the visco-fluid and equivalent fluid models are useful approximate models in weak stiffness porous material such as the marine sediment.

4:45

4pUW15. Asymptotic methods of evaluation of acoustic fields generated by underwater moving sources. Vladimir S. Rabinovich (Instituto Politecnico Nacional de Mexico, ESIME-Zacatenco, edif. 1, Av. IPN, Mexico, D.F. 07738)

The problem of acoustic waves propagation from sources moving in stratified and almost-stratified waveguides simulating real oceanic waveguides is considered. It is assumed that acoustic sources move under water in the ocean with a subsonic variable velocity. Our approach for the evaluation of the acoustic field is based on the combination of two asymptotic methods: (1) The asymptotic analysis of the Green's function for almost-stratified waveguides by the operator ray method with respect to a small parameter which characterizes the variation of waveguides in the horizontal direction; (2) a subsequent asymptotic analysis of the integral representation of the field generated by a moving source by the two-dimensional stationary phase method with respect to a large parameter which characterizes the smallness of variations of the amplitude of source and the smallness of the vertical component of the source speed. Asymptotic formulas for the acoustic pressure, for the mode and time Doppler effects, are obtained. These formulas have a clear physical meaning and are convenient for the numerical simulation of the problem.

5:00

4pUW16. Analysis of very high frequency propagation in sediments: Experimental results and modeling. Richard Brothers, Sarah Page, Gary Heald (QinetiQ, Newton's Rd., Weymouth DT4 8UR, UK, rbrothers@qinetiq.com), Tim Leighton, Matt Simpson (ISVR, Southampton Univ., UK), and Justin Dix (SOC, Southampton Univ., UK)

A current QinetiQ study is investigating the propagation of sound waves into sediment at frequencies higher than 300 kHz. Previous work has found notable discrepancies between model predictions and experimental results and comparisons are inconsistent and unreliable. This new work package investigates the development of new scattering theories for frequencies ranging from 300 kHz to 1 MHz. In particular, the application of a pseudospectral time difference approached is analyzed. The model originally developed for lower frequency applications, is set up in various geometrical scenarios and for varying very high frequencies. Results show the received simulated pulses obtained for hydrophones placed within the sediment and source colocated. Furthermore, simulations are compared in tank experimental data. The controlled tank experiments were conducted by Southampton University and data are analyzed and discussed for various conditions and frequencies.