

Passive source ranging by using mode filtering and mode phase comparing in waveguide

E. C. Shang, C. S. Clay and Y. Y. Wang

Citation: [The Journal of the Acoustical Society of America](#) **74**, S78 (1983); doi: 10.1121/1.2021147

View online: <https://doi.org/10.1121/1.2021147>

View Table of Contents: <https://asa.scitation.org/toc/jas/74/S1>

Published by the [Acoustical Society of America](#)

ARTICLES YOU MAY BE INTERESTED IN

[Source depth estimation in waveguides](#)

The Journal of the Acoustical Society of America **77**, 1413 (1985); <https://doi.org/10.1121/1.392034>

[A method of range and depth estimation by modal decomposition](#)

The Journal of the Acoustical Society of America **82**, 1736 (1987); <https://doi.org/10.1121/1.395825>

[A simple method for depth estimation of a sound source at known range in the deep sea](#)

The Journal of the Acoustical Society of America **146**, 4097 (2019); <https://doi.org/10.1121/1.5134443>

[Nonlinear time-warping made simple: A step-by-step tutorial on underwater acoustic modal separation with a single hydrophone](#)

The Journal of the Acoustical Society of America **147**, 1897 (2020); <https://doi.org/10.1121/10.0000937>

[Modal depth function estimation using time-frequency analysis](#)

The Journal of the Acoustical Society of America **130**, 61 (2011); <https://doi.org/10.1121/1.3592230>

[Passive broadband source depth estimation in the deep ocean using a single vector sensor](#)

The Journal of the Acoustical Society of America **148**, EL88 (2020); <https://doi.org/10.1121/10.0001627>

JASA
THE JOURNAL OF THE
ACOUSTICAL SOCIETY OF AMERICA

Special Issue:
Additive Manufacturing and Acoustics

[Read Now!](#)

MM14. Bandlimited cross correlation in a multipath environment: Simulation study results. Peter D. Herstein, Helen M. Sternberg, Bernard F. Cole, and Henry Weinberg (Naval Underwater Systems Center, New London, CT 06320)

The technique of intersensor cross correlation of acoustic signals is used to obtain such information as the spatial coherence of the environment or the position parameters of a broadband source. In general, acoustic energy propagates from a source to a sensor along multiple raypaths. However, cross-correlation performance is frequently analyzed in terms of a single wavefront (planar) model. For the planar model, the signal received at each sensor is approximated as the sum of the delayed and attenuated source signal plus uncorrelated Gaussian noise. This enables the use of performance criterion based on receiver signal-to-noise ratios. Extensive analysis of cross-correlation performance under the assumption of the planar model has been reported [G. C. Carter, IEEE Trans. Acoust. Speech Signal Process. ASSP-29(3) (1981)]. In this paper, modeling of the cross correlation between two sensors is extended to analyze the situation of a bandlimited signal propagating in a multipath environment. Using the generic sonar model (H. Weinberg, NUSC TD 5971C), a representative deep ocean configuration was simulated in which the propagation was dominated by four first-order bottom bounce type rays. Results are presented as functions of (a) the range and bearing of the source, and (b) the vertical tilt of the baseline of the sensors. It is shown that multipath effects can profoundly effect the level of the normalized cross-correlation peak. Signal-to-noise ratio at each sensor is found to be an inadequate estimator of correlation performance for this type of multipath environment. [This work was sponsored by the Naval Sea Systems Command, Washington, DC.]

2:43

MM15. Energy partitioning and optical-to-acoustic conversion efficiency during laser generation of underwater sound. Allan D. Pierce (School of ME, Georgia Institute of Technology, Atlanta, GA 30332)

Two mechanisms (thermoacoustic and ablative) are considered with regard to how much optical energy is eventually transformed into sound. The analysis of the former begins with a fluid dynamic analysis of the generation of entropy and acoustic modal fields taking into account viscosity and thermal conduction. The acoustic modal field satisfies the Westervelt-Larson inhomogeneous wave equation while the entropy modal field satisfies a transient heat conduction equation with similar source term. The derivation demonstrates that the Westervelt-Larson equation is valid under much broader circumstances than was previously asserted by Bozhkov and Bunkin. The bulk of the absorbed optical energy goes into the entropy mode, but the acoustic portion can be enhanced if the spatial and temporal dependence of the energy deposition resembles a solution of the wave equation, such that initially generated waves are continually pumped by the source. An upper limit to the conversion efficiency is of order $(\beta/\rho c_p)p_{\max}$, where β is coefficient of thermal expansion and p_{\max} is maximum attained (by source pumping) acoustic pressure in the source region. Ablation generates sound because of the recoil force acting on the surface when evaporated material jets off; the corresponding acoustic radiation efficiency is estimated using a model proposed by Bunkin *et al.* [JETP Lett. 13, 341-343 (1971)]. [Work supported by ONR.]

2:47

MM16. Pattern recognition by means of a hybrid adaptive autoregressive processing system. Bonnie Schnitta-Israel (KLD Assoc., Inc., East Hampton Field Office, 94 Pantigo Road, E. Hampton, NY 11937)

An automatic pattern recognition algorithm, consisting of event detection, feature extraction, and a decision process, was developed. The complete processing system was labeled SIGNET. The feature extraction aspect of SIGNET formulated the autoregressive (AR) coefficients from a hybrid adaptive AR algorithm in combination with a weighted linear threshold element into a linear prediction residual (LPR). The structure of the data sequence was then identified by extracting those LPR segments, which established event type boundary phenomena. SIGNET was evaluated

on two sets of data. The first set was comprised of nine independent underwater transient sources. The percent of correct recognition of SIGNET in that evaluation ranged from 93 to 98. The second data set was from a strong impulsive seismic source. The percent of correct recognition was 97. The mathematical foundation of SIGNET was also used successfully as a basis for a multiple source identification technique. [Work supported by ONR/Environmental Sciences.]

2:51

MM17. Passive source ranging by using mode filtering and mode phase comparing in waveguide. E. C. Shang, C. S. Clay, and Y. Y. Wang (Department of Geology and Geophysics, University of Wisconsin-Madison, Madison, WI 53706)

The conventional beamforming technique could not be used for source locating in waveguide owing to the modal interference structure of the field. In this paper a new method of passive source ranging in a layered waveguide has been proposed. The mode-filtering processor was used to process the field data of a vertical array in order to obtain individual modes. The source range information can be extracted by measurement of three individual mode phases. The source range was expressed in terms of the "mode interference distance" as following: $r = L_{ij}D_{ij} + \Delta r_{ij}$; $\Delta r_{ij} = D_{ij}(\delta\phi_{ij}/2\pi)$, where L_{ij} is a certain integer; $\delta\phi_{ij}$ is the phase difference of the i th mode and the j th mode; D_{ij} is the "mode interference distance" defined by: $D_{ij} = 2\pi/(k_i - k_j)$; k_i is the wavenumber of the i th mode given by a numerical mode code. The information of L_{ij} can be estimated by means of comparing the phase of the j th mode with another mode, say m th mode, and then L_{ij} was estimated by solving the following equation: $(\delta\phi_{ij}/2\pi) = \text{Fractional part } \{ (D_{ij}/D_{jm}) [L_{ij} + (\delta\phi_{jm}/2\pi)] \}$.

2:55

MM18. Models of fluid structure interactions to optimize acoustics performance of sonar systems. Jacqueline Larcher, Jean-Marc Parot, and Jean-Paul Berhault (Société METRAVIB, BP 182, 69132 Ecully Cedex 2, France)

In sonar systems, the interaction of transducer elements with the inner dome cavity and the boundary layer with the dome structure affect the overall acoustic performance of the system in terms of aberrations and self-noise. Simple mathematical models have been derived to represent both phenomena. For acoustic aberrations resulting from coupling between the transducer and the acoustic cavity plus dome structure, an analytic numerical model has been used to identify significant technological parameters controlling the performance. A statistical energetic model describes coupling between the hydrodynamic boundary layer, the dome dynamic structural behavior and the inner sonar cavity. Experimental data have been collected on full scale and model sonar structures representing realistic excitation and loads conditions. Results of theoretical models and experimental data show good agreement on the effects of cavity modes and area mass for acoustic aberrations and of dome structural dynamic properties for hydrodynamic self-noise.

2:59

MM19. A comparison of broadband sonar discrimination between human listeners and a filter bank model. Douglas W. Martin and Whitlow W. L. Au (Naval Ocean Systems Center, P. O. Box 997, Kailua, HI 96734)

Broadband sonar discrimination capabilities of human listeners as a function of signal-to-noise ratio were compared with the constant-Q filter bank model of Chestnut, Landsman, and Floyd [J. Acoust. Soc. Am. 66, 140-147 (1979)]. A 48-s pulse (122-kHz peak frequency, 39-kHz 3-dB bandwidth) was used to collect echoes from aluminum, glass, and bronze cylinders. Discrimination experiments were performed in pairs, aluminum-glass, hollow-solid aluminum, and aluminum-bronze. A modified method of constants with the noise levels randomized in ten-trial blocks and the signals time-expanded into audio frequencies were used in the human experiments. Thirty contiguous filters covering a frequency band of 50 to 200 kHz were used in the constant-Q model. The human listeners performed significantly better than the computer model, requiring at least 5 dB less signal-to-noise ratio at the 75% correct threshold. Listeners reported that dominant cues occurred in the time domain.