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RECONSTRUCTION OF LAYERED ELASTIC BOTTOM CHARACTERISTICS BY THE FREQUENCY DEPENDENCE OF SOUND REFLECTIVITY*

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The relation between the sound reflection losses measured at fixed grazing angles and the characteristics of the sediment layer and underlying half-space is considered. Based on this relation, a method of the reconstruction of the sea bottom characteristics is developed for a ocean bottom consisting of a single sediment layer overlaying a semi-infinite elastic half-space. Using this bottom model, the reconstruction of the characteristics of a layered elastic bottom is performed from the numerically simulated data with induced synthetic error.

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JOINT 3D TRAVELTIME INVERSION OF P, S AND CONVERTED WAVES*

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Converted waves can play a basic role in the traveltime inversion of seismic waves. The sought velocity fields of P and S waves are almost decoupled, when considering pure P and S arrivals: their only connection are the possible common reflecting interfaces in the Earth. Converted waves provide new equations in the linear system to be inverted, which directly relates the two velocity fields. Since the new equations do not introduce additional unknowns, they increase the system rank or its redundancy, so making its solutions better constrained and robust.

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COMPLETE FAMILIES AND RAYLEIGH OBSTACLES*

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Complete families in a given function space are sets of linearly independent functions, a linear combination of which can approximate any other function with arbitrarily high accuracy. Outgoing cylindrical wave functions are one such family, used to represent the scattered wave in exterior boundary value problems for the scalar Helmholtz equation in two spatial dimensions. When the incident wave is plane and the scattered wave is represented by a series of said functions, which converges up to the boundary of the obstacle, the obstacle is said to be in the Rayleigh class. One shall further distinguish between Dirichlet–Rayleigh and Neumann–Rayleigh obstacles, according to the applicable boundary condition. Discs are trivial obstacles of these classes. Ellipses of eccentricity η such that $\eta^2 < 1/2$ were shown to be in the Dirichlet–Rayleigh class by Barantsev *et al.* in 1971, who used the saddle point method to asymptotically estimate the Fourier scattering coefficients. Herewith, another one parameter family of obstacles is constructed by the same method. It is also shown that the same obstacles are in the Neumann–Rayleigh class. The relevance of these results to the numerical treatment of scattering problems is briefly discussed.

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A SIMPLE REGULARIZATION METHOD FOR SOLVING ACOUSTICAL INVERSE SCATTERING PROBLEMS*

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The problem of determining the shape of an object from far-field data is considered. We present a method, originally formulated in Ref. 1 and furtherly modified in Ref. 3, for the solution of this ill-posed nonlinear inverse problem whose main features are:

- the method is exact, that is no low- or high-frequency approximation is considered;
- it is not necessary to know the number of scatterers and whether or not the scatterers are penetrable by the waves;
- if the medium is not penetrable, it is not necessary to know whether the obstacle is sound-hard or sound-soft;
- in the case of an inhomogeneous scatterer, the method provides the shape of the inhomogeneity.

The method is particularly simple since it requires only the solution of a linear Fredholm integral equation of the first kind whose integral kernel is the far-field pattern. The numerical instability due to ill-conditioning can be reduced by using regularization algorithms such as Tikhonov method where the regularization parameter is chosen by using Morozov's discrepancy principle generalized to the case where the noise affects the kernel of the integral operator.

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THE USE OF THE HERGLOTZ FUNCTION METHOD TO RECONSTRUCT OBSTACLES FROM REAL AND FROM SYNTHETIC SCATTERING DATA*

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We consider the problem of the reconstruction of the shape of an obstacle from some knowledge of the scattered waves generated from the interaction of the obstacle with known incident waves. More precisely we study this inverse scattering problem considering acoustic waves or electromagnetic waves. In both cases the waves are assumed harmonic in time. The obstacle is assumed cylindrically symmetric and some special incident waves are considered. This allows us to formulate the two scattering problems, i.e. the acoustic scattering problem and the electromagnetic scattering problem, as a boundary value problem for the scalar Helmholtz equation in two independent variables. The numerical algorithms proposed are based on the Herglotz Function Method, which has been introduced by Colton and Monk.[1] We report the results obtained with these algorithms in the reconstruction of simple obstacles with Lipschitz boundary using experimental electromagnetic scattering data, that is the Ipswich Data[2,3] and in the reconstruction of "multiscale obstacles" using synthetic acoustic scattering data.

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NONLINEAR INVERSION OF PIEZOELECTRICAL TRANSDUCER IMPEDANCE DATA*

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We describe a nonlinear least squares inversion algorithm for obtaining elastic and electromagnetic properties for piezoelectric materials from measured impedances. Richard Brent's PRAXIS, a general unconstrained minimization code is used for the nonlinear least squares fit. No explicit derivatives of the goal functional are required by this code. Bound constraints are imposed in order to limit the variability of the parameters to physically meaningful values. Since PRAXIS is an unconstrained optimization code, these constraints are introduced via a novel change of independent variables. The forward modeling is achieved by using a coupled finite element time domain code for the elastic and electro-magnetic parts of the problem. We also describe how a linearized sensitivity analysis can be used to suggest *a priori* which parameters can be calculated from impedances measured on a given sample. Numerical results are included.

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AN ALGORITHM FOR THE FULLY NONLINEAR INVERSE SCATTERING PROBLEM AT FIXED FREQUENCY*

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We reconstruct an object which is described by a complex valued function from the scattered waves generated by irradiating plane waves at fixed frequency. The scattering process is modeled by the Helmholtz equation and includes multiple scattering. We present numerical results from computer generated data.

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MAXIMUM LIKELIHOOD INVERSION OF ACTIVE REVERBERATION FOR BOUNDARY LOCALIZATION ON A MOVING SONAR PLATFORM

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This paper addresses the problem of determining the environmental parameters of an acoustic channel based on partially processed data in an active sonar system. The premise is that a system has been designed to detect and track targets and may not have an auxiliary sonar system available to make environmental assessments. In this case, the data available to the processor may be beamformed in an unfavorable direction for the assessment (or parameter estimation) that is sought. Two methods to make such an estimation will be explored, including an approximate method which can make a computationally inexpensive estimate by fitting the likelihood functions.

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MATHEMATICAL SIMULATION IN DIFFRACTION ACOUSTICAL TOMOGRAPHY WITH MULTIELEMENT TRANSCEIVER*

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The parameters of diffraction tomography methods for inhomogeneity reconstruction is investigated. For a two-dimensional case with linear multi-element transceiver one single frequency and two multi-frequency measurement schemes are introduced. For these schemes the data regions in the spatial frequency domain of inhomogeneities function are presented. The new two-stage approach is developed for resolution investigation and image quality estimation. In the first stage, it is proposed to find the resolution for ideal measurement conditions (infinite measurement aperture, ideal transducers). Then in the second stage for real measurement conditions, it is enough to determine only the degradation factor which is calculated for all measurement schemes dependent on measurement parameters. For examination of this approach also the images for complicated inhomogeneity model are calculated. It is shown that resolution and point spread functions cannot fully describe image quality, especially for complicated data regions in the spatial frequency domain of the inhomogeneities function. Many numerical examples are presented.

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RADIAL ULTRASONIC TOMOGRAPHY TECHNIQUE AS A NEW METHOD OF FLAW IMAGING

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The problem of a flaw position estimation in cylindrical homogeneous objects is briefly discussed. A number of SAFT algorithms for ultrasonic reconstruction are reviewed. A new method of flaw position determination is developed. Its main advantages are that this method does not require knowledge of the radius of the cylinder and of the time delay into the wedge transceiver. In spite of a lack of data it is possible to estimate with sufficient accuracy the radial position of a flaw from so-called radial tomogram. The theory of radial tomography is presented. A numerical algorithm based on Radon transformation is described. An example of a flaws radial position reconstruction is shown. The main possible application of the radial tomography technique is reconstruction of small cracks with radial orientation for cylindrical objects with unknown radii.

MULTIRESOLUTION IN 3D SEISMIC TOMOGRAPHY WITHIN PHYSICAL LIMITS

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In the parametric inversion of traveltime of direct and reflected arrivals, the design of the Earth model is a compromise between two opposite needs: on one hand, we look for the finest details of the geometrical and physical properties of rocks; on the other hand, the limited signal band-width and the mathematical ambiguities suggest us to reduce the sought unknowns. We compare here two different approaches to this problem, i.e. adaptive versus staggered grids. Adaptive grids can fit the local resolution according to different physical and mathematical criteria, as the Fresnel radius and the null space energy. Staggered grids are less flexible, but much simpler and potentially more efficient. We compare these methods both in 2D and in 3D by synthetic examples, including the EAEG/SEG salt model.