

Semiclassical Approximations And Predictability In Ocean Acoustics

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LONG-TERM GOAL

Our long-term goal is to improve our understanding of the physics of the forward scattering of underwater sound. Of particular interest is understanding limitations on the predictability of underwater sound fields, especially using semiclassical (ray-based) methods. Improving our understanding of the mechanism(s) that contribute to the loss of predictability will lead to improved predictive models.

OBJECTIVES

The scientific objective of this work is to understand limitations on the predictability of acoustic wavefields in realistic (range-dependent) ocean environments. Both full wave and semiclassical predictive models are of interest. Both cw and broadband wavefields are of interest. We seek to both develop improved predictive acoustic models and to understand their limitations.

APPROACH

Using semiclassical methods, ideas relating to ray chaos provide a framework for studying predictability. Wavefield behavior in the ray limit is explored numerically and, whenever possible, analytically. The extent to which limitations on predictability carry over to finite frequency wavefields are then explored numerically, generally with parabolic equation based models. Both deterministic and stochastic models are of interest. Comparisons with data are made whenever possible.

Several tools have recently been developed and/or extended for use in our work: Tappert's co-insensitive PE model; the MaChl algorithm (Brown, 1994) for finite frequency ray-based wavefield predictions; a new stochastic ray model (Brown and Viechnicki, 1998) to model scattering by internal waves; and a new efficient algorithm to generate realistic internal wave induced sound speed perturbation fields (Colosi and Brown, 1998).

This work is being done in loose collaboration with the following individuals: F. Tappert (U. Miami; parabolic wave equations, waves in random media, ray chaos); M. Wolfson (Washington State U.; numerical modelling, waves in random media, ray chaos); G. Zaslavsky (Courant Institute; chaos in dynamical systems, stochastic methods, quantum chaos); S. Tomsovic (Washington State U.; quantum chaos and semiclassical breakdown); and J. Colosi (WHOI; internal waves, long-range propagation).

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 1998		2. REPORT TYPE		3. DATES COVERED 00-00-1998 to 00-00-1998	
4. TITLE AND SUBTITLE Semiclassical Approximations and Predictability in Ocean Acoustics				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Miami,Rosenstiel School of Marine and Atmospheric Science,4600 Rickenbacker Causeway,Miami,FL,33149				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM002252.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 3	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

WORK COMPLETED

The principal accomplishment of the recent years are 1) the development and numerical implementation of stochastic ray theory to describe and model the scattering of sound by internal waves in deep ocean environments; 2) the development (with J. Colosi at WHOI) of a new efficient, accurate, and robust algorithm to compute internal-wave-induced sound speed perturbation fields; 3) incorporation of this internal wave model into both ray and full wave propagation models; 4) demonstration that for a large class of problems involving boundary interactions, ray phase errors are inversely proportional to frequency and increase linearly with range; and 5) demonstration (Brown, 1998) that, in the ray limit, islands of stability in phase space exist when the environment is almost stratified and has quasiperiodic range dependence.

RESULTS

Stochastic ray theory and the new technique to compute internal-wave-induced sound speed perturbation fields are important new tools which can be used to address fundamental questions relating to the predictability of long-range sound propagation in deep ocean environments. The work relating to the structure of phase space provides critically important insight into - and a mathematical framework for the study of - wave propagation in environments with nontrivial range-dependence. Our predictability studies show that, even in the presence of chaotic ray motion, semiclassical wavefield representations accurately predict many important features of underwater acoustic wavefields.

IMPACT/APPLICATION

Our work gives insight into the limitations on the predictability of underwater sound fields. This is an important basic science issue which impacts all systems applications which require accurate predictions of underwater sound fields.

TRANSITIONS

The PI collaborates informally with the investigators listed above, ATOC investigators, and others. This includes the sharing of both ideas and software. It is not known whether any software produced by the PI has been used to address any applied Navy problems.

RELATED PROJECTS

This work is closely related to the ATOC project and the ONR-funded work being performed by P. Worcester (SIO), J. Colosi (WHOI), M. Wolfson (WSU), J. Spiesberger (PSU), S. Tomsovic (WSU), G. Zaslavsky (CIMS) and F. Tappert (U. Miami). All of these projects are concerned with aspects of long-range propagation.

REFERENCES

Brown, M.G., 1994, A Maslov-Chapman wavefield representation for wide-angle one-way propagation, *Geophys. J. Intl.* 116, 513-5263.

Brown, M.G., and J. Viechnicki, 1998, Stochastic ray theory for long-range sound propagation in deep ocean environments, *J. Acoust. Soc. Am.* 104, 2090-2104.

Colosi, J.A., and M.G. Brown, 1998, Efficient numerical simulation of stochastic internal wave induced sound speed perturbation fields, *J. Acoust. Soc. Am.* 103, 2232-2235.

Brown, M.G., 1998, Phase space structure and fractal trajectories in 1 1/2 degree of freedom Hamiltonian systems whose time dependence is quasiperiodic, *Nonlinear Processes in Geophysics*, in press.

PUBLICATIONS

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