Wave-Wave Interactions and the Infrasonic Pressure Field in the Ocean

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by

Cheng Yi Wu

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Abstract

Building on Kibblewhite's long term investigations of the nonlinear wave-wave interactions and the infrasonic ocean noise and the microseisms these induce, this thesis further explores the physical nature of these processes. The classical description of this interaction, which takes into account only the homogeneous component of the induced field, has been extended to include the inhomogeneous component. A complete expression for the wave induced noise spectrum is established following a geometrical analysis of the dispersion relations among interacting waves. The relative importance of these two components and their directivity properties are also calculated and discussed. It is shown that while at observation points deeper than 500 meters the effects of the inhomogeneous component can be regarded as negligible, it can cause an increase of noise level of up to 40 dB in the region near the surface of the sea. Furthermore, in contrast to the nearly omni-directional distribution of the homogeneous component of the induced acoustic field, there is a tendency for the energy associated with the inhomogeneous component to focus in the wind direction.

Based upon a multilayer analysis of a visco-elastic geoacoustic model, Green's functions and the spectral transfer functions relating the surface source pressure field to the underwater noise and microseism fields are derived for both near and far field cases. A 3-dimensional presentation defined on the dispersion plane (frequency and horizontal wave number) is introduced to discribe the sea bottom reflection-loss and Green's functions, and is extended to include the inhomogeneous region for the first time. The characteristics of this 3-D presentation are explained in terms of the geoacoustic parameters.

The influence of the interaction of multiple seas (and swell) on the induced acoustic field are also discussed in this thesis.

All these effects are considered in the calculation of the synthetic spectra of both the noise and microseism field. When compared with measured data excellent agreement is found between the theoretical and experimental results, which provides further confirmation that the nonlinear interaction is the most important source of the infrasonic ocean noise, as well as confirming the basic validity of the procedure introduced by Kibblewhite and Ewans to derive the ocean noise spectra from microseism records.

Acknowledgements

Now I am finally close to the end of the project. I am very excited. Four years ago, attracted by the interesting connection between the ocean wave activities and microseismic noise records reported by Kibblewhite and Ewans I began this study. When I firstly got from Professor Kibblewhite his collection of four fully packed boxes of reference papers I could not keep from being surprised by the complexity and involvement of this subject. So many branches of science: air turbulent motion, ocean wave development, underwater acoustics, and seismic wave propagation are involved and I wondered what I should choose to do first. It was Professor Kibblewhite who had then suggested and encouraged me to focus on the physical nature of the wave interaction process and the energy transfer in real environments. For the last four years I have been kept in going progressively in this direction without straying.

Reviewing the whole process I owe all the progresses in the study to Professor Kibblewhite, my supervisor. His close guidence is vitally important to my studies at each stage. His enthusasm for exploring unknowns as well as the spirit of devoting to science have greatly influenced me, and most importantly, his deep insight into the subject and rich in experiences of scientific researches have from time to time guided me solving all the problems I met. Infact, what I have done is only small improvements based on his previous wide range investigations. I owe him also most of original ideas and motivations in the development of this study. I got from him all the geoacoustic parameters and experimental data used in the thesis. Besides these, he finantially supported me to cover all the expenses. Without all these it would never be possible for me to finish this study. Another thing which often touched me deeply was the great patience he exercised in correcting my poor English drafts and even rewriting them.

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I thus always feel it not proper to put only my name as the auther of the thesis. In fact in this long period of study I received also large amount of help, beside those mentioned above, from all my friends and colleagues in the department.

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