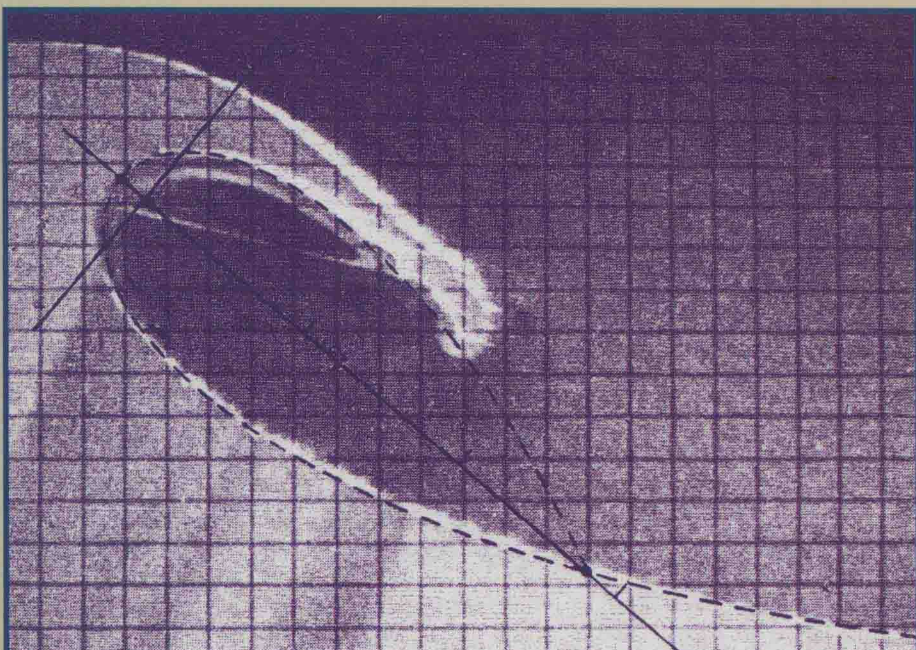
Advanced Series on Ocean Engineering — Volume 35

DYNAMICS OF WATER WAVES

Selected Papers of Michael Longuet-Higgins

Volume 3



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Preface by S G Sajjadi

It is a pleasure and honour to write this brief preface to introduce this three-volume selection of papers by a close colleague, Professor Michael Longuet-Higgins, FRS.

As a biographical sketch written by him follows this preface I will limit myself to some thoughts of mine having to do with his influence on our community. From the recognition which Professor Longuet-Higgins has received in appreciation of his work I would like to mention his work on microseisms.

Scientists have long known about microseisms, but, until recently, no one could determine where they came from. Microseisms were first recorded as a strange, continuous buzz on the earliest seismometers, devices that measure earthquakes. Every year, the cumulative energy released by these small vibrations equals the amount of energy released globally from earthquakes. Records of microseismic activity give scientists a history of wave interaction in Earth's oceans since the early 20th century. They are also used to examine the history of storms over the ocean. Scientists are interested in learning where these microseisms originate because the information can help them monitor stress in Earth's crust.

The theory of the origin of microseisms was first introduced in 1950 by Michael Longuet-Higgins whilst at the University of Cambridge in England. Longuet-Higgins suggested that the vibrations originated in places where ocean waves were traveling in opposite directions toward each other at the same frequency and at a certain ocean depth. According to his theory, when these waves collide, they combine to form stationary waves that remain in a constant position over large areas of the ocean. These waves create tall, pulsing columns of pressure that repeatedly beat down on the ocean floor, causing it to vibrate. The vibrations generate seismic surface waves, which spread out thousands of miles and are detected by seismometers as noise. This new study on microseisms, which appeared in the March 2007 issue of the Proceedings of the Royal Society, Series A was part of interdisciplinary collaboration, which included Longuet-Higgins and researchers from the California Institute of Technology, Pasadena and the Hydrologic Research Center in San Diego.

This three volume set presents selected original research papers of Professor Longuet-Higgins in the various areas of water waves, ocean dynamics, and fluid mechanics. I believe they will serve as a milestone and beacon for future generations.

Apart from the subject area covered in these three volumes, Longuet-Higgins has published papers in other fields such as electromagnetic measurement of tidal streams and ocean currents, time-varying currents depending on the Earth's rotation, projective geometry, etc. These papers have not been included in the present selection, but it is hoped that they will be published in a separate volume in the near future.

Finally, my thanks are due to a number of publishers for their permissions for photographic reproduction of the original papers. In particular I wish to thank the Royal Society of London, the Oxford University Press, the Cambridge University Press, MacMillan Publishing Co., the Journal of Physical Oceanography, the Journal of Marine Research, the American Physical Society, the American Geophysical Union, Prentice-Hall, Pergamon Press and Elsevier Publishing Co.

S G Sajjadi
ERAU, Florida
December 2008

Preface by Michael Longuet-Higgins

The practical consequences of wave motion for both the coastal engineer and the geophysicist are many and varied, and new applications constantly arise to keep the subject alive. At the same time, surface waves challenge the fluid dynamist to find an explanation for such spectacular phenomena as wave breaking, when the upper surface overturns on itself.

The present collection of original papers is not intended to cover the whole subject. It is simply a selection of basic contributions by a single author and his collaborators. On reflection, the papers can be seen to have been guided by certain points of view: (1) a preference for simple or "physical" explanations where possible, and particularly for geometrical interpretations. (2) a desire to solve problems by accurate analysis initially, but then to find simpler approximate models, easier to apply in practice. (3) an acknowledgement of the need to compare theoretical results with field observations or laboratory experiments. Like many other subjects, fluid mechanics advances by putting one foot forward and then the other.

For convenience, this collection is arranged according to subjects. Included in this first Volume are the author's principal papers on microseisms; on mass transport by water waves; on stochastic processes, especially applied to wind-waves; on various mechanisms of wave generation by wind; and on the theory and consequences of radiation stresses (momentum flux due to waves). Conference papers are generally omitted, since usually they consists of reviews of the original papers, doubtless in a more readable form. Preceding each group of papers, there is a brief introduction giving the circumstances under which the papers were written, and providing further background information.

As an appendix to Volume III, a list is given of the author's papers on other subjects. Some, as for instance time-varying ocean currents, are closely related to papers in this Collection, while other subjects are widely different.

My thanks are due to Professor SG Sajjadi for offering to undertake the editing of this selection of my papers. I would also like to express my indebtedness to some of my mentors, colleagues and collaborators, aside from those named explicitly in the subsequent text. In particular I wish to mention CV Durrell, the senior mathematics don at Winchester College, for his thorough mathematical grounding, and for his encouragement of my first forays into mathematical research; to Dr George Deacon, leader of Group W at the Admiralty Research Laboratory at Teddington, England, from 1944 to 1949 and subsequently the first Director of the UK National Institute of Oceanography at Witley, for his consistent support; to Norman Barber, a senior physicist in

group W; he was my first research supervisor who introduced me to "physical" ways of looking at mathematical problems; to Sir Harold Jeffreys, for his inspiring lectures on probability and statistics at Cambridge University; and to Sir Geoffrey Taylor, for his inimitable style of research. Walter Munk has been a long-time friend and advocate. It is be appropriate to mention those many anonymous referees who have helped me on my scientific journey.

Perhaps the greatest credit of all should go to the subject of water waves for affording the student such great pleasure and interest, and to the waves themselves, for following so obediently the laws of mathematical physics.

A Brief Biography

In 1943, at the age of seventeen, the author entered Trinity College, Cambridge, with a scholarship in mathematics from Winchester College, the school where he had spent the first four years of World War II. Already he had acquired a taste for research in geometry. By the summer of 1945, he had qualified for a Cambridge BA in mathematics. He was then required to do three years "work of national importance." Fortunately for him, he was assigned to "Group W" (for waves) at the Admiralty Research Laboratory, Teddington. This Group had been formed in June 1944 to study the long-distance propagation of ocean waves in preparation for projected military operations in the Pacific Ocean. The Group had been spectacularly successful, and its lease of life had been extended, with wider terms of reference. During three years at Teddington (1945–8), he worked not only on the theory of wind waves but also on the geomagnetic induction of voltages by tidal streams, and on the generation of oceanic microseisms. In September 1945, he returned to Cambridge to read for a PhD. There was, however, no break in his research; he continued to develop the same subjects of interest, reporting at the end of each term to Sir Harold Jeffreys, and later to Dr Robert Stoneley. In 1951, he was awarded a 4-year research Fellowship (Title A) at Trinity College. The first year (1951–2) he spent in the USA as a Commonwealth Fund Fellow, staying first at the Woods Hole Oceanographic Institute on Cape Code, Massachusetts, and then at the Scripps Institution of Oceanography at La Jolla, California, with Walter Munk. At Scripps he became interested in wave generation by wind, in the statistical properties of sea states, and in several other topics.

On his return to England in 1952, he spent two years of his Research Fellowship in Cambridge after which he accepted Dr George Deacon's invitation to join the newly formed NIO, the UK's National Institute of Oceanography, at Witley in Surrey. There he was to spend thirteen happy and fruitful years, working (mainly) on ocean waves. After 1963, he concentrated more on time-varying ocean currents, especially those which depend essentially on the rotation of the Earth. This period also included visiting appointments in the Mathematics Department at MIT (1957–8), the University of Adelaide, Australia (1964) and at the University of California, San Diego (1961–2 and 1966–7). In 1963, he was elected to the Royal Society of London. From 1967 to 1969, he spent two years assisting in the expansion of the Department of Oceanography at Oregon State University, in Corvallis, Oregon, but in 1969, he was appointed to a Royal Society Research Professorship, to be held jointly at Cambridge University, in the Department of Applied Mathematics and Theoretical Physics, and at The

National Institute of Oceanography at Witley. Once there, he decided on a multi-faceted attack on the problem of wave breaking, involving both theory and innovative experiments in the field and laboratory. He was also free to pursue research in other subjects.

In 1989, on reaching the age of formal retirement, he wished to continue doing research and for two years joined the La Jolla Institute in San Diego, California. In 1991, he was appointed to a position as a Senior Research Physicist at the Institute for Nonlinear Science in the University of California, San Diego, with an Adjunct Professorship at the Scripps Institution of Oceanography. There he turned attention to the natural sources of underwater sound, particularly the sound produced by the creation of bubbles in breaking waves (previously this sound was call "wind noise"). Financial support came mainly from the US Office of Naval Research and from the National Science Foundation. Since his second "retirement" in 2001, he has used his freedom as a Research Physicist Emeritus to indulge his interest in a variety of problems without the necessity of applying for outside grants. These interests have included the damping of incoming swells by sand ripples, and the construction of very simple but accurate approximations to gravity waves of limiting steepness.

Contents

†Conference papers (not included).

Volume II