WOODS HOLE OCEANOGRAPHIC INSTITUTION

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The 1959 Summer Program of Theoretical Studies in Geophysical Fluid Dynamics

by

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APPROVED FOR DISTRIBUTION____

Paul M. Fye, Director

1. Description of the program:

This ten-week work-study-discussion program is centered about a formal course called Geophysical Fluid Dynamics. Eight participants are selected from graduate and postgraduate applicants. In the discussions emphasis is placed on the formulation of tractable research problems in geophysics. The participants are encouraged to work on satisfactory problems thus formulated and to continue with their research after returning to their respective institutions.

2. Participants supported by the National Science Foundation grant:

Dr. Philip Drazin, Ph.D. in Applied Physics, Cambridge, England.

Dr. Louis Howard, Ph.D. in Physics, Princeton University
Associate Professor of Mathematics, M.I.T.

Dr. Robert Kraichman, Ph.D. in Physics, M.I.T.
Staff Member, Institute of Mathematical Sciences, N.Y.U.

Dr. Alan Robinson, Ph.D. in Physics, Harvard
Research Associate in Applied Physics, Harvard.

Dr. Edward Speigel, Ph.D. in Astrophysics, University of Michigan. Assistant Professor of Astrophysics, University of California, Berkeley.

Mr. John Gille, graduate student in Geophysics, M.I.T.

Mr. Samuel Tannenbaum, graduate student in Physics, Yale

Mr. Thomas Webster, graduate student in Geophysics, M.I.T.

3. Course topics for 1959:

The first two weeks of the course were presented by Dr. George Veronis of the Woods Hole Oceanographic Institution staff. The foundations of the theory of fluid instability were discussed. Emphasis was placed on inter-

preting the instabilities due to thermal forces and the finite amplitude steady motions which result.

Henry Stommel of the Oceanographic staff presented the theory of steady flows in rotating systems in the second two-week period. A study was made of the applicability of the Hough model to actual oceanic circulation. In the final days of this period Dr. Melvin Stern of the Oceanographic staff and Dr. Alan Robinson of Harvard University spoke on work of their own relating to the constraints on fluid motion imposed by rotation.

The third two-week period was devoted to the study of various theories of turbulence. Dr. Willem Malkus of the Oceanographic staff described the limited success of both the classical similiarity analysis and his own recent work in predicting aspects of these complex processes. Dr. Robert Kraichman of the New York University Institute of Mathematical Sciences discussed the several statistical theories of turbulence and their application to isotropic homogeneous fields of motion.

Mr. Edward Speigel of the Leuschner Observatory, Berkeley, California spent the seventh week in a thorough discussion of convective instability due to radiative heat flux.

In the first three days of the last week Professor Arnold Arons of Amherst College discussed wave motion. The last two days of the course were devoted to the student lectures described in the following paragraph.

4. Student lectures in 1959:

An important part of this program is the requirement that graduate participants prepare a one-hour lecture on original material. Their work can rep-

resent an extension of some topic covered in the course or an application of the techniques evolved to some geophysical problem. They are assisted by the staff both in the choice of their topic and as their work progresses. However, it is made clear that the originality of their effort will be the measure of its success. The three National Science Foundation supported graduates and one Oceanographic Institution fellowship holder spoke at the end of the 1959 course.

Mr. John Gille discussed the forces at work to produce electric currents in the ionosphere.

Mr. Samuel Tannenbaum discussed an extension of Heisenberg's theory of isotropic turbulence.

Mr. Thomas Phillips discussed the application of boundary layer techniques to non-linear electrical systems.

Mr. Thomas Webster discussed baroclinic instability.

All these students had made a considerable effort to prepare a stimulating and original lecture. Two succeeded in this effort.

5. Research work completed and embarked upon:

It is our hope that the Summer Program will encourage the post-graduate participants to formulate research problems in geophysical fluid dynamics. This summer five sound studies were started, two of which were brought to completion. These completed works are:

"The Boussinesq Approximation for Compressible Media," sent to the Astrophysical Journal by E. Speigel and G. Veronis, and "A Theory of the Equatorial Undercurrent," sent to Deep Sea Research by A. Robinson. The three studies in progress are: "Instability of the Eckman Layer" by L. Howard; "The Direct Interaction Hypothesis for Thermal Turbulence" by R. Kraichman; and "The

Stability of Jets" by P. Drazin.

We do not anticipate that future summer programs will bear this much fruit.

6. Changes contemplated for 1960:

Our experience this summer suggests that even well-prepared participants would benefit from a longer review period at the beginning of the course. Hence, we have planned to devote the first four weeks of the course to a formal study of advanced fluid dynamics. The following six weeks will deal with selected problems at the frontier of the field, as was done this summer. In the first period graduate students will be required to exhibit their mastery of the material covered. In the second period the graduate student will be primarily concerned with the selection and preparation of his lecture. Interaction of post-graduate participants with the Oceanographic staff was most reqarding last summer. We hope to further encourage joint research efforts, perhaps continuing into the academic year, between staff members and the senior participants.