devices, thermodynamics, sanitation, structures, materials, energy conversion, fluorescence, corrosion, wave propagation in various media, and many other areas of importance in engineering theory and design. Certainly, too, no graduate degree in engineering should be awarded without a minimum of content in modern physics.

This plan requires that engineering teachers themselves must have a full understanding of the meaning of modern physics and its results as applied to their own fields. It has been shown again and again that the most effective way to keep an educator at the forefront of scientific and engineering progress is to have him devoting part of his energy to work at the frontiers—that is, to research. As the line of demarcation between teacher and research worker breaks down, and as our engineering instructor becomes truly familiar with the new concepts by working them into his own problems, he will in turn be better able to find the best way of bringing these same concepts into the curriculum, both through existing and new courses.

ONCE this is done, our graduates will be better able to control the impact of modern physics upon our social structure, for the benefit of society and the engineering profession. Perhaps this turn of events can best be put as an allegory or parable. In ancient days success in battle was thought to result not only from wise generalship, but also from the design of Fate or the whim of the gods. Prediction or analysis of these conditions was the function of the soothsayer, and all well-equipped kings or generals had such a person as an important member of their staffs. No battle was purposely joined without the favorable assent of the soothsayer.

With the wider acceptance of monotheism, however, God became predictable as always being on the side of the right. The clergy were no longer asked to advise on the conduct of the campaign, but merely to assure the troops that they were on the side of God. Under these conditions, status as top staff members soon disappeared.

In modern times, without discounting in the least the importance of ethical and moral grounds for policy decisions, there is an increased need for men who can predict the future accurately upon the basis of sound knowledge. This modern successor of the ancient soothsayer is the informed, socially-conscious interpreter of right under complex scientific conditions which leave the layman or the uninformed hopelessly confused. A spectacular (and, thank God, a successful) instance is that of Eisenhower requesting counsel from his weather experts before the Normandy invasion.

For the years ahead, if we are wise enough to pick up the gage of Fate, that function of scientific and ethical leadership combined can well be discharged by the engineer. This, too, we might say, is the final impact of research in modern physics upon engineering education. Given the vision to adopt, use, and continue expanding the knowledge provided by science, engineers and engineering education may well provide the enlightened soothsayers of our technological future!

COOPERATIV

A Report o

*By **Marcel Schein***

A SUMMER Institute for Cooperative Emulsion Research was jointly sponsored by the National Science Foundation and the University of Chicago during the months of July and August, 1956. The work of the Institute was made possible through the great encouragement which we have received from the National Science Foundation and the authorities of our own University. It was of particular importance in this connection that the Nuclear Physics Branch of the Office of Naval Research, Washington, D. C., gave full support to the program of the Summer Institute and that we received permission to use microscopes and other equipment owned by the US Navy.

The participants of the Institute were selected upon application by the National Steering Committee of Cooperative Emulsion Research. All applications were received by April 15. It was decided to limit the membership to about 10, and as it turned out, we finally accepted 11 participants. The list of participants chosen by the National Steering Committee is as follows:

A. G. Barkow, Marquette University
K. E. Davis, Reed College
N. M. Duller, University of Missouri
P. L. Jain, University of Buffalo
Gabriel Kane, Manhattan College
John Lodge, Goucher College
V. Allan Long, Colorado School of Mines
R. E. McDaniel, New Mexico A & M College
Zachary O'Friel, St. Bonaventure University
C. A. Randall, Ohio University
Daniel Willard, Swarthmore College

Almost all the work of the Summer Institute was carried out in a large laboratory room in Eckhart Hall, University of Chicago. In addition, we made available some of our own precision stages and our darkroom facilities in Ryerson Physical Laboratory. Most of the participants used their own microscopes.

The work of the Summer Institute was divided into three major activities: (1) laboratory work, (2) theoretical classes, (3) seminars and colloquia.

In order to be able to carry out our program efficiently, a number of physicists were asked to collabo-

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mmer Institute at the University of Chicago, July and August 1956

rate. The following persons made major contributions in this direction:

W. F. Fry, University of Wisconsin
V. L. Telegdi, University of Chicago
A. D. Sprague, DePauw University
M. Koshiba, University of Chicago
R. Levi-Setti, University of Chicago
D. M. Haskin, University of Chicago

Mr. Haskin, of our own ONR and AEC project, Dr. Koshiba of the Physics Department, and Dr. Sprague of DePauw had major responsibilities to assist the group at all times and to see that the work progressed satisfactorily.

In general, the following schedule was set up:

Laboratory work	8:00 AM to 11:00 AM
	1:00 PM to 3:00 PM
Theoretical classes	11:00 AM to 12:00 noon
or on some days	10:00 AM to 12:00 noon
Informal seminars with tea	3:30 PM to 5:30 PM
Colloquium on Thursday	4:00 PM to 6:00 PM

To initiate the work of the Summer Institute, the writer called a general meeting on July 2 in which the participants got acquainted with the whole staff of the Summer Institute. On this day the writer outlined the general program. An informal discussion followed and agreement was reached regarding the proposed procedures. A few valuable suggestions were made by members of the Institute. It was agreed upon that the main purpose of the Summer Institute for Cooperative Emulsion Research was to get the participants well acquainted with: (a) the essential experimental techniques involved in the work with nuclear photoplates; (b) the underlying theory; and (c) new problems in the field.

Laboratory Work

FOUR essential problems were selected by the writer. It was agreed upon that every member should substantially contribute toward the solution of these problems. They were as follows:

(1) π-μ-electron decay
(2) Analysis of cosmic-ray stars
(3) Heavy nuclei breakups
(4) Processing techniques

To initiate the work on problem (1), we provided each participant with a single plate from a bigger stack which was exposed to one of the K-meson beams of the Berkeley Bevatron. A very large number (many thousand) of π-mesons came to rest in this stack. Since each plate contained a very large number of π-μ-electron decays, it took only a few seconds to locate a suitable case. First, the range of the μ-meson was accurately determined, taking straggling into account. Second, the mass ratio m_π/m_μ was determined. In order to determine the absolute value of the pion mass, scattering measurements were carried out on long tracks by using the method of constant sagitta. Finally, the energy of the electron arising from the decay of μ-mesons was directly measured by the method of multiple Coulomb scattering.

In problem (2) cosmic-ray stars were studied. This was useful for learning the technique of measuring angles in space and of analyzing complicated events. The participants were required to classify the tracks according to their ionization and to plot accurate target diagrams in space. They could also practice scattering measurements on some of the stopping particles.

Problem (3) dealt with heavy nuclei of the primary cosmic radiation. Each participant was given a plate exposed at an altitude of 100 000 feet or higher for a time of 8 to 12 hours. It was then rather easy to locate heavy nuclei on these plates and to classify them according to their Z (atomic number). The plates were exposed through the courtesy of the US Navy over Texas (41° N) or Minneapolis (55° N). Breakup processes of heavy nuclei into α-particles and protons were analyzed in greater detail. In some cases the secondaries could be followed for several centimeters of emulsion and were suitable for analysis. Finally, it was demonstrated to the members how heavy nuclei tracks can be used for aligning a stack of plates.

Problem (4) was of particular significance to the members of the Institute since it dealt with processing techniques of nuclear photoplates. The work was divided into two parts. First Mr. Haskin and others demonstrated to small groups of participants how to process plates which were exposed to the Chicago cyclotron and to the cosmic radiation in the stratosphere. For the latter purpose we launched a balloon flight in which we exposed a stack of pellicles to the cosmic radiation. The balloon ascension took place from Stagg Field of the University of Chicago on August 10 and landed in Dupont, Ohio. After demonstrating our processing techniques, the darkroom facilities were made available to the members of the Institute to carry out individual work. They learned the technique of fastening pellicles to glass, and got acquainted with the various aspects of temperature controlled development, fixing and drying procedures. Most of the plates developed by members of the Institute came out as well as could be expected. Finally, they were shown how to photograph a grid on each individual pellicle. Many of the important advantages of the grid became obvious in tracing through tracks and locating events.

Since most of the participants did satisfactory work on the above mentioned four basic problems during the first four to six weeks, it was advisable to include some advanced work into the program. For this purpose a number of pellicle stacks exposed to the cosmic radiation or to the various meson beams of the 6.3 Bev Berkeley Bevatron were turned over to the participants. It was important that each member of the Summer Institute had a stack at his disposal. In discussing the program of the Summer Institute on July 2, the writer suggested a number of advanced problems:

(1) Neutron spectra from light elements
(2) τ-meson decay
(3) Hyperfragment decay
(4) K-mesons
(5) Hyperon decays (Σ^+ and Σ^-)
(6) Work with 3- and 4-Bev pion beams
(7) Advanced work on heavy nuclei
(8) Nuclear collisions at extremely high energies ($E > 10^{12}$ ev)

From this selection of problems each participant could choose one or more according to his preference. We also suggested that the members of the Institute should look over some of our original events pertaining to K-mesons, hyperons, hyperfragments, heavy nuclei, and extremely high-energy collisions.

Theoretical Classes

FRY, University of Wisconsin, gave a detailed description of the π-μ-electron decay process. He then described the essential characteristics of the Berkeley Bevatron as a tool for high-energy research. He also discussed the problem of the straggling of the range, the theory of delta rays, nuclear capture of μ-mesons, etc. Some of the useful formulae of special relativity and transformations into the center of mass system were derived. Finally he described his work on K-mesons, on hyperons, and in particular, on hyperfragments.

Telegdi, University of Chicago, gave a series of lectures on the theory of energy loss of fast particles. In addition, he gave a detailed discussion of the problem of the range of high-energy particles. Finally he described some of the research problems suitable for plate work.

M. Koshiba, University of Chicago, gave a number of lectures on special aspects of the theory of multiple scattering. In particular, he discussed the influence of bremsstrahlung on the scattering of fast electrons. He described his recent experiments on tridents carried out in the 500-Mev electron beam of the Stanford linear accelerator. He also discussed the problem of heavy nuclei in the cosmic radiation.

R. Levi-Setti, University of Chicago, presented the theory of coulomb scattering. In addition, he described some of the precision measurements on τ-meson decays and discussed the energy spectrum of positrons arising from the disintegration of μ-mesons.

David Haskin, University of Chicago, gave a few lectures on experimental procedures pertaining to the laboratory work. In particular, he described the processing techniques used in our laboratory.

Marcel Schein, University of Chicago, gave lectures on problems of elementary particle physics with particular emphasis on K-mesons and hyperons. He also discussed some of the unsolved problems which are of current interest and which might be suitable for future work.

It is the impression of the writer that these introductory lectures were of considerable importance. They gave an introduction to basic problems of high-energy physics necessary for work with nuclear photoplates.

Seminars and Colloquia

EVERY afternoon, except Thursdays, the members of the SI assembled to hold an informal seminar. It was of interest to talk over some of the problems which arose in connection with the work of the Institute. The participants were asked to make constructive suggestions. We found that this type of personal contact was stimulating. One of the important aspects of the seminar consisted of having been able to informally discuss problems with the group as a whole. For instance, decisions could be made regarding future exposures or participation in future expeditions. As an example I should like to mention that a group in the Institute decided to undertake a joint project for exposing a larger stack to the cosmic radiation.

Every Thursday a regular colloquium of the Summer Institute was held. It was suggested that each member should choose a topic which seemed interesting to him. The writer provided the original literature, mostly in the form of reprints and advance copies of papers to be published. The members of the Institute studied a great deal of original literature in connection with the colloquium. Most of them did a thorough job and got well acquainted with the subject matter.

Acknowledgments

The writer wishes to express his great appreciation to the National Science Foundation for the constant encouragement and valuable support given to him. He also wishes to thank the Nuclear Physics Branch of the Office of Naval Research and the authorities of the University of Chicago for their excellent cooperation. It is a particular pleasure to acknowledge the invaluable contribution rendered by the previously mentioned staff members of the Summer Institute.