University of Chicago and its surroundings. Arrow on left points to accelerator building and research institutes. Arrow on right points to Ryerson Physical Laboratory and Eckhart Hall which is shared by the physics and mathematics departments.

*Chicago Aerial Survey Co.*

# *Physics at th*

*By **D. E. Nagle***

IN ADDITION to the research carried on in the University of Chicago's physics department, a substantial amount of physics research is pursued in the University's three research institutes: the Institute for the Study of Metals, the Institute for Nuclear Studies, and the Institute of Radiobiology and Biophysics. Supported jointly by the University and by subscriptions from private industries, the institutes may essentially be regarded as a new experiment in education and science and in the relation of the two to industry. Their laboratories, representing a capital investment of over twenty million dollars, provide facilities beyond the means of any single department. The participation of staff members from many departments makes possible the fullest utilization of the new facilities. The institutes have a total academic and professional staff of about 150 persons and about 185 other employees.

The University's department of physics has twenty-two staff members, who divide their activities between teaching and research. There are 125 students earmarked for physics, of whom seventy are in the preparatory stage of attending classes and reading for candidacy exams; the remainder are engaged in research for doctoral dissertations. Approximately seventy-five percent of the students are supported by scholarships, fellowships, and assistantships. Staff and students may avail themselves of research facilities of the department, the research institutes, and, in some cases, of other departments. Close cooperation exists among the departments of Physical Sciences Division. Several chemistry students, for example, are carrying out their research programs within the physics department, and somewhat similar cooperative arrangements have been made in a number of areas with the Argonne National Laboratory.

The spectroscopy group of the physics department is studying molecular spectra from the infrared through the far-ultraviolet and is applying the theoretical methods of quantum mechanics to these spectra and to various other problems in the structure and behavior of molecules. Topics of special interest include evaluation of integrals of atomic and molecular wave functions, which will be widely useful in prediction of molecular properties; study of relations among spectra of large condensed ring molecules and of dyes; studies of fluorescence; and studies of the strange spectra produced by the association of molecules in molecular "complexes".

The mass spectroscopy group is active in applying the mass spectrometer to problems in nuclear physics, chemistry, and geology. In the first category are problems such as fission yields, nuclear cross sections, radioactive decay schemes, and double beta decay. In the second are molecular energy levels and ion dipole bond strengths. Finally, geological studies in progress include age determinations and geochemical distributions of trace elements. The usefulness of the mass spectrometer as a research tool is clearly just beginning.

In the field of x-ray crystallography work continues on the structure of compounds of the 5*f* series of elements, a field in which Chicago has played a dominant role from the beginning. In addition, the Fourier inversion problem for the diffraction pattern has been attacked, and a new analytical method for determining

Edward Teller addresses an informal theoretical seminar. First row: G. Wentzel, M. Mayer, and J. Mayer. Second row: E. Adams, J. Faulkner, and (from Northwestern) L. Brown and M. Peshkin. Rear: I. Hodes, J. Ham, and H. McConnell.

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the signs of the Fourier coefficients for crystal structures with many degrees of freedom has been developed.

The cosmic-ray group in the physics department is continuing its flights of free balloons in the stratosphere. These experiments investigate the composition and time variations of the many different types of particles which go to make up the primary cosmic radiation. The large Wilson cloud chamber used in Colorado last year is now being equipped with lead plates to be operated at a station 17,000 feet above sea level in Bolivia. A study of the production and interaction of V mesons will be undertaken in cooperation with the Centro Barsiliero Pesquisas Fisicas. Nuclear emulsion techniques are used to study the decay schemes and interaction of cyclotron-produced mesons and to search for possible production of V particles by cyclotron-accelerated particles.

SOME EXPRESSION of the vigorous interaction between the several institutes of the University of Chicago is embodied in the continuity of their new buildings (see *Physics Today*, July, 1951, p. 19). As one walks along the main hallway of the institutes' buildings and of the accelerator building, one often encounters engineers, zoologists, and other species not common in physics departments. In colloquia, seminars, and less formal meetings, stimulating interchanges between followers of diverse disciplines are the rule.

It is therefore not surprising to find physics research in the Institute for the Study of Metals covering a broad range of topics extending beyond the field of metals into the solid state and to special problems relating to liquids and gases. Experimental investigations of conductivity in solids and liquids and of self diffusion are in progress, greatly aided by a high pressure laboratory capable of producing and sustaining pressures of $10^4$ atmospheres and more. Extensive research on the behavior of interstitial and substitutional atoms in solids is being pursued by the techniques of internal friction.

The low temperatures laboratory is equipped to produce fifty liters of liquid hydrogen per hour or nine liters of liquid helium per hour, which makes it one of the highest capacity installations in the country. The studies of superconductivity and ferroelectricity thereby made possible are of great interest, as are the studies of the peculiar behavior of the liquid helium II-gas-adsorbed film systems near the $\lambda$-point.

Many studies in the Institute for the Study of Metals lie in a boundary region between physics, metallurgy, and chemistry; for example, the work on the properties of surfaces, grain shapes, and infrared spectra of solids.

The 170-inch synchrocyclotron in the Institute for Nuclear Studies, constructed under contract with the Office of Naval Research and supported by the ONR and AEC, has operated with only minor interruptions for more than a year. In addition to its reliable operation and the high proton energy (450 million volts, at present the highest yet produced in any laboratory) a number of features contribute to make it an especially

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Enrico Fermi, Herbert L. Anderson, and John Marshall stand beside the meson window of the 170-inch synchrocyclotron at the University of Chicago's Institute for Nuclear Studies.

useful research tool. Among these may be mentioned the arrangement of internal movable target, shield, and analyzing magnets which results in external beams that are well defined in extent, energy, and composition. Available external beams include protons, neutrons, deuterons, and other nucleons, and pi- or mu-mesons of either sign. Several experiments in nuclear physics and in the physics of fundamental particles are being carried out with the aid of these beams and of such detectors as scintillation counters, cloud chambers, and photographic emulsions. One especially interesting question concerns the nature of the interaction between the nucleon (proton or neutron) and the pion (pi-meson). This problem is being attacked by scattering positive and negative pions from liquid hydrogen. Although a new insight has already been gained, much more should be learned in months to come from these and related experiments.

Because of these intense beams, it has been possible for the radiochemists in the Institute to make the beginnings of a new field: meson chemistry. For the first time it has been possible to observe meson-induced radioactivities, using the external meson beams and a combination of physical and radiochemical methods.

Sharing the Accelerator Building with the cyclotron is a 100-Mev betatron, which has been extensively used for radiochemical studies of photonuclear reactions. Some progress has been made in fast counting experiments on the photodisintegration of the deuteron at high energies. Additional shielding and new pole pieces recently installed permit higher intensity operation at energies up to 110 Mev.

Going lower in the energy scale, we come to the 40-inch cyclotron, at present being used primarily for radiochemistry, and next the 400-kilovolt Cockroft-Walton accelerator, which in the hands of "kevatron" group has proved a versatile tool for the study of nuclear energy levels, low energy nuclear reactions, and the mechanisms of energy loss of slow heavy particles.

A group in the Institute for Nuclear Studies is investigating two types of cosmic-radiation problems. The first is the development of the nucleonic component in the atmosphere by the primary radiations. It has been found that a very large latitude dependence exists for this component. The second problem, namely, the origin of the low-energy primary radiation, is being studied by a series of experiments including the measurement of the intensity changes of the nucleonic component with time. Continuous observing stations for this work have been established at Huancayo, Peru; Mexico City, Mexico; Sacramento Peak, New Mexico; and Climax, Colorado. Facilities are also available for aircraft flights over a wide range of latitudes.

Other facilities in active use include a precision beta-ray helical spectrometer, a microwave spectrometer, and a scintillation spectrometer.

The theoretical physicists in the Institute for Nuclear Studies are for the most part concentrating on high-energy nuclear and meson physics. Some of the problems being studied are nucleon-nucleon and nucleus scattering, meson-nucleon and nucleus scattering, strong coupling meson theory, meson production in nucleon-nucleon collisions, the effect of radiation reactions on meson scattering, and meson production. There is work going on in other fields such as the quantum statistics of interacting particles, the motion of electrons in perturbed periodic potentials, and the theory of *d-p* reactions.

The Institute for Radiobiology and Biophysics takes as its special province the quantitative study of fundamental biological processes, including problems of growth, genetics, and behavior. It exploits many physical methods in its biological studies, e.g., its Van de Graaff generator together with an ultra microstage to examine the effect of irradiating selected regions within a single cell. Again, cathode-ray tube display techniques are used in a most interesting low dosage x-ray fluoroscope. Many graduate students who plan on careers in biophysics complete the full physics academic program, excluding only seminar and research activities.