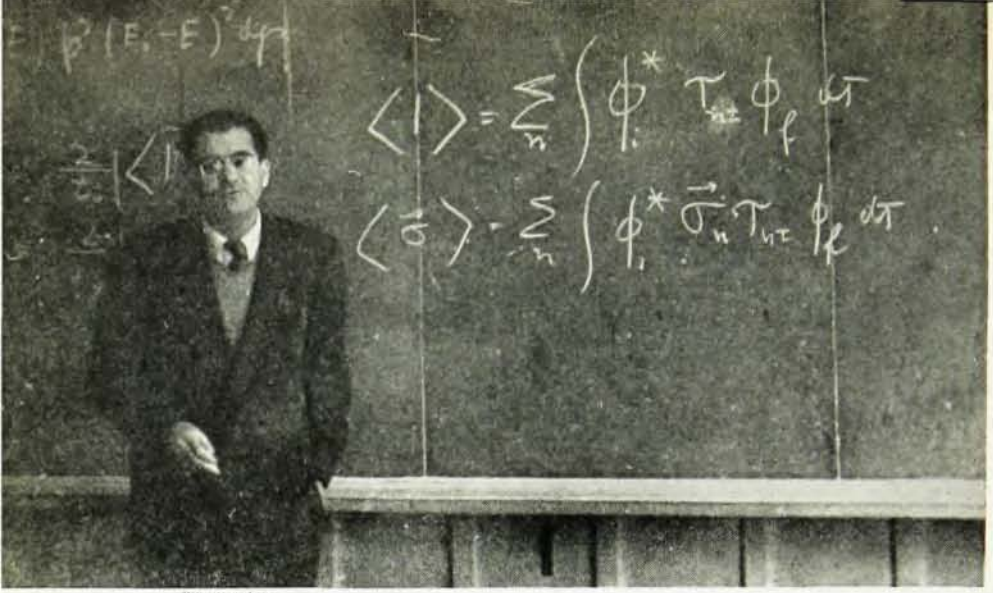

The author

physics i

DURING a good part of the school year, 1950–51, the author had the opportunity to be in Paris as a guest professor at the Sorbonne University. Chairs for Foreign Professors have been recently established at several French universities with the purpose of inviting scientists from abroad for a limited time in order to promote the exchange of ideas between France and other countries.

The duties of this assignment included a course on theoretical nuclear physics on a graduate level and a seminar on outstanding problems in this field. It provided a good opportunity to observe French physics and physicists in Paris at work.

The audience for these courses consisted mainly of young scientists, who are junior members of the numerous laboratories in and around Paris which are concerned with nuclear physics. In an American university they would have been graduate students or research associates. The task was made easy not only by the great enthusiasm and deep interest of the listeners but also by the excellent training in fundamental physics and mathematics which every French student receives during his schooling in high school and university. The French educational system provides a very thorough background of classical physics and mathematics. In this respect it is superior to our own system, although one notices frequently an overemphasis on obsolete subjects, which are kept in the curriculum purely for historical reasons.

Unfortunately, there are in France very few courses in advanced subjects on the graduate level which are in direct relation to actual research work. In fact, there exists no organized teaching program similar in nature to an American graduate school. Hence, the young research student is forced to acquire much of the necessary knowledge directly from books and periodicals. This is not necessarily detrimental to his education. Our own students are usually too strongly guided and consequently are apt to lose their sense of independence and initiative. On the other hand, in France one can observe the harmful effects of the other extreme: A great deal of valuable time is lost, and sometimes much effort is spent, on unimportant subjects because of the lack of sufficient guidance.

I must not fail to mention the excellent quality of the seminar talks from the point of view of representation. The French general education provides a better appreciation of language—in particular, the practice of clear, logical expression. In general, the speakers were better able to express clearly what they intended to say than speakers in an equivalent American seminar.

There are numerous physics research laboratories in and around Paris—many more than one generally believes. Their activities are spread over all topics of physics, and a very large number of people are engaged in physical research. It is impossible for a single person in a short time to get acquainted with all institutions. My observations therefore are limited to those laboratories that I came to know personally.

Before entering in a more detailed account of what goes on in these laboratories, a few general remarks are in place. Every visitor will be impressed by the scope of the activities in the French laboratories, and he will get the impression of a very active scientific life in French physics. One cannot deny, however, that in spite of the great number of scientific workers, the results are not as impressive as they once were. French physics today is not what it was during the days of Jean Perrin, of the Curies, of Langevin, P. Weiss, and at the time when P. Auger and L. de Broglie made their important contributions to physics, when the Joliot-Curies discovered artificial radioactivity, and even when, before the war, the fundamental experiments on uranium fission were performed in Joliot's Institute. Today one cannot help feeling that, apart from a few very noteworthy exceptions, much of the work is based upon ideas which were conceived elsewhere, and to which only a detail or a refinement is added here and there. In fact, in many instances one has the impression that

FRANCE

As seen through the eyes of a European physicist who came to America to live and work and who, as a Fulbright Fellow, has spent the past year as a visiting lecturer in France. *By Victor F. Weisskopf*

the same work is done more thoroughly and reliably at some other place in the world.

It is commonplace to say that the financial support of the French Laboratories is very small compared to the needs of modern research. It is true that, with the exception of the laboratories of the French Atomic Energy Commission, the research budget of any French laboratory is at least one order of magnitude smaller than that of an equivalent American one. This should be no reason, however, that the output be anywhere near as small as the budget. American physics laboratories are full of expensive machines, and therefore they are mostly forced to perform expensive experiments. There are, of course, many subjects in which important contributions can be made by cheap means. Actually the financial situation of French physics is probably better than in most other European countries thanks to the very efficient support of the "Centre National de la Recherche Scientifique," a kind of National Science Foundation about which more will be said later on.

The causes of the present small yield of French research in physics must be found elsewhere. Obviously, one good reason is the destruction and interruption caused by the two wars and by the terrible years of German occupation. But, in my opinion, there are other reasons too. One is the small number of experienced senior physicists able to guide the work of the great many excellent young scientists in the laboratories. There is a definite lack of scientists, say between the ages of 35 and 45 years, who have accumulated practical experience in their field of research and who should be in charge of initiating research work and helping and instructing the younger generation. In most of the laboratories there is only one leading professor who directs the research, and there are not enough men of experience and of independent ideas to take care of all activities. A great deal of good effort is wasted upon work which a more experienced physicist would have avoided.

An observer accustomed to the manner in which physics research is conducted in the United States will also notice a certain lack of contact between the different centers of research in Paris. There are very few opportunities for all physicists in Paris to meet in order to discuss their research work and to exchange ideas. Perhaps the individualism is carried a little too far; the different laboratories which are working on the same problems would profit by a more lively exchange of experience.

French physics has been accused of being ridden with political tensions. Although the political opinions of the physicists whom I have met were spread all over the spectrum from the extreme left to the extreme right, I have never observed any interference of this fact with serious scientific work or with the interchange of scientific information.

A few words are necessary regarding the organization of the French laboratories. Almost all laboratories which I have visited are under the direction of one professor of a school of higher learning. The only exceptions are the laboratories of the French Atomic Energy Commission. Some subsections are also headed by a professor now and then, but the largest part of the scientists are either students working on their doctor's thesis, or men similar to our research associates. The universities have no funds whatsoever to support anybody who is not a professor and only very limited funds for the support of research. Hence, French science could not exist on the present scale if it were not for the efficient financial support of the Centre National de la Recherche Scientifique (CNRS) which we have mentioned before. This Committee began its activities before the war, but only since the war has it assumed its present great responsibilities. It is a government agency supported with government funds. Its principles are very similar to those of the National Science Foundation in the United States.

Victor F. Weisskopf, theoretical nuclear physicist at the Massachusetts Institute of Technology, was born in Vienna, received his PhD at Göttingen, was a research associate at Berlin, Zurich, Copenhagen, and Rochester, and served as a group leader at Los Alamos during the war. He came to the United States in 1937.

At present the CNRS is under the direction of Professor G. Dupouy and its activities consist mainly of the following:

(a) Financial support for young scientists is given in the form of fellowships in France and abroad.

(b) Funds are provided to scientific laboratories for the purchase of instruments; these funds usually are much larger than the budget contribution of the universities themselves.

(c) New positions and possibilities for scientists have been opened by the creation of a great number of appointments as "chargé", "maître" or "directeur de recherches", which are independent of the university administrations. No longer is it necessary for a scientist to wait for the death of a professor to obtain a reasonable scientific position. Unfortunately, the CNRS positions are still considered as somewhat less "honorable" than a university job.

(d) A certain number of scientific laboratories are administered directly by the CNRS.

It is obvious from these activities that the contributions of the CNRS are the backbone of French science. Without the funds of the CNRS nearly all of the younger scientists would be without support. One must not forget that the number of professorships at a French University is very much smaller than in this country and that there are only very few positions (e.g., maître de conférence) which correspond to an assistant professorship or an instructorship. Almost all young scientists depend upon the support from the CNRS or from the Atomic Energy Commission if they work in the laboratories of the Commission.

The effect of the CNRS is clearly visible all around. A new cadre of young scientists is being created, with people who would have gone into other professions or would have emigrated to other countries if the CNRS had not given them an opportunity to work in the chosen fields of their science. The scientific profession is no longer reserved for those who can afford to wait until one of the few professorships is vacated.

I believe that one can be optimistic in regard to the future of French physics. The shortcomings of the present situation may not last long. There are many brilliant people among the young scientists and it is to be hoped that they soon will fill the posts that are necessary for a more creative use of the research facilities. A lot could be done to accelerate this development, however, by a much more extensive exchange of scientists between France and other countries—an exchange which is hampered at present by lack of funds and often also by a very unrealistic policy in the granting of visas on the part of the United States. Such exchange would give everybody an opportunity to get acquainted with methods of thinking and research different from his own.

IT is impossible to give a complete account of the research work which is carried on in French laboratories. I must limit myself to a short summary of what goes on at those laboratories that I came to know personally. I am sure that I missed a number of quite important ones during the limited time of my stay, among which are unfortunately the institutions outside of Paris —the institute in Grenoble (L. Neel), for instance, and the institute in Strasbourg (G. Foex), which continue the work in magnetism initiated by Langevin and P. Weiss.

At the University of Paris alone there are numerous independent physics laboratories. I was acquainted mainly with three of them: the Institut de Radium, the Laboratoire des Recherches Physiques, and the Laboratoire Chimie-Physique.

The Institut de Radium grew out of the historic discoveries of Becquerel and Pierre and Marie Curie. It was built for Mme. Curie at the height of her fame. Today it is directed by Mme. Irène Joliot-Curie. The Institute is chiefly concerned with the chemistry and physics of radioactive elements, and it is probably the place where one has accumulated the greatest experience in the radiochemistry of natural radioactive elements. The work in nuclear physics is mainly concentrated upon detailed investigations of the radiation emitted by the natural radioactive nuclei and the solution of many problems connected with the numerous soft β-rays and γ-rays which are emitted by these nuclei. The work of P. Benoist, R. Bouchez, M. Lecoin, P. and R. Daudel, J. Ratier, J. Taillac, Ch. Martin, M. Frilley, M. Valadores, and others gives ample proof of these activities.

The Laboratoire des Recherches Physiques of the University of Paris is directed by Professor J. Cabannes, whose fundamental work in the field of light scattering is well known. Many excellent spectroscopists came from his school and the activities of his laboratory are still in this field. A great deal of infrared spectroscopy is going on under J. LeComte, whereas J. P. Mathier is mainly concerned with Raman spectra of organic substances and also with the interesting field concerning the influence of crystal structure upon the Raman effect. L. Cojan and R. Lennuier are studying the resonance fluorescence in mercury with emphasis upon the effects of the hyperfine structure. By separating the fluorescence belonging to different hyperfine structure components, special investigations of metastable states can be made.

The Laboratoire Chimie-Physique under Professor E. Bauer deals with problems which are somewhat further away from my own fields of interest. My acquaintance with this institute is largely a result of the great personal interest which Professor Bauer and his colleagues have kindly shown for me and my relations to other French physicists. I have seen very interesting work by Mlle. Y. Cauchois on x-ray spectroscopy, which is internationally well known, and on dielectric constants and emission spectroscopy of polyatomic molecules by Professor Bauer himself. Dr. Magat's work on radiation chemistry of high polymers has given rise to some discussions as to the analogy between the concept of the compound nucleus in nuclear physics and the properties of an activated complex in chemical kinetics.

Activities in theoretical physics at the Sorbonne are

led by Professor Louis de Broglie who has assembled a group of theorists whose principal members are Professor J. L. Destouches, J. Courtois, B. Kwal, C. Morette, G. Petieu, M. Tomelat and J. Winter. The interest of this group is concentrated upon fundamental questions such as the theory of elementary particles, quantum electrodynamics and field theory. The weekly seminar of Professor de Broglie at the Institut Henri Poincaré is an important meeting place for the theorists in Paris. There is also a group of young people at the Institut Poincaré who work under the guidance of Dr. Proca on problems in field theory. The research which is done by these groups is of a rather abstract character and perhaps too much of the formal mathematical type. It is unfortunate that the work of the theorists at the Institut Poincaré does not have more relation with the experimental work in the many laboratories of the neighborhood.

A very interesting attempt to improve the training of young physicists in theoretical physics was made in the summer of 1951 by Mme. C. Morette. In spite of the great financial and bureaucratic difficulties, she succeeded in organizing a summer school in theoretical physics at Les Houches near Chamonix in the midst of the French Alps. About 30 young physicists gathered in a few log cabins whose backdrop was a magnificent view of the glaciers of Mount Blanc. They discussed all problems of modern physics and attended in a remodeled barn courses and seminars conducted by a number of theoretical physicists from many countries. A report on the summer school will be found on page 22 of this issue.

The next institution of higher learning that we should like to discuss is the Collège de France, which possesses two physics laboratories. One is called "Laboratoire de Chimie Nucleaire" but actually is largely devoted to nuclear physics under the direction of F. Joliot. The other physics laboratory is directed by Francis Perrin.

In the Laboratoire Chimie Nucleaire, whose assistant director for physics is P. Savel, most of the work is concentrated on research concerning artificial radioactivity. We find G. Renard doing research with low energy β-rays, and P. Suzor and G. Charpak studying some unusual phenomena occurring with the scattering of β-rays whose significance is not yet clear; other work is going on concerning nuclear spectroscopes (N. Marty and collaborators), negatron-positron branching ratios (J. Leberrique, T. Yuesa), or directional correlations of β-rays and γ-rays (M. Langevin), and many others are working with all the methods and tools which are commonly used for β-ray work. All research is done under the very direct and active leadership of F. Joliot, who spends much more time in his laboratory since he left the French Atomic Energy Commission. Two young theorists, C. Marty and R. Nataf, are supporting their efforts. The laboratory also contains a cyclotron producing a deuteron beam of 7 Mev which is chiefly used for the production of radioactive material.

The laboratory of F. Perrin is still in the process of construction. With the help of its assistant director, M. Magnan, a proton microscope has been erected which should have a much larger resolving power than the current electron microscopes. One hopes that the nomination of F. Perrin as the chairman of the Atomic Energy Commission will not interrupt the development of this laboratory.

F. Joliot, shown discussing part of the mechanism of ZOE, the French atomic pile, during the period when he served as chairman of the French Atomic Energy Commission. *Black Star.*

The physics research laboratory at the École Polytechnique is devoted exclusively to cosmic ray research. The director, Professor L. LePrince-Ringuet, has assembled a very active group of physicists, including C. Peyrou, B. Gregory, J. Crussard, E. Nageotte, F. Bousser, L. Janeau, A. Lagarrigque, A. Lecourtois, D. Morellet, F. Muller, Y. Treille, J. Trembleau, and some others. It is one of the leading cosmic ray research centers of the world. Their studies on the mass of the meson, the decay products of mesons, and the nuclear effects of high energy cosmic rays are known to everybody working in this field. The institute also runs a high altitude

station in the Mount Blanc region. The Ecole Polytechnique is by tradition a military school whose purpose is the training of engineers for the army and for government service. There is a striking contrast between the military discipline which governs the daily life of the students at the École and the free and easy atmosphere within LePrince-Ringuet's laboratory. Every Monday a seminar is held at the laboratory in which all relevant papers are lively and critically discussed, and I remember gratefully the numerous conversations with LePrince-Ringuet's collaborators in which I learned many interesting things about cosmic rays. Somehow every foreign physicist passing through Paris is first captured by LePrince-Ringuet's Institute and induced to deliver a talk at his seminar.

The largest of all academic physics laboratories is the Laboratoire de Physique of the École Normale Supérieure. This school was founded as an institution for the training of secondary school teachers. It has risen to a position of highest eminence in French intellectual life. Some of the greatest French scientists are graduates of this school. Not all secondary school teachers, by any means, are graduates of the Ecole Normale today. It must be said, however, that in general French secondary school teachers get a much more thoroughgoing education in their fields than their American colleagues.

The director of the Physics Institute is Professor Y. Rocard, a great expert in radio electronics and short waves. The laboratory houses many groups with quite varied interests: one group works very successfully on nuclear magnetic resonance problems (M. Soutif, Y. Ayant); another on the problems of the low frequency radio noise generated by the sun (J. Steinberg, J. Denisse); another on semiconductors (P. Agrain, C. Dugas); another on spectroscopic problems, resonance fluorescences, etc. (Professors A. Kastler, J. Brossel); and another on high voltage electronics. They have built a linear accelerator of 500,000 electron volts (Professor J. Grivet). The institute also houses the cosmic ray laboratory of Professor P. Auger in which his collaborators (A. Freon, R. Meze) are studying the mechanism of large showers. Unfortunately Auger is kept by his duties at the Unesco from devoting much of his efforts to science. There is also a little group for photographic investigations of cosmic rays (Professor M. Morand).

Professor Maurice de Broglie, brother of the theorist, Louis de Broglie, directs a research institute which is named "Laboratoire de Physique des Rayons X", a name which stems from the era in which M. de Broglie made his well-known contributions to x-ray research. At present all the work in this laboratory is in nuclear physics; a linear accelerator of 3 Mev is in construction, nuclear γ-spectra are investigated, α-radioactivity is studied by means of photographic plates, and other research of similar character is going on. The principal collaborators are M. Chenson, G. Ambrosius, H. Piatier, M. Lataste and P. Maignan.

We now come to those physics laboratories independent of any institution of higher learning. There are mainly two governmental agencies which possess scientific laboratories: one is the Centre National de la Recherche Scientifique (CNRS), and the other is the French Atomic Energy Commission.

Francis Perrin, successor to Joliot as chairman of the French AEC, is professor of physics and director of one of the physics laboratories at the Collège de France. *Black Star.*

The laboratories administered by the CNRS are very large institutions of various origins which deal with all kinds of natural science (biology, chemistry, physics) and are to a great extent devoted to their practical application in industry. However, some are pure science laboratories. I have visited the physics laboratories in Bellevue near Paris which, together with many other CNRS labs, are located in an enormous building. The physical problems studied there are all connected with two large magnets, one permanent and one electromagnetic. There Dr. Rosenblum has made his famous analyses of α-rays and has found many important results concerning the fine structure of α-rays, which have been of great significance for our knowledge of the structure of the nucleus. The resolving power of his instrument is perhaps better than that found in any other α-ray laboratory. There is also spectroscopic work done; Professor P. Jacquinot, for example, has measured the fine structure of hydrogen and helium and the deviations from the Sommerfeld formula, which are now of central interest in quantum electrodynamics.

Another physics laboratory of the CNRS is situated in Ivry near Paris, and is under the directorship of Joliot with M. Magnan as vice director. Its activities are all concentrated on nuclear physics. The problems investigated are naturally similar to those concerning artificial radioactivity which are explored in Joliot's

laboratory at the Collège de France. One finds at the Ivry laboratory a 900 kev proton Cockcroft-Walton accelerator which is used to produce γ-rays from the proton-lithium reaction. A shock generator for 3 Mev is in the process of erection. A number of problems concerning high energy β-rays, β-γ coincidences, and β-ray scatterings are being investigated by a group of such gifted young physicists as G. Vendryes, M. Spiegel, P. Hubert, and M. Georgesco.

Finally, I must report on the laboratories of the French Atomic Energy Commission. These are mostly still under construction. After completion the laboratories will be by far the largest physics laboratories in France. The activities of the French AEC are purely scientific. There is at present no work going on which points towards any industrial or military application of atomic power. The scientific director of the AEC is L. Kowarski. There are, or rather there will be, two laboratories. One in Chatillon, directly outside of Paris, is

Louis de Broglie, French theorist and Nobel Prize winner (1929), is in charge of theoretical physics at the Sorbonne in Paris. *Wide World.*

an old fortress very cleverly transformed into a scientific laboratory, and the other in Saclay, which is about 20 miles further away. The Chatillon Laboratory already is a going concern. Its work centers around the nuclear pile "Zoe" which is an experimental pile with very little energy production (Zoe = zero energie, oxide d'uranium, eau lourde). Obviously, a lot of work is done to study the physical, chemical, and engineering problems connected with the running and building of a pile. A second pile of considerably larger power is being constructed in Saclay.

But the pile is not the only object of interest in Chatillon. A Van de Graaff machine is being erected for energies up to 3.5 Mev. A resonance cavity linear accelerator is also being built. The laboratory will gradually be provided with all instruments necessary for nuclear research, Wilson chambers, β-ray spectrographs, isotope separators, etc. A large electronics laboratory supplies the electronic equipment not only for the Chatillon laboratory but also for other scientific institutions. Although a major portion of the activities in Chatillon are still devoted to the building of apparatus, a number of research projects are in progress. Berthelot is in charge of the experimental physics section and a number of physicists are working with him (R. Ballini, E. Cotton, R. Cohen, A. Levi, H. Farragi, H. de Laburlaye, V. Nagyar, F. Netter, and others). Research is being done on fission cross sections, the triple fission process, neutron capture cross sections, short period isomers, cross sections of neutron induced reactions, and other topics. Most of these experiments utilize the neutron flux from the pile, or the radioactive isotopes produced by it.

There is also a theoretical physics section headed by Professor J. Yvon. This section is in charge of the theoretical calculations in connection with the construction of the pile. It also takes an active interest in the theoretical background of the experimental work of the laboratory. At the same time it discusses and analyzes very thoroughly any interesting theoretical work in nuclear physics appearing in the literature. I enjoyed very much the many discussions which I had during my stay in Paris with this group which in addition to Yvon consists of A. Abragam, J. Horowitz, C. Mercier, M. Trocheris, P. Meyer, and others. Many problems became clearer to us during our meetings.

The laboratories in Saclay are in the stage of construction with the land about the buildings being muddy and torn by the many trucks and machines—a sight familiar to many of us during the early stages of the great atomic laboratories in this country. The scale of the Saclay project is comparable with the size of our AEC institutions and it will be similar in many respects to the Brookhaven National Laboratory. When it is finished it will house a heavy water pile with a contemplated neutron flux intermediate between the Argonne and the Chalk River piles; it will have a 63-inch cyclotron and the already mentioned Van de Graaff. Large chemical laboratories are erected for the handling of radioactive material. It is hoped that the great spirit which is put into the conception of this venture can be maintained later on in the actual development of the scientific work. The Saclay Laboratories offer a material possibility for developing nuclear physics on a scale so far unknown in continental Europe.