laration of friendship and good will from the American people to the Egyptian people."

The conference was attended by 173 delegates, including 108 from the UAR, 28 from the USA, and 37 from 15 other countries. Each of the sessions had as chairman a visitor from abroad, and as a cochairman a scientist from the United Arab Republic. The general topic of the conference was "Interaction of Radiation with Solids." There was considerable emphasis on radiation damage or effects. Three of the eight sessions were concerned with this topic, the others dealing with magnetic resonance, conductivity, metals, spectroscopy, and quantum electronics. Particular attention was given to glasses, as this is an aspect of the solid state in which the American University has specialized, using the facilities of the Egyptian Atomic Energy Establishment for high energy radiation sources when needed. The old and the new, for instance, were linked at the American University in Cairo in magnetic-resonance studies of irradiated silica glass from the Libyan desert, as well as of ancient glasses manufactured thousands of years ago. Glass lasers are being studied at this university. Egypt has the raw materials for glass, but metals are relatively scarce, and so research on glasses is a "natural."

The United Arab Republic realizes the vital role of science in modern civilization and so has developed large research institutes. The members of the conference therefore were given the opportunity of visiting its National Research Center and its Atomic Energy Establishment.

The American University in Cairo has an enrollment of about a thousand, and is small compared with the Cairo University of the UAR, which has over fifty-thousand full-time students. Also it is very young compared to the thousand-year-old Al Ashar University, where the conference members were tendered a luncheon. Nevertheless it has a significant role to play. In the words of Bartlett, its president: "This university is a meeting point of cultures and languages . . . it is organized along patterns of an American university, and draws most of its financial support from the United States. At the same time its staff is largely Egyptian, and over 65% of its students are from the United Arab Republic. Its work is tailored to fit the needs and resources of this country." Torkey says: "We of the Supreme Council for Scientific Research (which he heads) are following with great interest the solid-state science program at the American University in Cairo, and have noted with satisfaction the important role it is playing in the educational and scientific life of this country."

J. H. Van Vleck
Harvard University

Coherence and Quantum Optics

A three day international conference on coherence phenomena and quantum optics was held 22-24 June, 1966, at the University of Rochester. The second conference of its kind, it was sponsored by the Air Force Office of Scientific Research and the Air Force Cambridge Research Laboratories.

Three hundred registrants gathered for this occasion. There were pure mathematicians, theoretical physicists in classical optics and in quantum field theory, experimental physicists in fluctuations and in holography, experts in noise and in coherence, and research directors from universities, industries, and government laboratories. It is truly remarkable how this very young field of quantum optics and coherence establishes a common bond for such a varied group that usually does not speak a common technical language.

In an invited paper, R. Hanbury Brown (Sydney) described the very large stellar intensity interferometer that has been put into operation at Narrabri Observatory in Australia "to measure the apparent angular diameter of all hot stars brighter than $m_{pg} = +2.5$ and with spectral types earlier than F." Roy J. Glauber (Harvard) reviewed quantum optics and E. C. George Sudarshan (Syracuse) presented an elementary discussion of coherence theory, both classical and quantum mechanical.

Whereas these papers dealt primarily

with the general aspects of the theory, Willis E. Lamb (Yale) and one of his former students, Marlan Scully, presented the first detailed quantum theory of a laser. This theory is an important improvement of the semiclassical theory given by Lamb a few years ago, in which the laser field was treated classically. The theory can be used directly by the experimental physicist, since the operation of the laser is analyzed in detail and the relations of practical interest for it are now available. Some of these results were also reported by Melvin Lax who approached this problem from the very different angle of the theory of noise sources and their effects on lasers.

One of the most enlightening papers presented by the theorists was the invited talk by John R. Klauder on the mathematical problem of the diagonal representation. He settled a controversy that has been going on for some time concerning the conditions under which such a representation exists. Its existence is of course closely related to the possibility of a classical description of coherence phenomena in place of a quantum mechanical one. This equivalence theorem permits a classical phase-space distribution function for any quantum-mechanical density matrix, so that it yields the same average whenever one is dealing with bounded operators.

Among the many theoretical papers were several that succeed in obtaining results of quantum optics with weaker assumptions than was possible until now. In particular, the semiclassical approach proved very successful and one speaker, Edwin T. Jaynes, went so far as to speculate that quantum electrodynamics may actually not be necessary. He was immediately challenged to a fifty-dollar bet, which he accepted. This was one of several discussions at the conference that rose considerably above the "cool and collected" level.

A deeper and very interesting invited paper was presented by H. W. Lewis, who, in collaboration with Marvin L. Goldberger and Kenneth M. Watson, entered upon the quantum mechanical measurement theory of scattering: the measurement of fluctuations and of correlations in beams of scattered particles and its dependence on the signal-to-noise ratio.

An area of controversy still exists in the theory of the interaction of electrons with laser beams. Zoltan Fried and collaborators reported no intensity-dependent frequency shift in Compton scattering when computed by strict perturbation approximation (Feynman-Dyson). The work by T. W. B. Kibble and by Howard Reiss did not use this approach and yielded interesting predictions.

The experimental papers given at the conference also covered a wide range of topics, including electromagnetic-field fluctuations, scattering, absorption and emission of resonance radiation, and various nonlinear optical effects. In particular, the subject of laser noise and coherence was well covered, since almost every group in this field presented a paper.

Experiments on intensity noise in lasers were described by J. A. Armstrong and A. W. Smith of IBM, C. Freed and H. A. Haus of MIT, F. T. Arecchi of the University of Milan, and H. Gamo, R. Grace and T. Walter of the University of Rochester. The experiments described involved both the digital method of photon counting and the analog method of intensity correlations. It was generally agreed that the various different experimental observations are in substantial agreement concerning the properties of laser intensity noise. For a single-mode laser operating at an output power that is more than five times the output power at threshold the laser output may be usefully described as a superposition of an amplitude-stabilized field and a smaller narrowband Gaussian noise field. However, when the laser is operated closer to threshold the nonlinear character of the laser oscillator requires a more complicated description of the laser output. Observations in this region close to threshold were reported by Armstrong and Smith and by Gamo et al. In both cases the observations are in substantial agreement with the theories of the laser near threshold worked out by Hans Risken, by Lax and Hempstead, and by Lamb and Scully.

Leonard Mandel and Frederic Davidson of the University of Roches-

ter described experiments in which triple photon coincidences can be studied and which therefore measure sixth-order correlation functions of the electromagnetic field. Another experiment that further broadens the kind of field measurements possible was described by Arecchi. He obtains experimentally the joint photon-counting distribution for the probability that n_1 photons will be counted at time t_1 and that n_2 photons will be counted at a later time t_2. Very precise photon-counting equipment in use at RRE, Malvern was discussed by T. P. McLean.

Werner Martienssen and Eberhard Spiller from the University of Frankfurt described experiments in which laser light was scattered and combined with unscattered light in order to construct a field with desired fluctuation properties. These properties were then verified by photon counting. The conference papers fully covered the wide variety of experimental means that have been developed for measuring the higher-order moments and correlation functions of optical electromagnetic fields.

The subject of resonance radiation, and in particular the coherent forward scattering of resonance radiation, was covered in papers by G. W. Series of the Clarendon Laboratory and by E. W. Otten of Heidelberg University. Of special interest was the significant spectral narrowing observed in the forward scattered radiation.

Further topics of experimental papers included a review by S. R. Hartmann of the experiments on photon echoes carried out at Columbia and a description by F. S. Harris and G. C. Sherman of Aerospace Corp. of experiments in which they have compared the scattering by small latex spheres of both coherent and incoherent light. For the conditions under which the comparison was made no significant difference was found.

There is no doubt that this was a successful conference, thanks especially to the untiring efforts of the hosts Emil Wolf, Leonard Mandel and Joseph H. Eberly. □

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