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PITTSBURGH'S WEEKLY NEWSMAGAZINE

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NOBEL WINNERS

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DECEMBER 14, 1944

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when juvenile delinquency became a difficult problem the City had sent investigators to Philadelphia to study its system.

The result was that Pittsburgh emulated Philadelphia, soon came up with a curfew squad. Philadelphia had no curfew law; Pittsburgh had no curfew law. Police merely picked up youngsters found on the streets after 11 p.m. It was a police order.

Customarily, in Pittsburgh, they were taken to the police office in the City-County Building, their parents were notified, and they were released when the parents vouched for them.

From the period between May and the first of 1944, Pittsburgh's police had picked up 1,034 juveniles, 823 from the City, 211 from out of the City. The majority were released to relatives, a few were detained for Juvenile Court.

Pittsburgh's police were glad to report this week that from January to November 30 of 1944 they had picked up only 530 youngsters.

Said Director of Safety Fairley: "We think our curfew regulation has done a good job. It hasn't hurt any kids who have been on the street legitimately; we've had only one complaint from a parent.

"Philadelphia doesn't need a curfew law; all it needs is to carry out its police curfew order even as Pittsburgh has been carrying on after the fashion designed by Philadelphia. Perhaps Judge Winnet is knocking down straw men."

THE WEEK

This week the Pittsburgh district was struck by its most paralyzing snowstorm in history. More than eleven inches of snow fell from Monday afternoon until Tuesday morning. Traffic was so demoralized that commuters who ordinarily reached home in 35 or 45 minutes found themselves getting to their residences in no sooner than four hours. Some were forced to stay in downtown offices all night. Automobiles and trolley cars that moved, frequently ran into time-destroying accidents. In many instances sporting (the prize fights scheduled for Duquesne Gardens) and other amusement events were called off or postponed. Next day some department stores closed early.

In Washington, Pennsylvania's U. S. Senators, James J. Davis, Republican lameduck, and Democrat Joseph F. Guffey teamed with 50 other legislators to defeat a motion to put the much-discussed Beaver-Mahoning stub-end canal in the Rivers & Harbors omnibus bill.

District Attorney Russell Adams, annoyed because a sixth-time Turtle Creek numbers violator was fined and given six months probation, announced that "an effective repression of rackets cannot be accomplished without an adequate sentence by the court."

CHRONICLE

Named. Hiland G. Batcheller, president of Allegheny Ludlum Steel; to be No. 2 man on the War Production Board; by Chairman of the Board J. A. Krug. Krug designated Batcheller as chief of operations with authority to handle "broad policy questions" and to act in Krug's place as chairman when Krug was absent from Washington.

Re-elected. Anthony J. Federoff; to the presidency of the C.I.O. Steel City Industrial Union Council; by unanimous vote. Also reelected were Milton J. Weisberg, vice-president; Joseph A. Toney, recording secretary; and Alfred L. Oyler, treasurer.

Granted. A charter, to St. Clair Memorial Hospital, a postwar project intended to serve the boroughs of the South Hills; by Judge Thomas M. Marshall. The new hospital is designed for use of citizens from Bethel Township, Dormont, Castle Shannon, Brentwood and Mt. Lebanon.

Re-named. Police Sergeant Thomas D. English; to the presidency of the Fort Pitt Lodge, Fraternal Order of Police; defeating City Detective Martin J. O'Toole, 323 to 145. Interest in the election was high because O'Toole, formerly president of the organization, was discharged from the police force when a trial board found him guilty of slugging Attorney Morton Kagen. He later was reinstated by Mayor Cornelius D. Scully, who decided the reinstatement "was in the interest of Christian charity" and "O'Toole won't do it again."

Died. Elizabeth C. Mullaney, superintendent of nurses at Municipal Hospital; in Mercy Hospital in Johnstown; of pneumonia.

Died. Major John C. Anderson, 48, former backfield star at the University of Pittsburgh; at the Army Air Base at Richmond, Va., where he was base unit commander and football coach; after a heart attack. Major Anderson played for the Panthers under Glenn Scobey (Pop) Warner in 1921-22-23. Later he coached football and was a mathematics instructor at Donora High School.

Died. Robert Geddes, 89, retired director and sales manager of J&L Steel; at his Aylesboro Avenue home. He joined the J&L organization 48 years ago, was named a director in 1922.

Died. Charles Orchard, son of the late Mr. & Mrs. Thomas Orchard of Carbondale; for 32 years a special agent of the traffic department of Carnegie-Illinois Steel. Orchard also was treasurer and vestryman of the Church of the Redeemer; is survived by a son, Lieut. Commander Thomas Orchard, U.S.N.R., formerly associate producer of *The March of Time*, and a sister, Mrs. N. L. Moon, of Norristown.

NOBEL LAUREATES are physicists James C. Franck (1925), Dr. Stern and Dr. Rabi. Franck & Stern (*see cover*) met as German soldiers in World War I.

Prize for Pittsburgh

To pay tribute to Pittsburgh's first Nobel prize-winner, Dr. Otto Stern, some of the world's outstanding physical scientists, local dignitaries, and science students gathered at a banquet sponsored by Carnegie Institute and the Physical Society of Pittsburgh in the University Club ballroom last Friday night.

Dr. Stern, who came to Pittsburgh from the University of Hamburg only eleven years ago, is Research Professor of Physics at Carnegie Tech where he is conducting graduate classes and continuing the experiments in physical science begun in his native country before the war. Physicist Stern was recognized in 1943 by the Nobel Foundation for his fundamental research in the field of molecular physics, dealing with the velocities and deflection of molecular rays.

A modest, baldish little man, Dr. Stern gives much of the credit for his successful experiments to his associates, among them his former pupil Dr. Isidor I. Rabi, 1944 Nobel prize-winner, who shares with him the $30,000 prize which was awarded in New York last Sunday.

GUEST PHYSICISTS included Wolfgang Pauli, visiting professor at Princeton, and Stanford Professor Felix Bloch (*above*). Among others were Harvard's J. H. Van Vleck, Princeton Professors Eugene Wigner and Rudolph Ladenburg.

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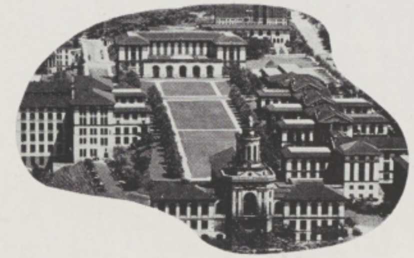
LOCAL COLOR was added by members of Tech board of Trustees and faculty. At one table were (*clockwise, left to right*), Dr. R. F. Mehl, Mrs. R. E. Doherty, H. N. Eavenson (*back of Mrs. Doherty*), I. G. Blackburn, G. E. Evans, J. L. Perry, Mrs. Frederick Seitz (her husband presided), Dr. Andrey Avinoff, Dr. E. R. Weidlein and Mrs. W. N. Jones. Albert Einstein, friend and former teacher of Stern, accepted his invitation but at last minute was unable to attend.

THE CARNEGIE TECHNICAL



THE OCTOBER CARNEGIE TECHNICAL

The Carnegie Technical, a publication of the undergraduates of the Carnegie Institute of Technology, is published at the Carnegie Institute of Technology, Schenley Park, Pittsburgh, Pa., and will appear 8 times during the year 1944-45 in the months of October, November, December, February, April, May, July and August. Subscription, one dollar, single copies, ten cents. Entered as second-class matter October 21, 1942 at the Post Office in Pittsburgh, Pennsylvania, under the Act of March 3, 1879.

Cover by Margaret Cole, Ind. Des. Sr. (Photograph by L. S. Lerman)—Dr. Otto Stern, Research Professor of Physics, 1943 Nobel Prize Winner (see page 9)

Masthead photograph by Lawrence H. Miller

Frontispiece cut courtesy Westinghouse

VOLUME 9 NUMBER 1

Otto Stern, Molecular Beams, and the Nobel Prize

by GEORGE E. PAKE
Physics, Sr.

That the 1944 as well as 1943 Nobel Prize was awarded for research in molecular beams (to Dr. I. I. Rabi, a former student of Dr. Stern's) testifies to the importance of such work. Dr. Stern's original investigations, described here, paved the way for further study.

By awarding the 1943 Nobel Prize for physics to Dr. Otto Stern, Research Professor of Physics at the Carnegie Institute of Technology, The Nobel Foundation has recognized his important contributions to the development of present day physical science. Much of his work has been fundamental research using molecular rays or beams as a means for probing into the secrets of atomic and molecular properties. For an appreciation of Dr. Stern's experiments, an understanding of the methods and principles involved in molecular ray production is essential and begins properly with the kinetic theory of gases.

According to the kinetic theory, the molecules of a gas or vapor are in unceasing chaotic motion, continually colliding with each other and the walls of their containing enclosure. At any given instant, the velocities of the individual molecules are very different, but a statistical average of these velocities is entirely independent of time, being as a matter of fact a function of the temperature and the mass of the individual molecule. For the production of a molecular beam, the enclosure need only be heated to a temperature corresponding to the desired average velocity of the beam. A small hole in one of the container walls will permit a stream of molecules to emerge from the enclosure, and two or three aligned collimating plates may be used to select a narrow sharply defined portion of the stream. The region into which the molecules pass from the enclosure must be evacuated by continuous pumping, since the beam would otherwise be scattered by collisions with residual molecules in the region.

Dr. Stern's early experiments, which used just such an oven to produce a beam of silver atoms, consisted simply of direct velocity measurements that checked the theoretical value for the average velocity and provided experimental verification of the Maxwell distribution of molecular velocities. This marked the beginning of the brilliant series of molecular ray experiments which brought Dr. Stern international recognition and the Nobel Prize.

The potentialities of the molecular ray method were fully realized by Dr. Stern and his co-workers, and since many of the experiments suggested by the method required measurement of ray intensity, various detection devices were designed. For example, the ingenius Pirani gauge or hot-wire manometer measures the intensity of the beam by collecting the molecules in an enclosure containing a wire filament heated by an electric current. The molecules build up a pressure in the enclosure determined by the rate at which they enter, and this collected gas serves to cool the filament. The resistance of the filament is a function of its temperature and thus measures the beam intensity, since intensity determines the amount of gas present, which in turn fixes the rate of cooling. A second kind of gauge uses a hot filament placed in a positively charged cylinder. Proper selection of the filament temperature and the anode potential produces a space-charge limited emission current of electrons from the filament to the cylinder. If a molecular ray passes into the region between filament and anode, the fast-moving electrons ionize the gas molecules which remain as positive charges and produce a large change in plate current. In this way, the emission current measures the intensity of the beam.

Dr. Immanuel Estermann, also of the physics department at Carnegie, has been a close associate of Dr. Stern. One of the experiments on which the two men collaborated concerned verification of the wave nature of moving atoms and molecules. De Broglie had suggested in 1924 that perhaps an undulatory effect with wave length dependent upon momentum is associated with moving particles. Stern pointed out that molecular rays could be used to test this hypothesis, and his subsequent experiments showed definite diffraction maxima at the theoretically predicted angles for beams of hydrogen or helium molecules which were reflected from a crystal lattice used as a grating. [This experiment is discussed in more detail as part of an article entitled "Matter Waves," which will appear in the November issue of the TECHNICAL.—Ed.]

In 1921 Dr. Stern suggested the use of molecular beams as a crucial test to decide between classical theory and the quantum theory of atomic and molecular magnetic properties; the result was the famous Stern-Gerlach experiment. Both theories agreed that an atom possesses angular momentum arising from the motion of its electrons. Furthermore, the motion of the electrons constitutes, in effect, a small current loop, and such a loop possesses a definite magnetic moment which may be represented by a vector in the same direction as the angular momentum vector (actually antiparallel for a negatively charged electron). The total angular momentum is represented by a vector quantum number J. Similar vector quantum numbers L and S represent respectively the so-called orbital electron angular momentum and the electron spin momentum; thus the total electronic angular momentum is $J = L + S$. The magnetic moment is proportional to J and is, in fact, measured in units called Bohr magnetons such that the magnetic moment is J Bohr magnetons. If, now, a beam of molecules or atoms is passed through a magnetic field at right angles to the beam, classical theory predicts that the J vectors will enter the field inclined at an arbitrary angle to the field direction and will precess about the field at that angle. Quantum theory, however, indicates that only certain discrete values are permitted for the projection of the precessing J vector along the field direction. When the field is inhomogeneous in a direction at right angles to the beam, a net translational force will be exerted upon the atomic magnets. The direction and magnitude of this force depends upon the direction and magnitude of the magnetic moment; therefore, classical theory calls for a continuous range of forces and beam deflections between two symmetrical maximum values, whereas quantum theory forecasts a small number of discrete values for the forces and resulting deflections of the ray.

The apparatus for the experiment is illustrated schematically in figure 1. From an oven O issue silver atoms which are collimated by two plates into a ribbon-like beam. The beam passes between magnetic pole pieces N and S, specially designed to produce an inhomogeneous magnetic field, and finally condenses on a cold plate P. If the classical theory is valid, a continuous spread of the beam at the plate is expected. The quantum theory, on the other hand, permits the splitting of the original beam into just two component beams, one deflected upward and the other downward. In terms of the quantum numbers, $L = O$ for silver atoms in the ground state and the magnitude of S has just one value, $|S| = \frac{1}{2}$. Thus the projection of J on the field direction can have but two values, $+\frac{1}{2}$ and $-\frac{1}{2}$; only two deflecting forces, equal in magnitude but opposite in direction, are possible. After conducting the experiment, Stern and Gerlach found on the condensing plate two distinct silver deposits, each with the same shape as the cross section of the ribbon-like beam. Dr. Stern's brilliant work had produced valuable experimental evidence of the validity of the quantum theory.

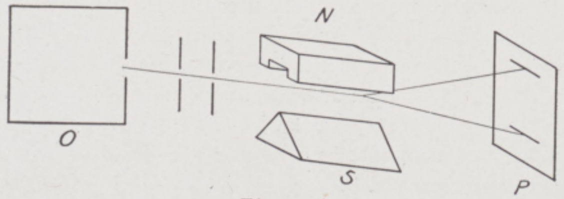


Figure 1
Stern-Gerlach experiment.

The Stern-Gerlach experiment suggested investigations of atomic and molecular electric moments, and the same method has recently been applied to the measurement of nuclear magnetic moments. Other recent research has been conducted by Dr. Stern and his colleagues in the Molecular Physics Research Laboratory at Carnegie Tech concerning the effect of gravitational forces on molecular beams. A precision method for measuring the Bohr magneton by balancing gravitational forces against magnetic forces has been under study, as has velocity sorting by means of the free fall of atoms in a beam.

Dr. Stern's work, however, has by no means been confined to molecular beams. One of his first scientific papers, published jointly with Professor Einstein, indicated from data on the heat capacity of hydrogen at low temperatures that the molecules of solids are not at rest at the absolute zero of temperature, but possess a zero-point energy. This conclusion, at variance with the ideas then existing, is now generally accepted and is predicted by wave mechanics. In 1925 Dr. Stern suggested in a paper on the equilibrium between matter and radiation in the universe that both the annihilation of material particles with the formation of radiation and the reverse process may occur. After Anderson discovered the positron in 1932, physicists learned that positrons collide with negative electrons, producing two photons of radiant energy, and that photons may form positron-electron pairs. Dr. Stern has also written a series of papers which apply quantum theory to the calculation of solid substance vapor pressures and the magnetic properties of solids at low temperatures.

Whether Dr. Stern has dealt with molecular beams or other branches of physics, throughout all of his work, far too extensive to be completely covered here, his genius as an experimentalist has been skillfully guided by his vision and alertness as a theorist. The Nobel Prize is indeed a fitting tribute to his accomplishments in modern science.

The TECHNICAL *wishes to thank Mr. Pake for his promptness in preparing this article.*