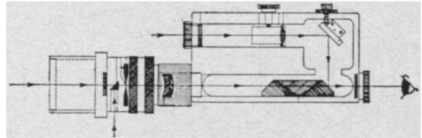


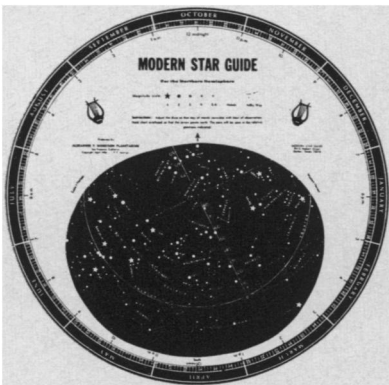
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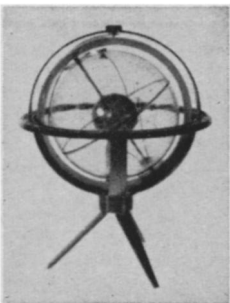
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**films OF THE WEEK**

**QUANTUM MECHANICS—THE FABRIC OF THE ATOM.** A series of 10 illustrated lectures by Dr. Philip Morrison, professor of physics and nuclear studies at the Massachusetts Institute of Technology, from BBC-TV series, obtainable from Peter M. Robbeck & Co., 230 Park Avenue, New York, N.Y. 10017.

All of the following films are 16mm, b&w, 30 min. Rental \$30 or purchase \$180. The price for rental of the 10 films is \$250, and the price for the purchase is \$1,250.

**ON THE STABILITY OF MATTER.** We know only since Rutherford that, like the solar system, the atom of matter is mostly space within which the electrons move, held by forces at least analogous to the force of gravity. In spite of internal motion and spacious structure, an atom somehow remains itself; that which changes in matter, the rusting blade, the hard coal turned to smoke, is but a rearrangement of the same tiny particles. To suggest the extraordinary stability, the incorruptibility of the atoms themselves, they were named by the Greeks, and the word atom means "The Uncut." The material world is stable because its atoms (bricks) are stable.

**THE GRAININESS OF ENERGY.** Matter is grainy. Its grains are the atoms which themselves are grainy and which have atoms of their own. The structure of any two atoms of the same element is identical. Also, the atoms of the atom, the electrons outside the binding central nucleus, are also each to each identical. Inside the nucleus, there is also a grainy structure of identical sub-units. The measure of electrical response, or electronic charge, comes in only a one-sized package, one quantum. A particle may bear a single unit of charge, or any integer multiple of that, never a fractional quantity of charge. Mass and charge come in lumps or particles. Measures of motion, quantities like energy, are also found to occur only in the grainy mode. Atoms are not mere rock-hard; they are quantum-rigid; easily changed by a sufficiently large energy packet, totally unmoved by one only a little smaller. The permanence of our world rests on the fact that no energy store can change by less than its smallest quantum.

**THE QUANTUM OF ACTION.** The quantum of action is a measure of motion. On the atomic level, the quantum of action, Planck's constant  $h$ , is the sovereign measure. The motion of an electron in an atom, with the velocities appropriate to the motion under electrical forces, has just one, two or three such quanta. As  $c$  (the speed of light) parted old space and time from the new relativistic fusion, so  $h$  (Planck's constant) parts Newtonian forces and trajectories from the fused cause and chance of the new mechanics.

**THE FUSION OF CAUSE AND CHANCE.** The atomic world of small action is ruled by a fusion of cause and chance. Light is the most commonplace source of events of small action, ruled by the quantum. The eye, the photographic plate, etc. display an atomic form of recording. A grainy, individual reaction is the mode of these light detectors. Light itself can transfer its energy and momentum only in packets, called photons which cannot be split. The stability of the individual photon is never altered. Light has atoms, too. For every photon, the energy and the momentum strictly satisfy the precise laws of conservation, but just where the next photon will strike, just when it will be counted, are matters which obey the mathematical laws of chance.

**MATTER WAVES.** In light, the wave is far from tangible, determining a mere probability by its strength; its particles are far from isolated, but deposit their invariable stores of energy in accordance with the probability pattern defined with stringency by the wave-like field. Today we believe that all the particles, from neutrino to uranium, all the wave fields, from sound itself to light, gravitation, and the rest, form wave-field patterns (called quantized wave-field). Mass, energy, momentum, change, etc. are always casually conserved, never missing, never new-born. But when and where these grains of quantity are to be found is ruled by a wave pattern which is always to be found in space and time. How it permits the transfer of one or more of these basic grains is up to chance. Again, this is the fusion of cause and chance.

**THE PRINCIPLE OF UNCERTAINTY.** In the past it was believed that since every cause produces an effect, and since every cause itself was an effect, and since we have a continuous history of cause and effect, then we could, therefore, predict what would happen next. This was proven to be untrue. The principle of uncertainty has made our scientific world open up. It tells us what kinds of mechanical knowledge we may or may not obtain. We know atoms always carry

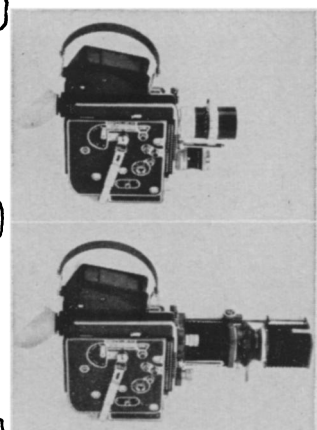
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(Films from p. 406)

mass, charge, energy, momentum, etc., but we cannot hope to follow the motion of an electron in the orbit of a normal atom. If we could, we mark time in its passage. But then the energy would spread, and the atom would be in no well-defined energy level. Uncertainty?

**THE PHYSICS OF IDENTITY.** The grainy nature of quantum systems permits them to be in such states that all representatives, say all electrons spinning parallel to a given axis, or all stable hydrogen atoms, are truly identical, not merely similar, as are peas in a pod. Of course, no direct measurement can establish identity; it can certify merely as to the smallness of differences. The distinction and relation between the single individual and the class is a rich one; the most striking result of quantum mechanics is to have found this very point deep in physics.

**THE QUANTUM FABRIC OF MATTER.** The whole of the material world, with radiation, falls under the domain of quantum mechanics, from the scale of the nucleus within the atom up to the structures of living beings, wherever nuclear physics or atomic chemistry plays an essential role. Every sort of structure, each nucleus, atom, molecule, crystal, has its proper energy levels, calculable by the laws of quantum mechanics from the nature of the elementary building blocks and their familiar forces of inter-action. All matter obeys the structural dictates of the quantum.

**CREATION AND DESTRUCTION.** Stability and form have been emphasized, but change is equally part of the material world, and is equally well treated by the quantum theory. Particles can be created and destroyed under certain restrictions. Electrons, for example, are born to die always twinned with positrons. A photon can pass its energy and momentum on as a legacy to an electron-positron pair, itself disappearing at once. But it cannot do so in free space for the energy and momentum cannot be balanced there. Some external force must be present, and the typical seat of this process is the region near the nucleus where there is a strong electronic field.

**ELEMENTARY PARTICLES: THE ELUSIVE ULTIMATE.** The quantum theory relies upon the existence of these truly identical entities, electrons, protons, neutrons and many unstable "particles." Their nature has been illumined, but still only dimly by this theory. We know many particles, of various families. No really crisp results exist about the particles themselves; their compounds, however, are very well understood. No sign of the failure of quantum mechanics has yet appeared, only a frustration of consistent application to the various interactions. It is not expected that the picture of fused cause and chance, of conservation and virtuality will be discarded. The quantum will always remain.

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