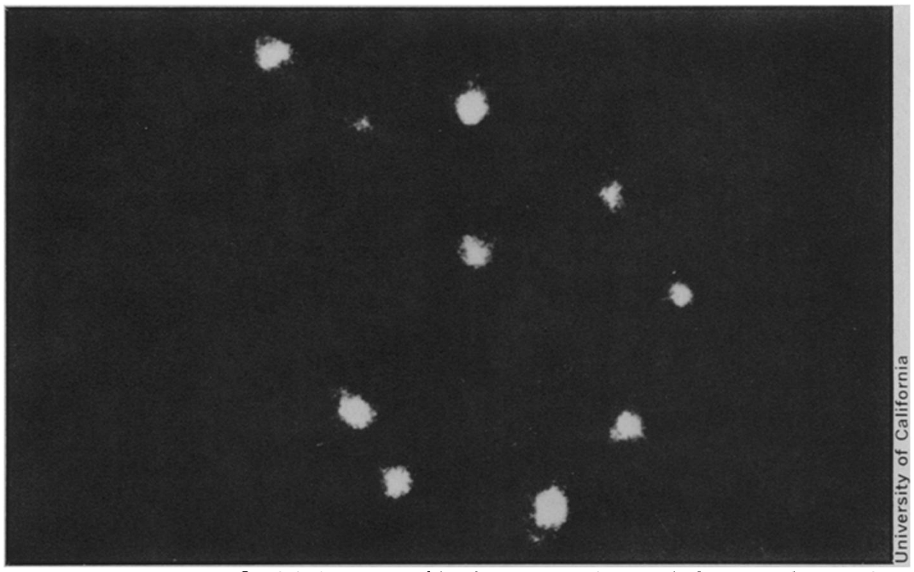
Science News of the Week

Quantum mechanics you can see



Vortex lines in superfluid helium: Visible, but not in form of theoretical triangle.

Quantum mechanics is the physical theory that governs motions and actions on the level of molecules and smaller. It is radically different from the classical physics that rules the macrocosm. Quantum mechanics is discontinuous. It does things in fits and starts. Energy comes out in globs called quanta. In classical physics transitions tend rather to be smooth more often than not, and energy production is in continuous streams.

Getting used to quantum mechanics requires a certain wrenching of the mind out of accustomed paths and byways. The theory deals mainly with things we can never see, hear nor touch, and it asks us to believe things about them that classical physics simply does not prepare us for. It is thus perhaps somewhat reassuring that quantum mechanics touches the macrocosmic world in a couple of points.

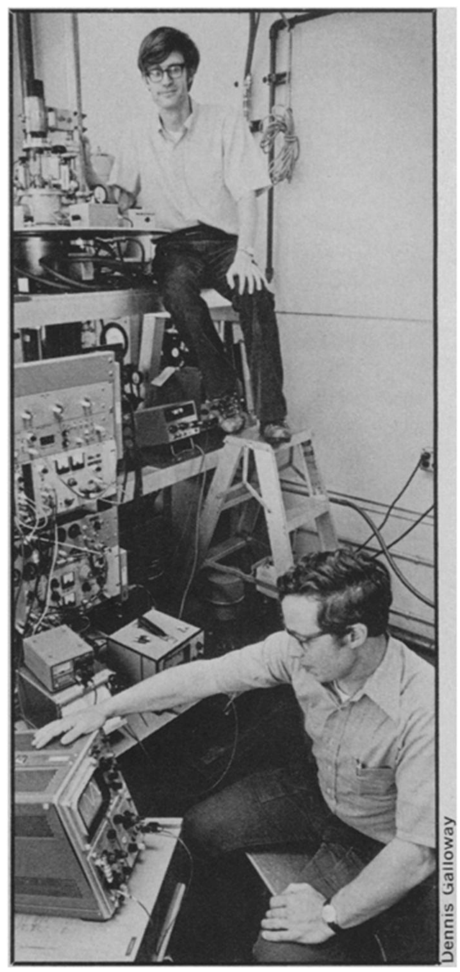
One of these is superfluidity. Superfluidity is a property exhibited by liquid helium when it is cooled to a temperature within a few degrees of absolute zero. The liquid loses viscosity. It can flow through very fine orifices; it will climb the wall of its container, and it does other bizarre and circuslike tricks. This superfluid state is predicted and controlled by quantum theory. So here is quantum mechanics meddling not with a gang of neutrons and protons that we will never in all eternity see, but with a liquid that we can see and into which we could dip our fingers—if our fingers could stand the cold.

One of the macroscopic quantum effects predicted in superfluid helium is a kind of eddy and flow behavior called quantized vortices. The latest news is that these vortices have been rendered visible by Gary A. Williams and Richard E. Packard of the University of California at Berkeley—visible quantum mechanics. The report is in the July 29 Physical Review Letters.

The existence of quantized vortices was predicted independently by Lars Onsager of Yale University and Richard P. Feynman of California Institute of Technology. They suggested that if a sample of superfluid helium was placed in a rotating vessel, instead of the general motion expected of an ordinary fluid, the motion of the superfluid would break down into tiny whirlpools. The speed of the superfluid around the vortex and the number of vortex lines that appeared at different rotation speeds would change in quantized units. The quantum unit for the lines is Planck's constant divided by the mass of the helium atom. So here is a place where the ubiquitous constant of subatomic physics, the most basic constant of quantum mechanics turns up governing a macroscopic effect.

The prediction is based on the belief that the behavior of superfluid helium is controlled by a quantum mechanical wavefunction. The cores of the vortices represent the nodes or zero points of the wave function. Of their method of visualization Williams and Packard point out that it "is one of the only measurements we know which directly measures the positions of the nodes of a wavefunction."

In the 20 years or so since the prediction, evidence has accumulated that circulation in superfluid helium is indeed quantized, and that it comes into rotation in quantum steps. Until now no one has succeeded in making the positions of the vortices visible. Unlike the water vortex above the bathtub drain, the superfluid vortices are too subtle to be directly visible even if one could peer into the rotating chamber, a difficult feat in itself considering the



Williams, Packard and refrigerator.

temperature difference that has to be maintained.

The method of Williams and Packard is conceptually simple but technically difficult to achieve. Electrons from a radioactive tritium source are introduced to the rotating helium from below. The electrons form bubbles, which, for certain fluid dynamic reasons, are trapped on the vortex lines. The electrons remain thus trapped for about 10 seconds. Then an electric field pulls the electrons through the surface of the liquid.

Electric and magnetic fields are used to make the electrons form an image on a phosphor screen. Complicated optics are used to carry the image out of the refrigerator, amplify it and record it on high-speed film. The dots in the picture represent the ends of vortex lines as they intersect the surface of the liquid. To make the method work Williams and Packard had to push electron optics to its technical limits, and they had to build the world's only rotating helium dilution refrigerator capable of working at temperatures less than 0.1 K. Now they hope to add television to the system so that they can watch how the vortex lines move around.

Theory predicts that the vortex lines should form a rigid triangular lattice that rotates with the container. Williams and Packard do not find this pattern. The deviation may be caused by some disturbance. On the other hand, some experts believe that even in an undisturbed superfluid, reality is too complex for the theory, and the triangular pattern will not appear. Williams and Packard want to study the matter further. □

Inducing interferon to prevent colds

Interferon is a glycoprotein produced by surface cells in the body in response to a virus attack. Since its discovery in 1957, investigators have hoped that it might be used to prevent colds and other viral infections. The idea would be to enhance the body's natural production of interferon by administering either interferon or some chemical that would stimulate interferon production in the body.

They have had trouble, however, in harvesting enough human interferon to carry out clinical tests and in finding just the right amount of interferon that is necessary to prevent colds. They have also had difficulty finding a chemical inducer that is both effective and without harmful side effects. The synthetic RNA known as poly I:C looked especially promising in tissue culture and animal tests. But when David A. Hill and his team at the National Institute of Allergy and Infectious Diseases used poly I:C to prevent colds in human volunteers, they obtained disappointing results.

But research has been more promising during the past year or so. Thomas C. Merigan of Stanford University School of Medicine and his colleagues have found that by using relatively large doses of human interferon they could prevent colds in human volunteers (SN: 3/31/73, p. 208). And now Charoen Panusarn and his colleagues at the University of Illinois College of Medicine have found that a particular interferon inducer—a type of propanediamine—effectively protected human volunteers against colds.

The scientists conducted a double-blind, placebo-controlled study on young adult volunteers. Seven volunteers who had no antibodies in their blood against cold viruses were given a placebo and exposed to a common cold virus—rhinovirus Type 21. All of them became infected, six became ill, five showed a rise of antibodies against cold viruses. Interferon appeared in the nasal tissue of three out of four volunteers tested for it, but not until after exposure to the virus. Nine antibody-free volunteers were given the interferon inducer and exposed to the same cold virus. Five of them became infected, two became ill and four experienced a rise in antibodies against cold viruses. Interferon was secreted by the nasal tissue of six out of seven persons tested for it, and it was detectable before virus challenge.

These results show that while the interferon inducer did not reduce infections from cold viruses, it did reduce the number of illnesses, probably by mobilizing interferon before the cold virus arrived.

Seven volunteers who already had antibodies against cold viruses in their blood then received a placebo and were exposed to the cold virus. Four became infected, two ill. Interferon appeared in the nasal tissue of four out of seven persons tested, but not until the time of virus challenge. Six volunteers who already had antibodies against cold viruses received the interferon inducer and were then exposed to the cold virus. Four of them became infected, none ill. Interferon was secreted by the nasal tissue of all volunteers tested (six) and it appeared before virus challenge.

These results suggest that if a person already has antibodies against cold virus in his blood, then receives an interferon inducer, his chances of fighting off a cold are even greater than if he only received the inducer. The antibodies apparently assist interferon in fighting the virus. □

Sea floor drilled to record depth

The Deep Sea Drilling Project now more than ever can put the emphasis on "deep." On the thirty-seventh leg of its global mission to sample the ocean bottom, the research ship Glomar Challenger bettered by more than seven-fold its previous record for depth of penetration into the basement rock lying beneath the sediments on the sea floor. Repeatedly changing the bit at the end of its drill string, it drilled, at one point, 1,910 feet into the rock near the Mid-Atlantic Rift.

Prior to Leg 37, the Challenger's deepest penetrations into the igneous rocks underlying the bottom sediments had been 260 feet. But on the latest leg, only a few miles from where a school of submersibles under Project Famous were probing the Mid-Atlantic Rift, the drills bored their way into depths of 333, 405, 1,023, 1,092 and 1,-910 feet. On the deepest attempt, nine reentries were required (three of them to change bits, the others for such causes as the collapse of the hole sides, requiring the bit to be removed and reinserted), more than the total in all the previous holes, according to a project official.

The results from Leg 37's holes were striking. Chief scientists Fabrizio Aumento of Dalhousie University in Nova Scotia and William G. Melson of the Smithsonian Institution in Washington report the discovery of layer upon layer of alternating marine basalt (lava) flows and sediment. That the layers seem to have been deposited in a span of as little as 100,000 years, about 3.5 million years ago, is further evidence identifying the Rift region as the birthplace of new material in the Atlantic Ocean floor.

The most significant find may turn out to be a complex sequence of plutonic rocks—igneous rocks formed at great depths—which just may represent samples of the deep crust material that underlies both the sedimentary and basalt layers. Yet strangely, they seem to contain no traces of basalt, which ought to be the middle layer in the sea floor "sandwich." A possible theory, the scientists suggest, is that the plutonic rocks were originally upthrust to sediment level just before a volcanic episode began, so that the subsequent lava would be on top.

Replacing a drill bit is no major achievement itself. It is the ability to put the new bit back into the old hole, after first having to lower it through more than 6,000 feet of water, that has added new potential to the Challenger's already fruitful mission.

In the past, a dull drill bit almost