Quantum mechanics in a whirl

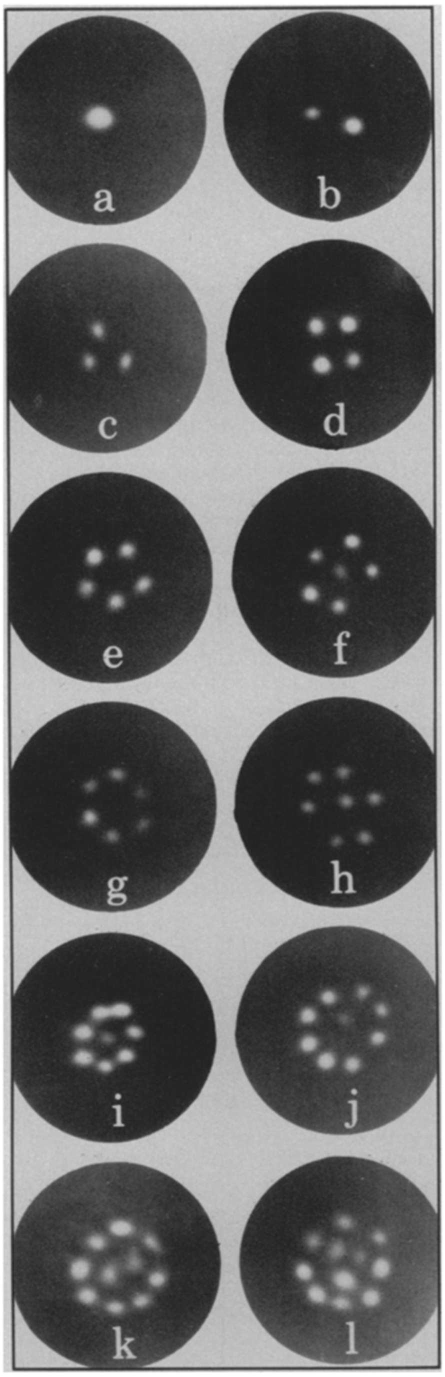
Helium is physics's answer to silly putty. When it is cooled to temperatures approaching absolute zero it starts exhibiting the most extraordinary properties. It becomes a "superfluid" that flows without friction, a liquid that can climb the walls of its container seemingly against gravity. Perhaps superfluid helium's most amazing trick is performed when its container is rotated. When a vessel filled with an ordinary fluid (such as water) is rotated faster and faster, the liquid inside also circulates uniformly at a continuously increasing speed. But superfluid helium refuses to do this. Instead of circulating in a continuous flow, it rotates in quantum steps. This unique flow has been photographed at the University of California at Berkeley (SN: 8/3/74, p. 68), and now three physicists from that same laboratory have finally matched the observations with the theory.

When a container of superfluid helium starts to rotate, the helium at first stays at rest. When the vessel's rotation reaches a critical speed, the helium begins to flow, but as a tiny whirlpool in the center that stretches from the surface down the length of the container. As the vessel rotates faster, the one quantized vortex remains until the next critical speed is reached, at which time a second whirlpool appears. Additional vortices are formed at higher and higher critical speeds.

The vortices represent the nodes or zero points of the wave function that describes the behavior of the helium. The strength of each vortex (a number that tells how fast the fluid rotates at a given distance from the center) is also quantized in units of Planck's constant h divided by the mass of a helium atom. This is striking because atomic constants are being used to describe a macroscopic flow. Quantum mechanics, in a sense, becomes visible to our very eyes (visible, at least, with the right equipment).

After many years of work, the vortex lines were first photographed five years ago, but their positions were not as predicted by theory. But now, the theoretical, symmetrical arrays have been captured on film by Edward J. Yarmchuk, Michael J.V. Gordon and Richard E. Packard after refining the techniques developed earlier. Electrons from a radioactive tritium source were injected into the superfluid helium and formed bubbles that were drawn into the vortices (just as objects are sucked into tornados), marking the position of the vortex. An electric field was then applied to accelerate the electrons out of the liquid and have them focused on a phosphor screen.

Yarmchuk says they were finally able to observe patterns that were in good agreement with the theory because of the reduced vibrations in their new system. A television camera, which continually monitored the phosphor screen, enabled them to take a picture of the vortices every ten seconds instead of only several pictures per hour as previously. Such elaborate techniques are needed to see the whirlpools since they are only two-hundredths of a centimeter apart. The superfluid helium was held in a cylindrical bucket 2 millimeters in diameter and 25 mm long. A special refrigerator (which also rotated the bucket) kept the liquid at temperatures near 0.1°K. □



Yarmchuk, Gordon and Packard

Superfluid helium rotates in quantum steps instead of in one continuous flow. The pattern is that of tiny whirlpools centered in the vessel. As the vessel rotates faster and faster, new vortices appear only at certain speeds.

Heavy crudes decontrolled

AP

President Jimmy Carter's energy program hangs in limbo during the congressional summer recess, but Carter signed an executive order August 17 removing the price controls on heavy crude oil (SN: 7/21/79, p. 42). As he demonstrated during the signing, heavy crude is so thick it won't pour, and must be heated to be extracted. At present, heavy crude reserves in the United States are estimated at 10 billion barrels, and 250,000 barrels a day are being produced — about 3 percent of the total domestic oil — at $6 a barrel. Decontrol is expected to raise the price per barrel to between $15 and $18 a barrel and produce 500,000 more barrels of oil a day by the year 2000, the White House says. The order, which is effective immediately, considers heavy crude any oil with a specific gravity of 16 degrees or less. □