even in your local science museum's tornado vortex demonstrations. Lord Kelvin further proposed that elementary particles were associated with the phenomenon of linked vortex rings, but this idea was dropped after the Michelson–Morley experiments disproved the idea of an electromagnetic ether as a transmission medium for light.

Here is the twist on Lord Kelvin's legacy: the Higgs mechanism, long embraced in the standard model, endows the vacuum with at least one relativistic field — which has properties similar to a superconductor or superfluid. There is an ether; so the discredit of Lord Kelvin's notion was perhaps premature. Ask your favourite high-energy theorist this question: how many Higgs fields are part of the vacuum? Each of those may or may not have topological defects depending on the order (symmetry) of the fields.

And a final puzzle: how much of the stability of the known elementary particles is topological in nature? How much of the turbulence in plasmas and fluids is topological in nature? The scientific community is not settled on these questions. Studying vortex rings and knotted vortex rings may well be important in finding a final answer. ❐

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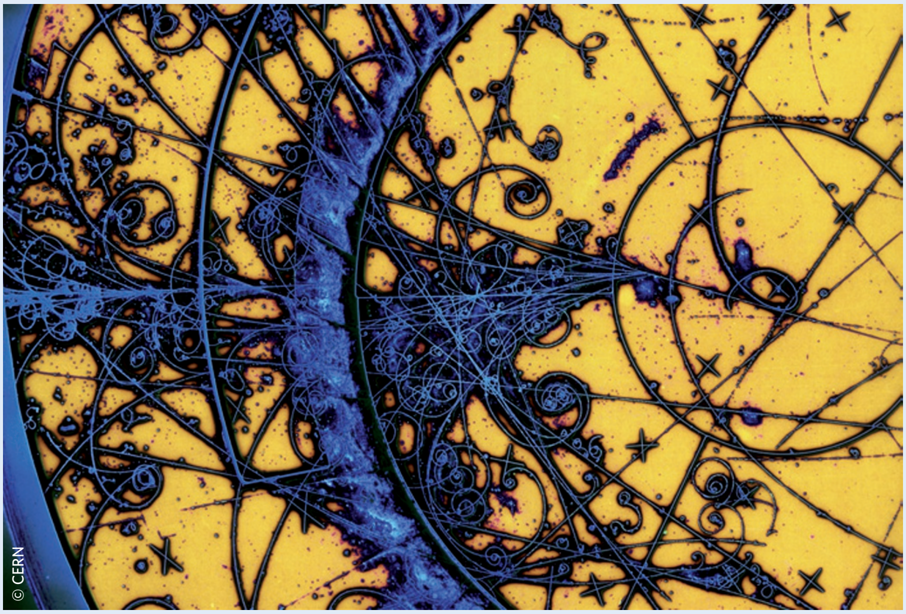
DONALD A. GLASER

Brilliant bubbles

They are some of the most beautiful, iconic images in particle physics, indeed in all of physics: the curling tracks of subatomic particles photographed as their ionization energy causes a trail of bubbles to nucleate in a body of superheated liquid.

The bubble chamber was invented in 1952 by Donald Glaser, who had studied for his doctorate at the Californian Institute of Technology under Carl Anderson, discoverer of the positron. Particle physicists were then facing the challenge of understanding the 'strange particles' that had been spotted in cloud-chamber tracks of cosmic rays in the late 1940s, and also of improving particle detection capabilities to match the new accelerator technology — synchrotrons that could accelerate protons to energies of a few gigaelectronvolts. Something bigger than a cloud chamber, and with a faster cycling time, was needed.

Glaser calculated that the thermal instability of a superheated liquid could be exploited to make a high-density, large-volume detector, such that energetic particles passing through would cause a trail of vapour bubbles large enough to be captured photographically and from which the particle trajectories could be determined accurately. Some of his early laboratory investigations of bubbling liquids apparently involved bottles of beer and ginger ale, but the first serious experiments were performed using diethyl ether.



Glaser's 15-cm propane-filled prototype became the first bubble chamber to be used for high-energy physics, at the 'Cosmotron', a proton synchrotron at Brookhaven National Laboratory. Soon, laboratories around the world were building bubble chambers, of ever increasing size and often filled with liquid hydrogen for optimum performance. And the data — on types of particle, their masses, spins, lifetimes and so on — flooded in. In 1973, from the freon-filled bubble chamber Gargamelle, at CERN, came the first evidence of the weak neutral current: a crucial step in understanding the relation of the electromagnetic and weak forces, leading later to the discovery of the *W* and *Z* bosons.

This famous image was recorded by the Big European Bubble Chamber (BEBC) — one of its 6.3 million photographs recorded between 1973 and 1984, on 3,000 km of film, pored over by 600 scientists from 50 laboratories. BEBC was filled with 35 m^3 of liquid (hydrogen, deuterium or a neon-hydrogen mixture) whose pressure was regulated using a 2-tonne piston. (BEBC, its piston and Gargamelle are all on display at CERN.)

Ultimately, the bubble chamber was superseded by technology capable of electronic, rather than photographic, data read-out — the wire chamber, in particular. Having carried off the 1960 Nobel Prize in physics for his invention of the bubble chamber, Glaser moved on to a research career in molecular biology, and then later in neurobiology. He died on 28 February 2013.

ALISON WRIGHT