Strange Matters

Can advanced accelerators initiate runaway reactions?

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If you have trouble sleeping, you don't want to know about the physicist's worst nightmare: an atom smasher produces a new form of matter even more stable than everyday protons and neutrons, thereby triggering a cataclysmic, self-sustaining reaction that consumes the earth.

Although no serious scientists believe an atomic collision could ever lead to a global meltdown, they still want to be very, very sure it will never happen. Since the beginning of the nuclear age, researchers have met many times—usually behind closed doors—to discuss whether there was any chance that a proposed experiment might initiate a catastrophic event. Physicists rarely discuss the issue openly, fearing bad public relations, but recently some have given candid accounts of the secret meetings. "It's a real concern," observes Henry J. Crawford of the University of California at Berkeley. "Whenever scientists have started a new accelerator program, one of the first talks is always on this topic."

Indeed, one of the most astonishing debates of this subject was revealed by Subal Das Gupta and Gary D. Westfall in Physics Today. The story began some 30 years ago, when the Lawrence Berkeley Laboratory was planning to build a particle accelerator called the Bevalac. At the time, two theorists, Nobel laureate Tsung Dao Lee and the late Gian-Carlo Wick, raised the possibility that conditions of extreme energy and density could create a new phase of dense and stable nuclear matter. If this substance, known as Lee-Wick matter, existed and could be generated, the physicists feared, it would quickly accrete every atom around it—namely, the laboratory, California and the rest of the planet.

Researchers realized that the Bevalac had a shot at making Lee-Wick matter, and under no circumstances did they want to prove the theorists right during a test run of the machine. "We took the issue very seriously," comments Westfall, who was a member of the Bevalac's scientific sta› at the time. "We appointed a blue-ribbon committee to make sure there was no chance it would happen."

The committee, which included Miklos Gyulassy, who is now at Columbia University, met several times. Together they concluded that the Bevalac had no chance of initiating a nuclear disaster. The physicists reasoned that nature had already performed the relevant experiment: the earth, moon and all celestial bodies are constantly bombarded with an extraordinary number of high energy particles that are produced by stars. Some of the particles collide with atoms on the earth and create conditions that equal or surpass anything the Bevalac could do. Yet the planet was still reassuringly here. Nor had any such event destroyed the moon, which had been struck by countless high-energy particles for at least a few billion years.

In the 1970s the operation of the Bevalac and other accelerators confirmed that Lee-Wick matter did not exist. This happy state of affairs can be explained. When an atomic nucleus collides with another and is compressed into a volume about one fourth its normal value, it expands in about a thousandth of a billionth of a billionth of a second. Nuclear matter that has been compressed somewhat is simply not stable.

But what happens if nuclear matter is compressed to more extreme densities? If two nuclei collide at energies a bit beyond those that modern atom smashers can achieve, the nuclei should transform into so-called strange matter. The protons and neutrons of an atom are themselves made up of quarks, and when the quarks collide at high energy, they may yield a heavier particle: the strange quark. The consensus among theorists is that certain combinations of strange quarks with others are stable. Strange matter should grow through the accretion of ordinary atoms. But not to worry. The droplet of matter should not get much larger than a few million strange particles, theorists think. All such particles should carry a relatively large quantity of positive charge that should ultimately cause the droplet to burst apart. "The basic idea is that at equilibrium the stuff has a net positive charge, and as a result it would turn its own reactions off," Crawford says.

So how can theorists be absolutely certain that an accelerator will never spawn a voracious clump of strange matter? The question was first posed seriously in 1983, when researchers were designing the Relativistic Heavy Ion Collider (RHIC). The collider, now under construction at Brookhaven National Laboratory, promises to be the world's most powerful smasher of heavy atoms and could quite possibly generate strange matter. Piet Hut of the Institute for Advanced Study in Princeton, N.J., put everyone's fears to rest. Applying the same logic his predecessors had used, Hut showed that innumerable cosmic particles collide with atoms on the earth and moon, creating conditions far more extreme than those of RHIC. Calculations similar to Hut's have been done "for all the accelerators that have been built so far," Crawford says, and therefore physicists know they are "not going to be walking in any dangerous territory."

Although there is no instrument yet built that could cause the earth to become a lump of strange matter, such transformations may occur in other celestial bodies. If a droplet of strange matter forms within a star made of dense neutral matter, it might initiate a chain reaction that would create a strange-matter star. Physicists say such events can occur only in the heavens. Let's hope they are right. —*Russell Ruthen*

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