The enlightening transition from stuff to stuff

In practice, much of particle physics involves looking at how stuff turns into other stuff. When high-energy particles decay into new particles, the properties of those decays tell you all sorts of things about the original particles. Conversely, some of the properties of the new particles can be deduced from how they came into being. The process of change is just as important as the characteristics of the stuff involved in that change when it comes to understanding the laws of nature.

In many cases, the process is obscured; physicists see only the start or the end of it. When all of the energy that goes into a particle collision can't be accounted for in the aftermath, it means physicists are not seeing some of the end products—neutrinos, perhaps, or something more exotic that their detectors aren't picking up. In other cases, only the end products are visible, such as in experiments where physicists see light coming from high-energy muons that were created as neutrinos hit the detector. Astrophysicists may look for gamma rays that are the end product of dark-matter annihilation, which we can't see directly.

But in the best cases, when both the initial and end products are visible, physicists can often close loopholes involving exotic particles or unknown physical phenomena. One example recently is the OPERA experiment's observation of muon neutrinos turning into tau neutrinos in a process called oscillation. This marked the first time that the second half of the process—the tau neutrino appearing out of the oscillation—had been captured. (See the May 31 post in *symmetry breaking* online for more details of that experiment.)

A planned experiment called Mu2e, in which muons might be seen turning into electrons, is another example of capturing both the initial components and end products of a change. (See page 10.) Physicists don't yet know if this process actually exists, but the question of whether it does or not (see "Explain it in 60 Seconds" on the back cover) has big implications for the fundamental structure of the laws of the universe, especially as scientists try to unify all the particles and forces into a sensible, consistent framework.

Particle physics, or at least the news reports of it, often seems concerned only with the existence and characteristics of various particles. However, physicists are just as interested in what happens as those particles turn into each other. The universe is not merely a zoo of strange stuff. It is an oddly behaved, mysterious, and intriguing dance of evanescent players, with an ever-changing choreography, and new performers appearing on the floor as it progresses. It is the dance of the universe that enlivens us and drives us, gradually revealing its steps to those persistent enough to watch closely.

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