of water that has just come to a boil. That is the multiverse. It was created as a science fair project by an alien being whose name roughly translates to Timmy. He mixed together what we might call—in a very crude analogy—chemicals and heated them on the stove. (The secret, his mom said, is to add just the right amount of inflatons.)

As the pot started to boil, Timmy's eyes grew wide with delight. He leaned forward to take a closer look, and as our universe floated up, he said, "Wow!"—an exclamation that took, by our reckoning, 100 billion years.

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Footnote on femtochemistry

Marcos Dantus commented on the femtosecond bond formation by bringing readers' attention to his and others' early contributions in the 1990s (PHYSICS TODAY, November 2015, page 10). I would like to add to the discussion an interesting interview comment by Yuan T. Lee, who shared the 1986 Nobel Prize in Chemistry for his work on molecular beams.[1]

When Lee was asked, "Do you think that what is called femtochemistry has overtaken what you had been doing?," he replied,

> Not really. The people doing femtochemistry always say that for studying the molecular beams they have to go to femtochemistry. However, when we do chemical reactions, we already have the rotational period as a clock. In the reaction of potassium and methyliodide, what Dudley Herschbach was doing, it was possible to see the product bouncing backward in the time period of one rotation. That clock is a picosecond clock. It made it possible to tell how fast that chemical reaction took place. One of the reactions was particularly interesting. It was a charge transfer reaction between potassium and oxygen. At a long distance there is an electron transfer and the oxygen starts vibrating. Then at some point the electron jumps back to potassium. By looking at the angular distribution, it was possible to see the oscillation of electron jump probability based on the molecular vibration. It is a femtosecond phenomenon. In the beam experiments, there is a lot of information provided on a femtosecond timescale. Of course, when you use spectroscopy, you can see electronic excited states and how they decay on a femtosecond scale. However, it won't tell you anything about approach and molecular alignment and other spatial characteristics. Neither will it give information about angular momentum and the conservation of angular momentum.

Lee's arguments about the pico- and femto-clocking capability of molecular rotations and vibrations can be traced back to his Nobel lecture, in which he referred to more detailed expositions in the lecture by Herschbach, his colaureate. In molecular-beam studies, the intrinsic clocking capability and insights gained from angular distributions of reactants and products are admittedly powerful and revealing. But rather than overshadowing traditional molecular-beam achievements, femtochemistry has contributed fundamentally to our understanding of molecular-reaction dynamics. Even for the seemingly simple bond-formation mechanisms mentioned by Dantus, there is still much more to discover. But that will happen only as we welcome more innovative theoretical and experimental advancements, following the legacy of Lee, Manfred Eigen, Ronald Norrish, Herschbach, Ahmed Zewail, and more.

Reference

1. I. Hargittai, M. Hargittai, *Candid Science VI: More Conversations with Famous Scientists*, Imperial College Press (2006), p. 445.

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