The Biggest News in the Universe

June 2, 2014 | by **Elizabeth Wason**

In the beginning was the Big Bang. The universe surged expansively outward, and then, with a slamming jolt, resumed its outward sprawl at a much slower pace. The shocks caused by this sudden burst of growth shuddered through the universe, sending ripples of gravitational waves through space and time.

And this all happened within a single second of the universe's existence.

Physicists called the universe's initial, massive outward burst "inflation" and theorized that the tremors created by its sudden start and stop stretched as the universe expanded, forming the gravitational waves that account for Newton's falling apple.

Einstein guessed at gravitational waves a century ago. The idea of inflation was conceived in 1981. The concepts were mathematically sound, but no one had uncovered tangible evidence to confirm these leaps of imagination. So while it was solid theory, it was also, in a way, pretend.

"Because we're at the forefront of technology, we get to be creative," admits LSA physics professor Katherine Freese. "We invent something and we hope that it matches reality." Freese, like many other physicists, imagines what the universe is like, without being able to see or touch it. Her mathematical models serve as educated guesses about the history of the universe, which remain unconfirmed until new technologies or discoveries bring new data. "Actually, I like that about physics," Freese says. "You just invent something, it works, you move on."

As a young researcher 25 years ago, not long after she got her PhD, Freese and two of her

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colleagues came up with a model of how inflation could have happened after the Big Bang. On paper, it worked. But so did thousands of other inflation models that popped up in the 25 years since then, some of them wildly different.

For decades, gravitational waves, the inflation event that created them, and myriad inflation models all seemed like plausible, but unsubstantiated, explanations. Not any more.

Big News

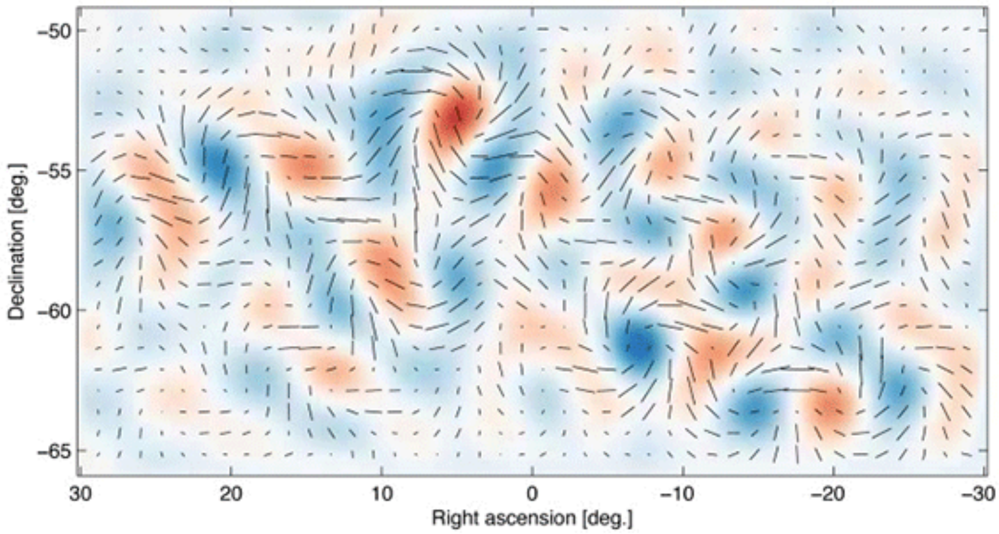
On a Tuesday night in March, Freese was scheduled to speak to the Society of Physics Students about WIMPs, the weakly interacting massive particles she studies. But everyone was too excited and talking about the big news that had come out over the weekend: gravitational waves had been spotted in a patch of space above Antarctica!

Freese would talk about the discovery of gravitational waves instead of WIMPs for tonight's meeting, was the murmur that flashed through the group of students as they ate dinner outside the West Hall classroom. The students dropped their unfinished pizza and rushed into the next room when she arrived.

Photo courtesy of World Science Festival.

The excitement in the room was so thick that Freese focused on sharing the underlying research to the exclusion of all else, including the propriety of proper footwear. She kicked off her boots and strode across the front of the room as it filled with students. She waved a wooden stick as a pointer for the slideshow projected onscreen. She used chalk to write on the blackboard, for emphasis.

She was saying that researchers in Antarctica claimed to have detected gravitational waves using a telescope called BICEP2 (pictured at top of page). For years, those researchers had peered at the Cosmic Microwave Background (CMB), which Freese described as light left over from the early universe, about 380,000 years after the Big Bang. The researchers were scanning a patch of the CMB for B-mode polarization, a recognizable pattern in the vibration of light particles in outer space, which would provide distinct evidence that gravitational waves at one point rippled through the universe. B-mode polarization would be a sort of gravitational wave trail, just like footprints in snow that reveal someone's path, or iron filings that scatter to reveal the presence of a magnetic field. The researchers in Antarctica believed they had spotted B-mode polarization in the CMB. And this was what everyone was so excited about.



Like scattered iron filings that reveal a magnetic field, the B-mode polarization shown in this figure reveals that gravitational waves once rippled through outer space.
Harvard-Smithsonian Center for Astrophysics/Corbis.

As we speak, cosmologists eagerly await confirmation of these observations by other experiments. “If confirmed,” Freese said, “the BICEP2 results are spectacular.”

The discovery instantaneously made real Einstein’s century-old vision of gravitational waves and all but verified inflation as the true story of the birth of the universe. The results from BICEP2 also wiped out thousands of existing inflation models, the majority of which couldn’t account for this new information.

“Theorists constructed thousands of inflation models in the absence of data,” Freese said to the students, signifying the thousands by spreading her hands a few feet apart, palms facing each other. She moved her palms closer and closer together until only an inch separated them. “Between Friday and yesterday, the new evidence ruled out all but *this many* existing models of inflation.” Freese’s is one of those few surviving models.

“No matter how brilliant and creative an idea is, it just may not turn out to be the way the world works,” Freese writes in her new book, *The Cosmic Cocktail*. “Getting the right answer also requires a lot of luck. Most good ideas turn out to be wrong when new data show that they just don’t match our Universe.”

“Of course, you hope that your model will work, but you don’t really expect that,” Freese says. “So the fact that our inflation model hasn’t been ruled out, and most of the other models have been, is like, whoa—it’s really exciting.”

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