FISHER SCIENCE EDUCATION

HEADLINE DISCOVERIES

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# "KISS YOUR UNIVERSE GOODBYE..."

The Universe is an exceedingly simple place. But it'll fool you.

It fooled Einstein. Twice.

For most of the history of science, people considered the Universe to be stable, ever-present and safe. Turns out: the Universe is not only flying apart, but that its rush to annihilation is accelerating. Creation is doomed. This is the (short) story of how we know.

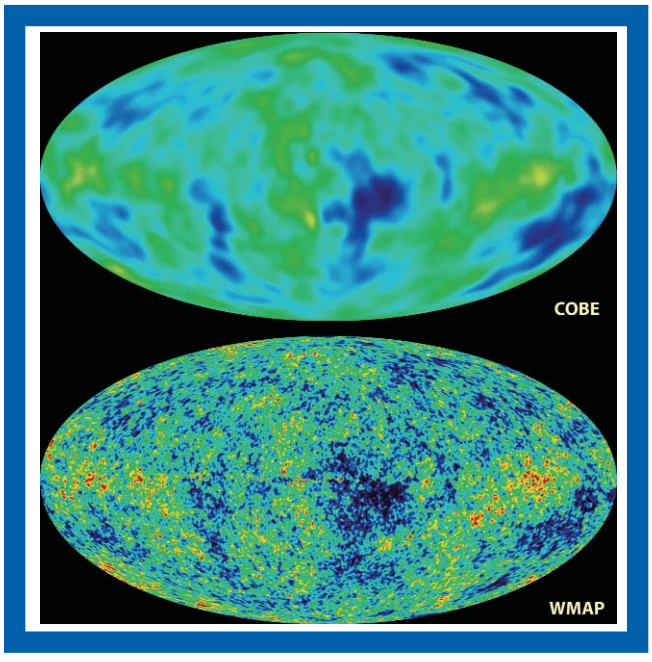
## Expansive Math

It's 1914 and young Albert Einstein is in Berlin scratching his head. He's come up with a way to adjust Newton's theory of gravity to account for how light behaves. Einstein thinks that the very shape of space is created by the masses of the matter within it. The Sun makes a dimple in space and all the planets are trying to roll "downhill" toward it, etc. He'll publish this "General Theory of Relativity" next year. But first he has to fix a big problem. At least he thinks it's a problem. His theory fits the observable Universe like a glove, but Einstein's math is clearly telling him that the Cosmos is swelling up and spreading out. "Well, that can't possibly be," thinks Einstein. And he writes a fudge-factor—a "cosmological constant"—into the equations to calm his nervous Universe into the steady, stately sky that common sense demands.

At about the same time, on a mound called Mars Hill near Flagstaff, Arizona, Vesto Slipher is trying to capture the spectrum of every interesting thing in the night skies. A spectrum, of course, is what you get when you break up the light of a star, or planet, or galaxy, into its constituent colors. But not just colors; you also get a series of dark lines. Slipher can read these spectral lines like a book—a cookbook, in fact, for how the Universe makes each object. But Slipher is puzzled by something. The spectral patterns of different galaxies appear quite similar, but the spectral lines are "shifted" by varying amounts. Well, if you've ever heard a car or train horn blowing as it passed you by, you have a clue as to what Slipher was seeing. The horn's pitch rises as it comes toward you and shifts downward as it goes away. And so it goes with the light of galaxies. If they're moving away from you, they seem to get redder. Slipher has discovered what astronomers now call "redshift."

Fast forward to 1928. Astronomer Edwin Hubble has been spending inhumanly long hours high above Los Angeles in a cold, drafty observatory. Hubble and his assistant Milt Humanson (who began as a janitor) are hand-guiding a cranky behemoth of a telescope, holding it on various fuzzy targets for the hours and hours required to collect their ancient light. Five years earlier, Hubble had rocked the universe of astronomers by proving that the blurry object called Andromeda was actually a separate galaxy of stars, not just another nebula within our own. He did it by photographing a predictable type of star—called a Cepheid variable—within Andromeda, and comparing its brightness to nearby Cepheids whose distances are known. Now, Hubble and Humanson have bagged Cepheids in 20 different galaxies.

Hubble combines Slipher's spectra, which show motion, with his own brightness data, which gives distance. And he comes to a startling conclusion. Just about every galaxy seems to be moving away from every other—the farther from Earth, the faster they move. Hubble and Humanson, without ever really knowing much about Einstein's troublesome expanding Universe, have proven that it exists after all.




*NASA is attempting to image the universe using infrared (COBE satellite) and microwave (WMAP probe) methods.*

## Surprising Sameness: The Cosmological Principle

Hubble's proof rests on the assumption that the Universe is, well, universal. Let's say you put on SCUBA gear, shrank yourself to the size of a rice grain and went for a dunk in the middle of a milk shake. Once you're immersed in the frothy slush, it all looks pretty much the same wherever you look. That's what astronomers see when they look at groups of galaxies. It's a big fog of foam out there. The distribution of matter is approximately the same anywhere they swing their scopes. This texture of the Universe seems so universally similar that we're pretty sure alien astronomers in all those other galaxies are getting the same picture. Cosmologists call this "invariance under translation."

Now, because it all looks the same, words like "up," "down," "north," "south," "right," and "left" don't really have any meaning on the grand scale of the Universe. Locally, your science classroom looks very different from your bedroom (at least we hope it does). But as you step back and look at bigger and bigger things (stars, galaxies, clusters of galaxies, super-clusters of galaxies), space stuff looks more and more alike. So it gets harder and harder to give "road directions" as larger and larger landmarks have fewer and fewer distinguishing features. The Universe is pretty uniform. Cosmologists call this "isotropy."

And it is from the isotropy of the Cosmos that cosmologists come up with this amazing intuitive leap: "If something looks all the same, it probably is all the same!" (See, I told you this was all simple.) Take the evidence that it's all expanding. Add the evidence that it's all the same. And run the movie backwards. Result? Your Universe probably all came from one very tiny, very simple, very hot, very dense thing. Cosmologists call this a "singularity."

But somehow, it wasn't a completely perfect thing. If space and time were perfect, neither could actually exist. We wouldn't exist. Objects bust the perfection of space. And Events bust the perfection of time. Cosmologists call this "broken symmetry." When it broke, it broke fast. In a 1927 paper, Belgian priest and theoretical physicist Georges Lemaître calls it "a cosmic egg exploding at the instant of Creation" and a "primeval atom."

Twenty-two years later, astronomer Fred Hoyle, who prefers Einstein's fudged but steady state Universe, scoffed at Lemaître's concept, calling it "this Big Bang idea." And, as we all know, the name stuck.

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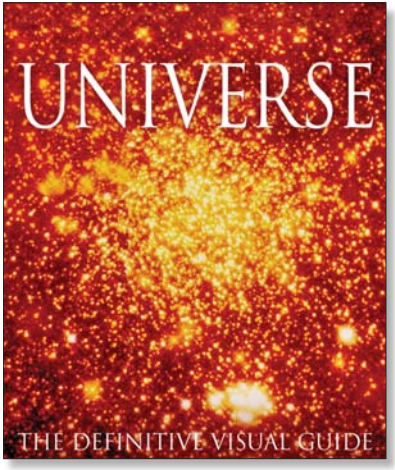


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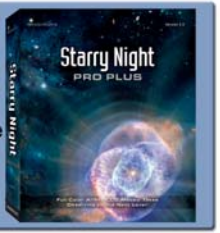


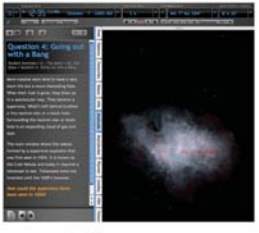

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