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Hunt for Big Bang gravitational waves gets $40 million boost

The nonprofit Simons Foundation will fund a new observatory to search for signs of stretching in the very early universe.

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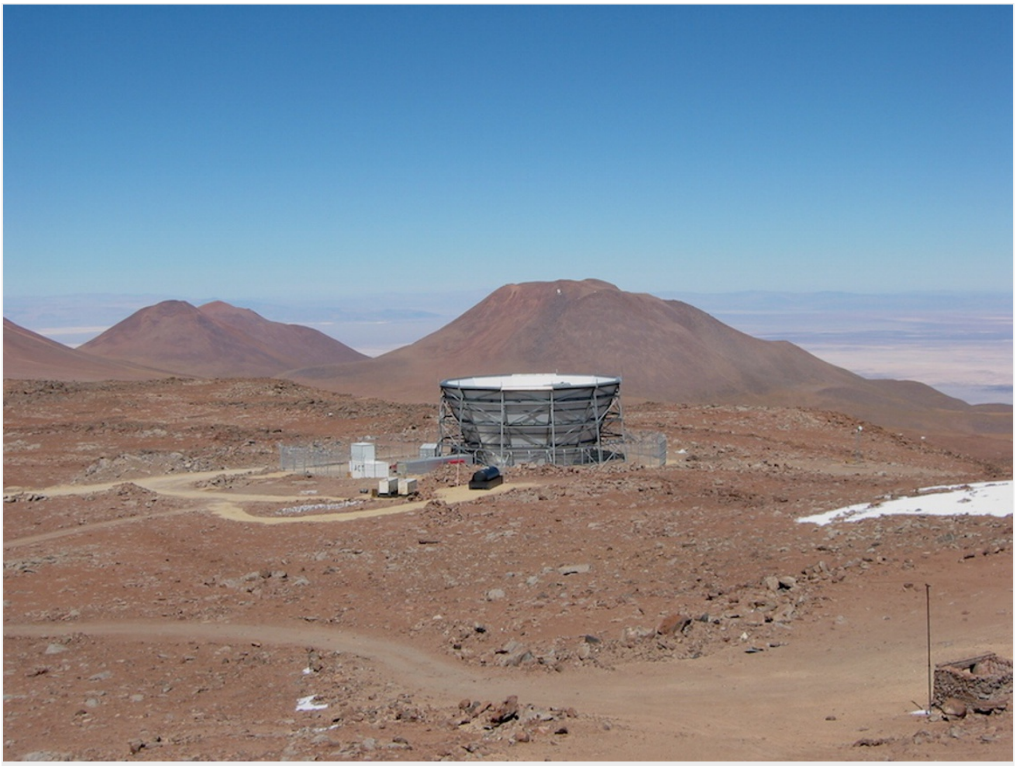

Princeton University

The Simons Observatory will expand on facilities such as the Atacama Cosmology Telescope (pictured), in Chile's Atacama desert.

How did it all begin? The origin of the cosmos is probably the biggest mystery in science—but amazingly, researchers do have some hard evidence to consult in their attempts to solve it. The cosmic microwave background (CMB), a microwave fog that pervades space, is the oldest light in existence—it was released about 13.7 billion years ago when the extremely hot and dense baby universe cooled enough to allow photons to travel freely for the first time. That was about 380,000 years after the Big Bang, and the light has been flying through space ever since. Although the light itself is already unimaginably ancient, it may preserve a record of things that happened even earlier—specifically, it might contain imprints from gravitational waves that may have ripped through the cosmos in the very first moments of space and time.

To search for these waves, scientists are launching the Simons Observatory, a $40 million telescope project to be built in Chile's Atacama Desert and funded by the New York-based nonprofit Simons Foundation. "We don't know the level at which [gravitational waves] will appear, but there's a level where if they're smaller we won't be able to measure them," says Simons Observatory spokesperson Mark Devlin, a cosmologist at the University of Pennsylvania. "None of the current experiments are anywhere close to being able to do that. What this Simons grant allows us to do is make a huge leap forward in making progress."

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These primordial gravitational waves—not to be confused with the waves recently spotted to much fanfare by the Laser Interferometer Gravitational-Wave Observatory (LIGO)—are predicted by a theory called inflation, which suggests the universe may have dramatically ballooned in size during the first fractions of a second after its birth. Such wrenching, rapid expansion would have produced gravitational ripples in spacetime that could have been imprinted on the CMB in the form of so-called "b-modes"—a curling pattern in the polarization, or orientation, of the CMB light. “I think we have a very good shot at getting the answer to whether or not inflation really took place,” says Simons Foundation founder Jim Simons.

Smoking gun?

The discovery of b-modes would be taken by many as smoking-gun proof of inflation, but would not convince everyone. The theory has a growing number of skeptics who say the fact that primordial gravitational waves have not been seen to date already rules out many of the most plausible versions of inflation. “It’s already profoundly important that we don’t see them, and if we continue to not see them, I think it will be an important psychological effect on people, making them hopefully look around and see if there are better ideas,” says Princeton University physicist Paul Steinhardt, who is one of the founders of inflation but has grown disillusioned with the theory. Yet many astrophysicists stand by inflation because it can explain numerous features of our current universe, such as the fact that space appears to be flat and roughly the same in all directions. “Inflation is the best idea we have at the moment, but I wouldn’t be surprised if it’s not the theory we’ll have of the early universe in 50 years,” says Princeton University theoretical physicist David Spergel, a member of the Simons Observatory’s executive board. “That’s to me one of the motivations for getting better data. We might find some intriguing anomaly that points the way toward a deeper theory.”

This possibility appeals to scientists on all sides of the debate. “I think it’s an extraordinarily generous and visionary contribution to the field," Steinhardt says of the Simons Foundation grant (he is not affiliated with the project). “It’s going to have historic value, I think, whichever way it goes. The team of people involved in these experiments are absolutely terrific, highly reliable, and this is very challenging, precision work that requires the utmost care.”

About two years ago scientists made a false-alarm announcement of primordial gravitational waves. Researchers with the Background Imaging of Cosmic Extragalactic Polarization 2 (BICEP2) experiment at the South Pole claimed to have seen strong evidence of b-modes, but their findings later turned out to be based on contamination from dust in our galaxy. BICEP2 is one of a handful of experiments—including telescopes on the ground and airborne balloons—still searching for signs of ancient gravitational waves.

The next big step

The Simons Observatory will be equipped with about 50,000 light-collecting detectors—about 10 times more than anything currently operating. This project in turn will set the stage for an even larger future initiative dubbed CMB Stage Four, which will build radio dishes with a total of some 500,000 detectors, Devlin estimates.

The Department of Energy’s High Energy Physics division plans to help fund Stage Four, along with likely funding from the National Science Foundation and possibly international agencies. “Sometimes private philanthropy gets something going which government support then continues,” Simons says. “By our getting it going, it will encourage them to fall in.” The Simons Observatory is also being funded by the participating institutions—Princeton University, The University of California at San Diego, The University of California at Berkeley, The University of Pennsylvania and the Lawrence Berkeley National Laboratory—as well as the Heising-Simons Foundation.

The telescope—or perhaps telescopes—will likely begin construction in around three years, and could start observing in a decade. “The CMB is just so rich and powerful scientifically,” says University of Chicago physicist John Carlstrom, who is not participating in the Simons Observatory project. “We’ve been trying as a community to figure out how we can continue to extract this information. It’s getting to the point where we really need to pull together and need a community effort to get to the next level. This looks like a way to really start pushing for that.”

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