UC San Diego
UC San Diego News Center

By Kristin Luciani May 19, 2016

The new project will use the Simons Array, a system of three powerful telescopes located in Chile's Atacama desert,and the Atacama Cosmology Telescope (seen in the background) to provide a greater understanding of the early universe. Photo by Nate Stebor

New $40 Million Observatory to Probe First Moments of Universe

Physicists understand fairly well what happened after the Big Bang and the laws of physics that govern the universe. It's what the universe looked like immediately after the event—a trillionth of a trillionth of a trillionth of a second after—that is still a mystery. A new observatory in Chile's Atacama Desert could be the key to understanding that instance.

Called the Simons Observatory, it is being funded by grants totaling $40 million from the Simons Foundation and the Heising-Simons Foundation and will involve a consortium of researchers, including astrophysicists from UC San Diego.

“This is an ambitious project with the potential to greatly expand our understanding of the universe, and it wouldn’t be possible without private support,” said UC San Diego Chancellor Pradeep K. Khosla. “We are deeply grateful to the Simons Foundation and the Heising-Simons Foundation for their partnership. Philanthropy is increasingly important to fuel basic science research and pursue high-risk, high-reward experiments.”

The Quest

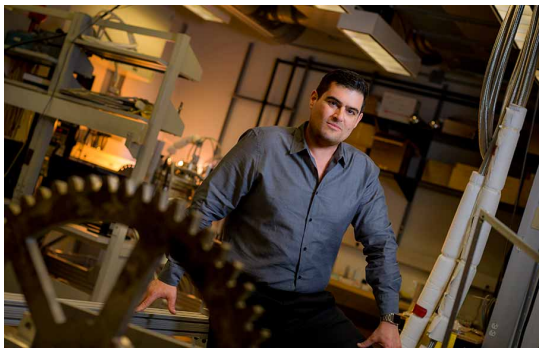
How does one study the beginnings of the universe? A primary objective of the project is to search more than half the sky for the signature of the gravitational waves generated immediately following the Big Bang.

Building on two existing facilities, the Atacama Cosmology Telescope and the Simons Array, the funding will support the development and deployment of new technologies to explore the cosmic microwave background (CMB), a window to the physics of the earliest universe. The cosmic microwave background is essentially remnant radiation from the Big Bang that has cooled and stretched with the expansion of the universe to microwave lengths. It acts as an enormous backlight, illuminating the large-scale structure of the universe and carrying an imprint of cosmic history.

Gravitational waves are ripples in the fabric of space-time, first predicted by Albert Einstein as part of his theory of general relativity. During inflation, the rapid expansion of space following the Big Bang (and the leading theory about the beginning of the universe), gravitational waves induced faint, but characteristic polarization patterns in the CMB, at radio wavelengths that can be detected by specialized telescopes and cameras.

Detecting these ancient signals is considered the “holy grail” of cosmology. It would have profound impacts for not only understanding how the universe was formed, but also the fundamental physics that govern it.

“We have this beautiful edifice of everything that’s happened in the universe and the laws of physics since about a second after the Big Bang,” said Brian Keating, a professor of physics at UC San Diego’s Center for Astrophysics and Space Sciences and the current director of the Simons Observatory. “But we want to go back orders of magnitude—perhaps as many as 30 orders of magnitude farther back in time or higher in temperature. We’re trying to understand the nature of matter and energy and understand the first moments of the universe, potentially what brought it into existence.”



Brian Keating. Photo by Erik Jepsen/UC San Diego Publications

The Simons Observatory will also be used to study dark matter and dark energy, two of the most mysterious substances known to science, but which make up about 96 percent of the universe's total matter and energy.

New Collaboration and Technology to Advance the Search

The search for gravitational waves is not new. Einstein first predicted their existence in 1916; in the 1960s and 70s, advances in technology enabled scientists to attempt to detect these ripples in space-time. However, it's only in the last decade or so that the search has really taken off. Just this year, researchers at the Laser Interferometer Gravitational-Wave Observatory (LIGO) announced they had detected the existence of gravitational waves—a "whisper" heard as two black holes collided. The announcement marked a significant achievement for astrophysicists and a positive sign for Keating and his team, who are not looking for just any gravitational waves; they're searching for signals from those generated in moments after the Big Bang.

Located in Chile's Atacama Desert, the Simons Observatory will bring together leading researchers from UC San Diego; University of Pennsylvania; University of California, Berkeley; Princeton University; Lawrence Berkeley National Laboratory; and University of Wisconsin at Madison, and will provide funding to develop and deploy new telescopes and technologies. The participating institutions are also contributing financial support to the project.

"People are used to thinking about mega- or giga-pixel detectors in optical telescopes, but for signals in the microwave range 10,000 pixels is a lot," said Keating. "What we're trying to do— the real revolution here—is to pave the way to increase our pixels number by more than an order of magnitude."

Keating and his colleagues believe that this investment in new infrastructure and scientific collaboration will position the observatory to significantly advance the search for primordial gravitational waves.

"This new observatory follows the great tradition of astrophysical discovery at UC San Diego and will enable astronomers to have a world-class instrument for decades to come," added Mark Thiemens, dean of UC San Diego's Division of Physical Sciences.

The Simons Foundation is a longtime supporter of UC San Diego's efforts to understand the early universe. Co-founded in New York City by Jim and Marilyn Simons, the foundation's mission is to advance the frontiers of research in mathematics and the basic sciences. In addition to this latest grant, the foundation helped fund the original three-telescope Simons Array at UC San Diego's James Ax Observatory in 2012.

For Keating, the Simons Observatory represents an opportunity to answer an age-old quest to understand the place that humans have in the universe, and to understand the origins of time and space.

“I’ve always been interested in answering the biggest questions, and this is the biggest question of all,” said Keating. “The very first Neanderthals must have looked up and wondered, ‘Where did everything come from?’ We’re finally able to start to answer those questions.”