Rainer Weiss ’55, PhD ’62, professor emeritus of physics at MIT, won the Nobel Prize in physics for 2017. Weiss won half of the prize, with the other half of the award shared by Kip S. Thorne, professor emeritus of theoretical physics at Caltech, and Barry C. Barish, professor emeritus of physics at Caltech.

The Nobel Foundation, in its announcement, cited the physicists “for decisive contributions to the LIGO detector and the observation of gravitational waves.”

“We are immensely proud of Rai Weiss, and we also offer admiring best wishes to his chief collaborators and the entire LIGO team,” said MIT President L. Rafael Reif. “The creativity and rigor of the LIGO experiment constitute a scientific triumph; we are profoundly inspired by the decades of ingenuity, optimism, and perseverance that made it possible. It is especially sweet that Rai Weiss not only served on the MIT faculty for 37 years, but is also an MIT graduate. Today’s announcement reminds us, on a grand scale, of the value and power of fundamental scientific research and why it deserves society’s collective support.”

At a press conference at MIT, Weiss credited his hundreds of colleagues who have helped to push forward the search for gravitational waves.

“The discovery has been the work of a large number of people, many of whom played crucial roles,” Weiss said. “I view receiving this [award] as sort of a symbol of the various other people who have worked on this.”

In describing what the award means to him in a larger context, Weiss said: “This prize and others that are given to scientists is an affirmation by our society of [the importance of] gaining information about the world around us from reasoned understanding of evidence.”

Listening for a wobble

On September 14, 2015, at approximately 5:51 a.m. EDT, a gravitational wave—a ripple from a distant part of the universe—passed through the Earth, generating an almost imperceptible, fleeting wobble in the world that would have gone completely unnoticed save for two massive, identical instruments, designed to listen for such cosmic distortions.

The Laser Interferometer Gravitational-wave Observatory, or LIGO, consists of two L-shaped interferometers, each 4 kilometers in length, separated by...
1,865 miles. On September 14, 2015, scientists picked up a very faint wobble in the instruments and soon confirmed that the interferometers had been infinitesimally stretched—by just one ten-thousandth the diameter of a proton—and that this minuscule distortion arose from a passing gravitational wave.

The LIGO Scientific Collaboration, with the Caltech-MIT LIGO Laboratory and more than 1,000 scientists at universities and observatories around the world, confirmed the signal as the first direct detection of a gravitational wave by an instrument on Earth. The scientists further decoded the signal to determine that the gravitational wave was the product of a violent collision between two massive black holes 1.3 billion years ago.

The momentous result confirmed the theory of general relativity proposed by Albert Einstein, who almost exactly 100 years earlier had predicted the existence of gravitational waves but assumed that they would be virtually impossible to detect from Earth. Since this first discovery, LIGO has detected three other gravitational wave signals, also generated by pairs of spiraling, colliding black holes.

“We are incredibly proud of Rai and his colleagues for their vision and courage that led to this great achievement,” says Michael Sipser, the Donner Professor of Mathematics and dean of the School of Science at MIT. “It is a wonderful day for them, for MIT, for risk-taking and boldness, and for all of science.”

A gravitational blueprint
The detection was an especially long-awaited payoff for Weiss, who came up with the initial design for LIGO some 50 years ago. He has since been instrumental in shaping and championing the idea as it developed from a desktop prototype to LIGO’s final, observatory-scale form.

In 1967, Weiss, then an assistant professor of physics at MIT, was asked by his department to teach an introductory course in general relativity—a subject he knew little about. A few years earlier, the American physicist Joseph Weber had claimed to have made the first detection of gravitational waves, using resonant bars—long, aluminum cylinders that should ring at a certain frequency in response to a gravitational wave. When his students asked him to explain how these Weber bars worked, Weiss found that he couldn’t.

No one in the scientific community had been able to replicate Weber’s results. Weiss had a very different idea for how to do it, and assigned the problem to his students, instructing them to design the simplest experiment they could to detect a gravitational wave. Weiss himself came up with a design: Build an L-shaped interferometer and shine a light down the length of each arm, at the end of which hangs a free-floating mirror. The lasers should bounce off the mirrors and head back along each arm, arriving where they started at the exact same time. If a gravitational wave passes through, it should “stretch” or displace the mirrors ever so slightly, and thus change the lasers’ arrival times.

Weiss refined the idea over a summer in MIT’s historic Building 20, a wooden structure built during World War II to develop radar technology. The building, meant to be temporary and known to many as the “Plywood Palace,” lived
on to germinate and support innovative, high-risk projects. During that
time, Weiss came to the conclusion that his design could indeed detect
gravitational waves, if built to large enough dimensions. His design would
serve as the essential blueprint for LIGO.

**An observatory takes shape**

To test his idea, Weiss initially built a 1.5-meter prototype. But to truly detect
a gravitational wave, the instrument would have to be several thousand
times longer: The longer the interferometer’s arms, the more sensitive its
optics are to minute displacements.

To realize this audacious design, Weiss teamed up in 1976 with noted
physicist Kip Thorne, who, based in part on conversations with Weiss,
soon started a gravitational wave experiment group at Caltech. The two
formed a collaboration between MIT and Caltech, and in 1979, the late
Scottish physicist Ronald Drever, then of Glasgow University, joined the
effort at Caltech. The three scientists—who became the co-founders of
LIGO—worked to refine the dimensions and scientific requirements for an
instrument sensitive enough to detect a gravitational wave.

Barry Barish soon joined the team as first a principal investigator, then
director of the project, and was instrumental in securing funding for the
audacious project, and bringing the detectors to completion.

After years of fits and starts in research and funding, the project finally
received significant and enthusiastic backing from the National Science
Foundation, and in the mid-1990s, LIGO broke ground, erecting its first
interferometer in Hanford, Washington, and its second in Livingston,
Louisiana.

Prior to making their seminal detection two years ago, LIGO’s detectors
required years of fine-tuning to improve their sensitivity. During this time,
Weiss not only advised on scientific quandaries but also stepped in to root
out problems in the detectors themselves. Weiss is among the few to have
walked the length of the interferometers’ tunnels in the space between
LIGO’s laser beam tube and its encasement. Inspecting the detectors in this
way, Weiss would often discover minute cracks, tiny shards of glass, and
even infestations of wasps, mice, and black widow spiders, which he would
promptly deal with.

**A cosmic path**

Weiss was born in 1932 in tumultuous Berlin. When his mother, Gertrude
Loesner, was pregnant with Weiss, his father, neurologist Frederick Weiss,
was abducted by the Nazis for testifying against a Nazi doctor. He was
eventually released with the help of Loesner’s family. The young family
fled to Prague and then emigrated to New York City, where Weiss grew up
on Manhattan’s Upper West Side, cultivating a love for classical music and
electronics, and making a hobby of repairing radios.
After graduating high school, he went to MIT to study electrical engineering, in hopes of finding a way to quiet the hiss heard in shellac records. He later switched to physics, but then dropped out of school in his junior year, only to return shortly after, taking a job as a technician in Building 20. There, Weiss met physicist Jerrold Zacharias, who is credited with developing the first atomic clock. Zacharias encouraged and supported Weiss in finishing his undergraduate degree in 1955 and his PhD in 1962.

Weiss spent some time at Princeton University as a postdoc, where he developed experiments to test gravity, before returning to MIT as an assistant professor in 1964. In the midst of his work in gravitational wave detection, Weiss also investigated and became a leading researcher in cosmic microwave background radiation—thermal radiation, found in the microwave band of the radio spectrum, that is thought to be a diffuse afterglow from the Big Bang.

In 1976, Weiss was appointed to oversee a scientific working group for NASA’s Cosmic Background Explorer (COBE) satellite, which launched in 1989 and went on to precisely measure microwave radiation and its tiny, quantum fluctuations. Weiss was co-founder and chair of the science working group for the mission, whose measurements helped support the Big Bang theory of the universe. COBE’s findings earned two of its principal investigators the Nobel Prize in physics in 2006.

Weiss has received numerous awards and honors, including the Medaille de l’ADION, the 2006 Gruber Prize in Cosmology, and the 2007 Einstein Prize of the American Physical Society. He is a fellow of the American Association for the Advancement of Science, the American Academy of Arts and Sciences, and the American Physical Society, as well as a member of the National Academy of Sciences. In 2016, Weiss received a Special Breakthrough Prize in Fundamental Physics, the Gruber Prize in Cosmology, the Shaw Prize in Astronomy, and the Kavli Prize in Astrophysics, all shared with Drever and Thorne. Most recently, Weiss shared the Princess of Asturias Award for Technical and Scientific Research with Thorne, Barry Barish of Caltech, and the LIGO Scientific Collaboration.

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The MIT Pappalardo Fellowships in Physics, a leader amongst the world’s postdoctoral fellowship programs in physics, completed its 19th annual competition in January 2018 with the acceptance of four fellows for the 2018-2021 fellowship cycle. Arriving this fall are Denis Bandurin (experimental condensed matter physics), a 2017 PhD and Leverhulme Early Career Fellow from the University of Manchester, UK; Bernhard Mistlberger (theoretical nuclear and particle physics), a postdoctoral fellow at CERN (2015 PhD, ETH-Zurich); Hoi Chun “Adrian” Po (theoretical condensed matter physics), a 2018 PhD from Harvard University, and student of 2001-2004 Pappalardo Fellow Ashvin Vishwanath; and Steven Villanueva (theoretical astrophysics), a 2018 PhD from The Ohio State University.

Detailed biographies, including research descriptions and selected publications for all Pappalardo Fellows (current and former), are available at web.mit.edu/physics/research/pappalardo/index.html. The MIT Pappalardo Fellowships in Physics program was initiated, and is sustained, by funds generously provided by A. Neil and Jane Pappalardo. (C. Breen)

Clockwise from top left: Denis Bandurin, Bernhard Mistlberger, Hoi Chun “Adrian” Po, Steven Villanueva

Physics Department Head Peter Fisher and Associate Professor of Physics Jesse Thaler traveled to London in early May 2018. Jesse gave a talk titled, “Confronting the Invisible Universe” at the IET London Savoy Place for alumni, parents and friends. Dima and Walid Fakhry ’89 (11), ’90 (XV), SM ’94 (1) hosted a small gathering at their home, where Peter and Jesse spoke about their research. (E. McGrath Tribble)
The Department celebrated its 13th annual Patrons of Physics Fellows Dinner on April 13, 2018. Over 80 guests gathered for a dinner and reception in the Green Center for Physics’ Pappalardo Community Room. Physics Department Head Peter Fisher started the evening with remarks about the Department and how important fellowship support is so we can attract the top students and give them freedom to try different research areas. Thomas Hartke, 2017–2018 Frank Fellow; Chiara Salemi, 2017–2018 Marble Fellow; and Christopher Whittle, 2017–2018 Whiteman Fellow, were the student presenters. Patron donor Tom Frank concluded the evening with remarks on the importance of fellowships and scientific research. In attendance were Hale and Dorothy Bradt, Tom and Renate Cardello, Jim and Sylvia Earl, George Elbaum and Mimi Jensen, Tom Frank and Alex Hastings, Mark Mueller, Norma Olbert and Elizabeth Olbert, Paul Swartz, and Linda Duboc Walker and Charles Walker. (E. McGrath Tribble)
The Department’s premier postdoctoral fellowship program, the Pappalardo Fellowships in Physics, held its 17th annual symposium at the close of the academic year on May 17, 2018. Five fellows from its current membership of gifted young physicists presented highlights of their research to members and friends of the MIT physics community.

Emceed by Department Head Peter Fisher, the symposium opened with introductory remarks by Professor of Physics Pablo Jarillo-Herrero, current Chair of the Pappalardo Fellowships Executive Committee and an experimental condensed matter physicist at the cutting edge of research exploring quantum transport in novel condensed matter systems such as graphene and topological insulators.

Dr. Julieta Gruszko (“Shedding ‘Nu’ Light on the Nature of Matter”) led the talks, followed by Dr. Zhen Bi (“The Universe in Topological Phases”); Dr. Michael Wagman (“Nuclei, Neutrinos, and New Physics”); Dr. Lampros Lamprou (“Spacetime from Quantum Mechanics”); and Dr. Itamar Kimchi (“Dirty Quantum Entanglement”).

Joining physics faculty, students, postdocs and staff in the Pappalardo Community Room were program founder and benefactor Neil Pappalardo, along with his son Michael, grandsons Che and Declan Pappalardo and Max Lemke, and son-in-law novelist Todd Lemke. Also in the audience were longstanding Department friends, alumnus and Meditech, Inc., CEO Howard Messing and his wife Colleen; and generous supporters alumni Curt Marble and Mark Mueller.

Videos of this and prior Pappalardo Fellowships symposia are available online at web.mit.edu/physics/research/pappalardo/videos.html. For more information on the Pappalardo Fellowships in Physics program, its Fellows, and founders A. Neil and Jane Pappalardo, please visit web.mit.edu/physics/research/pappalardo/symposia_archive.html. (C. Breen)