2011

2011 Research at Andrews

Andrews University

Hearing the Cosmic Violin

The Search for Gravitational Waves

If a tree fell in the forest outside Livingston, La., and there was no one to hear it, the four-kilometer-long LIGO detectors would hear the sound it made. The L-shaped configuration of mirrors and lasers is trained to pick up gravitational waves, ripples in the fabric of space-time predicted by Einstein's theory of relativity. These detectors are sensitive enough to pick up gravitational waves, but that also means they pick up any vibrations in the surrounding area. "We can tell when rush hour starts in the area because the detector output increases at a certain frequency," says **Tiffany Summerscales**, associate professor of physics. She is a collaborator on the Laser Interferometer Gravitational Wave Observatory (LIGO) project, part of which is taking place in the physics laboratory at Andrews University.

According to Einstein's theory of relativity, which treats space as if it were a flexible object somewhat like an infinite trampoline, gravity is a dimple in the fabric, and

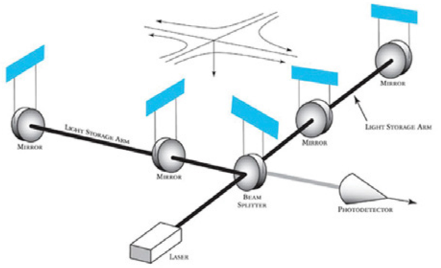
"Some people liken it to listening for a single person playing a violin in the middle of a city in rush hour."

objects are attracted to the nearest dimple. A change in the arrangement of the objects creating gravity will cause a change in the dimples and send out ripples —gravitational waves. These waves cannot be detected with traditional instruments. The LIGO project was initially begun in 1994 in Hanford, Wash. Its two LIGO detectors in Hanford, and Livingston, as well as the Virgo detector in Cascina, Italy and GEO600 detector near Hanover, Germany, measure changes in distance that two laser beams travel. "Any tiny change in distance along the arm can be measured," says Summerscales. "And we're measuring changes in distance that are smaller than the diameter of a proton." The detectors produce immense data readout, consisting of a mixture of noise and gravitational wave signals.

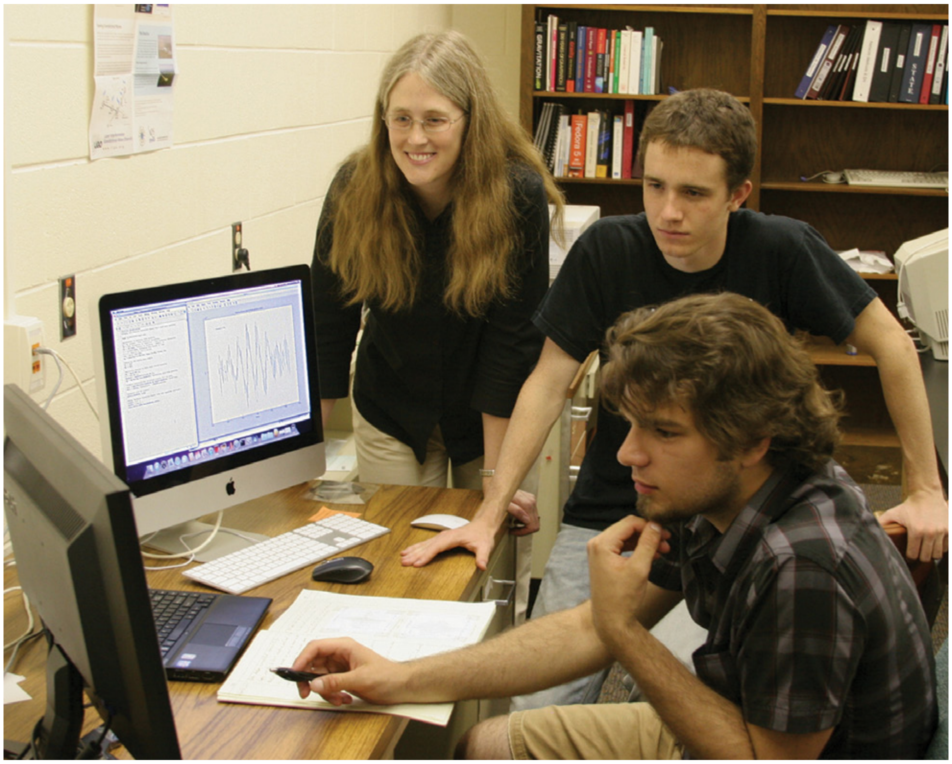
Different objects produce different types of gravitational waves. Two objects orbiting each other, a neutron star and black hole for example, will spin faster and faster until their orbits combine. This gravitational wave appears as a "chirp" on the sensor. Supernova explosions would go "pop," and a dense star with a bump on its side emits one constant sound. (Summerscales makes a few chirps and "woo's" for illustration.)

Gravitational waves are inferred from the observed behavior of neutron stars orbiting each other. The stars lose energy and move closer together exactly as predicted if they were emitting that energy in the form of gravitational waves. However, gravitational waves have yet to be directly detected. After six "science runs" beginning in 2003 to calibrate and test the LIGO detectors, they were taken offline for updates and repairs in 2010. The upgraded detectors, with much greater sensitivity to detect gravitational waves, are expected to become operational in 2015.

The LIGO team's mission is to first detect all these kinds of gravitational waves and then separate them from the noise signals produced from "tumbleweed collection or



Above and following page: Diagram and photos of the LIGO Hanford Observatory in Hanford, Wash. (Courtesy of LIGO Laboratory)



L–R: Tiffany Summerscales, associate professor of physics, conducting research with Chris Greenley, junior physics major, and Michal McMearty, sophomore physics major

someone dropping a brick," jokes Summerscales. "We're focused on just getting gravitational waves and trying to get rid of everything else. Some people liken it to listening for a single person playing a violin in the middle of a city in rush hour."

This is done through a myriad of computer programs designed to filter the 16,384 samples of data taken each second. Researchers design computer programs to sift through the readout for specific kinds of gravitational signals coming from known sources. But not every gravitational signal comes from a known or visible object, and this is the group in which Summerscales works. Her team searches for "bursts," short segments of data where there seems to be something in the detector other than noise. With four student researchers, Andrew Hoff and Garret Catron, both 2011 graduates, Michael McMearty, a sophomore physics major, and Chris Greenley, a junior physics major, Summerscales' team is currently developing computer programs to search for these bursts. They send the developed programs to a cluster of computers at the California Institute of Technology, where the data is stored. The results come back to Andrews University for analysis. Given that there has not been any known gravitational waves observed, the team has been running fake test gravitational bursts through their programs. They test the sensitivity of their analysis programs by varying the intensity of the bursts, and determining at what point the signals can be extracted again.

Summerscales' research has earned her a National Science Foundation grant of $105,000, which covers the cost of

research computers and provides the salaries of her student assistants. She, and LIGO researchers across the country, will continue perfecting their computer programs in order to have them ready by the time the improved LIGO detectors are up and running.

When the LIGO detectors become operational in 2015, more than 500 researchers in the United States and 200 in Europe will be looking for gravitational waves in hopes of both proving that gravitational waves exist and gaining a better understanding of some of the strangest objects in the universe. "Some of the really massive things that are doing exciting things out in the universe, like black holes, are also some of the more mysterious," says Summerscales.

The LIGO researchers hope to gain a new understanding of astronomy from the gravitational waves. "Previously, we learned about objects by the light they produced," says Summerscales. "Now, things that don't produce adequate amounts of light—black holes, for instance—will send out gravitational waves that we can pick up and decipher."

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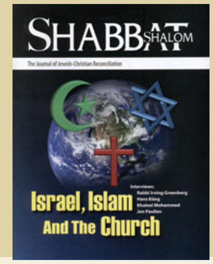

Raised in the convergence of three cultures—Jewish, French and Muslim—**Jacques Doukhan**, professor of Hebrew and Old Testament Exegesis, has been a voice for Jewish-Christian dialogue for several decades. Two of his recent projects—*Israel and the Church: Two Voices for the Same God* (Hendrickson, 2002), and *On the Way to Emmaus: Searching the Messianic Prophecies* (forthcoming), stem from his longtime research interest at the intersection of Judaism and Adventism.

In *On the Way to Emmaus*, Doukhan examines Scriptural Messianic prophecies from an Old Testament and historical perspective. He utilizes exegesis of the text, its immediate historical context, other Scriptural writings, and ancient Rabbinic texts to determine which Messianic texts were legitimate in their time rather than given a Messianic interpretation later in history.

Doukhan identifies himself as a Jewish Adventist and has an extensive scholarly background in Jewish and Biblical studies that has transferred into a lifelong involvement in Jewish-Christian dialogue. He was the editor of *Shabbat Shalom*, a journal of Jewish-Christian reflection, for 16 years and served as the leader of Beit B'nei Shalom, a local Hebrew-Adventist congregation, for 11 years. Since 1999, he has served as the director of the Institute of Jewish-Christian Studies at Andrews University, an organization responsible for symposiums on the Holocaust, Jewish/Christian/Muslim relations, and other interfaith dialogues. "We produce a book after each symposium, and our intent is to provide information and make [Jewish-Christian relations] present in people's minds," he says. Doukhan has attended Jewish-Christian dialogues worldwide, and was involved in the first historical encounter between top Orthodox Jewish scholars and evangelical theologians at Emory University, Atlanta, Ga. This summer he was invited to Paris to join a