

OPN Talks with ...

David Reitze

LIGO Expert and CLEO/QELS
Plenary Speaker

Angela Stark



Photo courtesy of David Reitze

David Reitze works with the Laser Interferometer Gravitational-Wave Observatory (LIGO) on developing large-scale gravitational wave interferometers, the world's largest precision optical instruments. LIGO was designed to probe the universe in a fundamentally new way by detecting gravitational waves, which occur as a result of violent events in space, such as the collisions of stars.

Reitze led the design effort for one of the major subsystems of LIGO interferometers. As the spokesperson of the LIGO Scientific Collaboration, he oversees a group of 600 scientists worldwide who are engaged in the search for gravitational waves. Reitze will give a plenary presentation on gravitational waves—including what makes them so challenging to detect and how researchers are seeking them out using “really big interferometers”—at this year's CLEO/QELS conference in San Jose, Calif.

>> What steps are under way to detect gravitational waves? Why is it so difficult?

Over the past 15 years, scientists in the United States, Europe and Japan have built several large-scale interferometer detectors that are capable of measuring incredibly small changes in the distances of the two arms of the interferometer.

A gravitational wave is manifested as a strain, or a change in length per unit length. A binary neutron star merger (a typical astrophysical source) located 50 million light years away would produce

a strain of roughly 10^{-21} (at best) in the LIGO interferometers. That's roughly the equivalent of measuring the distance to the nearest star, Alpha Centauri, to the width of a human hair. To put it another way, LIGO measures the change in distance of two mirrors separated by 4 km to less than 10^{-18} m.

There are many sources of noise that make it very difficult to measure distance changes with that level of precision. LIGO must work in the presence of the Earth's seismic motion; correlated shot noise and radiation pressure noise; laser amplitude, frequency and pointing fluctuations; and the thermally induced motion of the mirror surfaces and the wires that suspend them. It is designed to reduce these noise sources to as low a level as possible.

>> How close are scientists to detecting the first gravitational wave?

To quote the famous philosopher and baseball player Yogi Berra, “Predictions are difficult, especially about the future!” Although we know how sensitive LIGO detectors are to strains produced by a passing gravitational wave, it is impossible to say with any certainty when a gravitational wave will be detected.

We're in the process of making improvements to LIGO that will increase its sensitivity. Early in the next decade, we'll undergo a large upgrade to Advanced LIGO. After that, we are likely to see many gravitational wave events per year

from the coalescence of binary neutron star systems.

>> What is needed to develop a laser that will help detect gravitational waves?

Laser development for gravitational wave interferometers is fairly mature. In the short term, the real need lies in developing optics that can handle the power. Thermal lensing caused by absorption in the mirror substrates and coatings was initially a problem in the LIGO interferometer mirrors, and it will only get worse as we go to higher laser powers. We use auxiliary CO₂ lasers to provide heat in a complementary spatial profile to compensate for the intrinsic heating of the mirrors induced by the laser.

If we can address the power handling problems in the interferometer, we can contemplate using single frequency kilowatt class lasers. Here, the challenge is producing high powers with Gaussian or near-Gaussian spatial modes that can be stabilized to the levels needed by noise considerations of gravitational wave interferometers.

>> What kind of research are you doing now?

I am currently working on upgrading the LIGO detectors to improve their sensitivity. We expect to conduct another long science run in 2009-2010 with better sensitivity than we had during our last major run. Two of the LIGO interferometers will be upgraded to higher laser

power (35 W) and to a new method for sensing the gravitational wave—direct homodyne readout.

>> How did your research on ultrafast lasers and pulse shaping lead to your LIGO pursuits?

It was an interesting and nonlinear evolution, to be sure! I started graduate school in the early 1980s with the intention of studying general relativity theory at the University of Texas at Austin. But I soon learned that jobs were scarce in that field.

After exploring other research possibilities, I decided to work in femtosecond spectroscopy and ultrafast lasers, an emerging area at that time. I continued that work through Bellcore and Lawrence Livermore National Lab and at the University of Florida as an assistant professor. In 1996, I was given the opportunity to become involved with LIGO, through a connection between a University of Florida colleague, Guenakh Mitselmakher,

and Barry Barish, the executive director of the LIGO laboratory at Caltech. Given my interest in general relativity and my experience in lasers, it took me less than a few seconds to say yes. Thinking back on it, I realize it was a risky move for a mid-tenure-track assistant professor—but it worked out well.

Although the majority of my research focuses on gravitational wave detectors, I still maintain a small research effort in femtosecond spectroscopy, because that is really interesting, too!

>> What advice would you give to optics students?

Don't focus too narrowly; be willing to look beyond your current field of research. I find that everything in optics (and physics in general) is interesting. Also, don't be afraid to take risks in your research—try new things, even if you think they may not work. LIGO is a good example. Many people thought

it was crazy when they first heard that LIGO was designed to measure displacement changes at a level less than 1/1000 the diameter of a proton. But it works!

>>What do you enjoy most about being a physicist?

There are many rewarding aspects: working with and learning from really smart people, seeing students grow and develop into mature physicists, and getting to play with one of the most sophisticated optics experiments ever conceived. ▲

David Reitze will deliver his talk, "The Laser Interferometer Gravitational-Wave Observatory: Probing the Dynamics of Space-Time with Attometer Precision," at the CLEO/QELS plenary session on Monday, May 5, in San Jose, Calif., U.S.A. For more information or to register for the conference, visit www.cleoconference.org.

[Angela Stark (astark@osa.org) is OSA's public and government relations coordinator.]

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