CONVERSATIONS

Investigating the Final Frontier with **LASERS**

Optics & Photonics News asked this year's Frontiers in Optics/Laser Science (FiO/LS) plenary speakers to tell us more about their research. Interestingly, OSA Fellows **Joss Bland-Hawthorn** and **David Reitze** are both astrophysicists, but their work is quite different.

David Reitze

LIGO Laboratory Caltech, USA; and University of Florida, USA

PLENARY: "LIGO and the Coming Dawn of Gravitational-Wave Physics and Astronomy"

Q. Do you think gravitational-wave detection will be as dramatic for you as your work on the nature of liquid carbon?

Yes, and even more so! The liquid carbon work solved an outstanding question about carbon's ephemeral liquid state. It was very exciting for me as a young scientist to be able to do that.

In contrast, gravitational-wave science will really only begin with the first detection of gravitational waves, and that's even more exciting! Gravitational wave observations have the potential to open new vistas onto the universe and revolutionize our understanding of some of the most cataclysmic and violent astrophysical events in the cosmos. General relativity coupled with electromagnetic astronomical observations give us some good ideas about what kinds of gravitational waves we'll detect, but I wouldn't be at all surprised if we see something totally unexpected that changes the way astrophysicists think about the nature of the universe.

"I wouldn't be at all surprised if we see something totally unexpected."

—*David Reitze*
@LIGO

Q. Recent upgrades have expanded LIGO's search volume by a factor of 1,000. How will you digest all that data?

The interferometers are expected to produce approximately one petabyte of data per year in full-time operation, so LIGO is definitely a Big Data producer. Only one percent of that data, the "strain channel," will contain any gravitational wave signals, but the other 99 percent are important for sensing the operational state and overall health of the interferometers as well as for assessing strain channel data quality.

Fortunately, the LIGO Scientific Collaboration is made up of more than 900 scientists and engineers from around the world. About half of them are directly involved in the analysis of LIGO data, working on developing algorithms for sifting through the data for different types of gravitational-wave sources as well as on developing methods for ensuring that the data we produce and analyze is high quality.

Q. If and when LIGO scientists do detect gravitational waves, how do you plan to celebrate?

The hunt for gravitational waves began over 50 years ago, and the big interferometers have been searching for gravitational waves for almost 20 years. So the entire gravitational-wave scientific community will want to celebrate the first discovery in a big way. I intend to splurge for a bottle of Dom Pérignon champagne and share it with some of my friends. And once the parties are over, we'll all get to back to work!

Joss Bland-Hawthorn

University of Sydney, Australia

PLENARY: "Astrophotonics: Future Developments in Astrophysics and Instrumentation"

Q. Was there a defining moment in your research that marked the beginning of astrophotonics?

In the 1990s, my R&D group began exploring new concepts for optical and infrared instruments. Given our interest in fiber-based instruments, it made sense to go beyond optics and consider photonic functions. In 2001, the field of astrophotonics was born. But soon after that we hit a wall. Most photonic functions require single-mode propagation to work efficiently, but coupling an atmospherically distorted observation to a single-mode device is very inefficient. I struggled with several approaches to fixing this problem until I noticed Tim Birks and his team's elegant work on mode control and splitting at the University of Bath, U.K. In 2004, I visited Birks and S. Leon-Saval who brought together photonic concepts that would lead to the first "photonic lantern." Many of our spectrograph concepts use the lantern as the underlying technology.

> "Given our interest in fiber-based instruments, it made sense to go beyond optics and consider photonic functions."
>
> —*Joss Bland-Hawthorn*
> *@JossBlandHawtho*

Q. What's the status of your group's efforts to filter out the bright spectral lines caused by hydroxyl in the upper atmosphere?

Suppression of the atmospheric hydroxyl (OH) emission is one of the great unsolved problems of experimental astrophysics. A view of the night sky from a ground-level near-infrared telescope is covered with bright spectral lines from OH, blocking deep observations of the universe. And given that the largest telescopes will always be sited on Earth, OH emission will remain a fundamental stumbling block for the future development of infrared instruments.

Our collaboration with the Australian Astronomical Observatory and Germany's InnoFSPEC Potsdam on solving the OH-emission problem has now almost completed a fully optimized instrument, PRAXIS, which will see first light in early 2016. PRAXIS will use fiber Bragg gratings (FBGs) for atmospheric OH suppression. We spent a decade perfecting these FBGs; they suppress 100+ unevenly spaced, narrow notches in the 1,450 – 1,750 nm interval. For atmospheric line filtering, PRAXIS will employ the prototype GNOSIS FBG bundle and and our new multicore FBGs. This instrument is designed to detect our faint astronomical targets for the first time. So stay tuned!

Q. What does the future hold for laser-based astronomy instruments?

Whichever way you stare into the crystal ball, you come back to the same answer. Telescopes will continue to grow even beyond the 25 – 42 m behemoths now under construction. Just look at the budgets for particle accelerators and space missions. The behemoths function by simply focusing light to an uncorrected image plane. But if the telescopes are to break new ground, they *must* work efficiently with laser guide stars in order to suppress atmospheric scintillation—the adaptive optics imperative!

If you get anywhere near the diffraction limit of the telescope, the signal-to-noise gains can be enormous. Initially, this will be achieved on-axis for single targets using a single laser guide-star to possibly search for exoplanets. In the second phase, multiconjugate adaptive optics (five laser guide-stars placed around a sky field) will be needed to tomographically correct for the 3-D air volume above the telescope. This is all wonderful news for astrophotonics. Once you are in the domain of near diffraction-limited imaging or spectroscopy, the case for photonic instruments becomes compelling due to the relative ease of coupling light into few-mode or single-mode devices, at least in principle.

I look forward to a new generation of adaptive-optics-corrected, OH-suppressed instruments that combine imaging and spectroscopy. These instruments will be needed to support observations with the James Webb Space Telescope due to launch in Oct 2018. OPN

FiO/LS 2015 will take place 18 to 22 October in San Jose, Calif., USA. For more information, go to www.frontiersinoptics.com