Q&A with Scientists of the LIGO and Virgo Collaboration (LVC)

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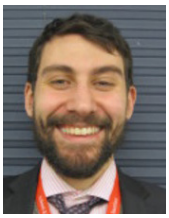

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What are the most challenging and rewarding aspects of working in the LVC?

MCW: The most challenging aspect of working in the LVC is probably coordination. However, the most rewarding aspect is related to this: It's amazing to be part of a 1000+ person science engine that can achieve such a high quality level of cutting edge research. Additionally, being a member of the LVC awards me the opportunity to work closely with many amazing, bright people on a regular basis. I know my personal research abilities have grown exponentially due to the support from the LVC community.

GM: Uncertainty! We have faced uncertainty in many forms. Some of my best advisers cautioned me about going into gravitational waves. I read intently about the detector and got familiar until I could justify that my trust was based on good science. Then we had to wait for a signal! Yet lack of certainty is a window for possibility. Our international collaboration abounds in opportunities to work with dedicated scientists, whose experiences and curiosities are more diverse than I imagined. The LIGO-Virgo Collaboration is a sort of family; some branches are growing better detectors, others reaching for sensitive analyses, but its roots remain anchored in general relativity, in the fabric of space-time. I have learned how much more exists, even in gravitational-wave astrophysics, than any one person could comprehend. While I may not always know the destination, the journey is an adventure. The universe is full of surprises — that is why I joined the LVC.

SN: I love working with and being part of a truly international and diverse team of scientists and engineers — the collaboration's expertise spans experimental, observational and theoretical aspects of gravitational waves physics, with members coming from all backgrounds and with their own unique ways of approaching science. Personally, I find supervising undergraduate and graduate students particularly rewarding — their enthusiasm and endless curiosity reminds me daily of how amazing the instruments and the scientific goals are of the LIGO and Virgo detectors. Perhaps the most challenging aspect is the sheer number of emails per day that I receive but this in itself is an illustration of how gravitational wave physics is a worldwide effort 24/7!

MBW: It is quite a challenge to be part of a large collaboration working on such a complex endeavor. But I'm so grateful to be a member of this amazing community. The LVC has given me opportunities to travel, get to know wonderful people from around the world, and contribute to some spectacular science!

CG: Currently my most challenging and rewarding work is helping to ensure we have the best Operator Team running the LIGO Hanford interferometer. This is a complex machine: helping to lead my excellent staff of operators to run this machine was a daunting task. A truly rewarding experience was being on shift in the Control Room, and being humbled by the big picture: from starting with the project almost two decades ago and turning my first bolt to collecting data in the middle of the night in search of events that are truly mind-blowing is unequivocally rewarding.

How did you come to join the LVC team?

MCW: I joined as a graduate student, but I really made the decision to join as an undergraduate. I specifically targeted graduate schools that were strong in LIGO research. I saw a seminar given by Larry Price my senior year of undergrad, and I got more excited about physics research during that talk than I had been any time in my physics career thus far.

GM: In my freshman year at Reed College, I noticed posters on the physics department wall for Research Experiences for Undergraduates (REU) internships funded by the National Science Foundation. LIGO was seeking undergrads for an REU. I had heard of it in the news a few years earlier, when LIGO started its first

science run, so I decided to apply. A few months into 2005, Dick Gustafson, at LIGO Hanford Observatory, invited me out to the high desert of Eastern Washington. After ten weeks of hands-on time with the electronics and optics of a gravitational-wave observatory — and another ten weeks on data analysis at Caltech in 2007 — I applied to grad school. In 2008, Keith Riles at Michigan hired me to study the detectors and search for neutron stars. I have been an LVC member ever since.

SN: I joined the LVC team first at Caltech and then at Radboud University in the Netherlands. It is incredibly exciting to be building a new group in gravitational-wave astronomy at Radboud, with so many enthusiastic and passionate young scientists in this frontier field of observational astronomy!

MBW: For my undergraduate general relativity class, I chose to do a presentation about LIGO because I have family living in Washington near Hanford. As I did research for that assignment, I was fascinated by the LIGO project. I was currently working on my teaching certification and was not planning to go to graduate school, but I decided to spend that summer doing LIGO research at Louisiana State University. I enjoyed the summer so much that I returned to LSU the following year to pursue my PhD.

CG: I first joined Caltech in 1997 when I accepted a position as an Operations Specialist at the LIGO Hanford Observatory. I helped install the initial LIGO Seismic Isolation System, then operated the iLIGO detectors, then helped build/install the aLIGO Seismic Isolation System, and then became the Lead Operator for LHO.

How did your background prepare you for work in the LVC?

MCW: I've always been good at working with other people, which is certainly required in the LVC. I've also served in leadership roles throughout my life (from captain of a sports team to vice president of student council), and I believe this experience in leadership roles has helped me co-chair the calibration team in LIGO.

GM: An observatory in the Pacific Northwest is no common sight. I was delighted to discover LIGO Hanford is just a drive down along the Columbia River Gorge from where I grew up, though the tumbleweed-strewn landscape was a world apart. Computers connect those two worlds. Tinkering with machines feels familiar, and the concomitant patience and experimental zeal helps with every aspect of the LVC. I was lucky to have a mechanical family in youth and to have a fantastic lab science program, and even reactor experience, in undergrad. While I rarely derive equations in my work, every so often math offers a profound insight into a knotty problem. I am grateful to all my professors who insisted on rigorous solutions. My parents encouraged me to explore both nature and culture: that above all nurtured the excitement I have now for this world-spanning research.

SN: I discovered gravitational wave physics as a second year undergrad working on a summer project in Princeton — and have literally been hooked ever since! Over the past 15 years, I have been fortunate to have worked in many aspects of gravitational wave astronomy from source modeling and analytical relativity to Bayesian source characterization to transient astronomy.

MBW: My physics and math courses were important for me to be able to understand the research in the LVC, but I'm also glad to have had some teaching experience, which helped me develop communication and collaborative skills.

CG: My B.S. degrees in physics and applied math were big tools for getting my foot in the door with my work. I always keep in my role as a role model especially to Native American youth. In my academic career there were not many role models like myself. I hope my work and my example can inspire other underrepresented groups to consider pursuing studies and work in physics.

What does this discovery mean to you?

MCW: This discovery means not only the validation of the field that I've dedicated my career to, but it also establishes a supremely exciting future for the field of gravitational-wave physics. We have now entered the era that I've always been longing for — the days when gravitational-wave observations can become a routine contributor to our understanding of the universe and the remaining mysteries it holds.

GM: Even though it may be a cliché, I am eager for "a new window on the universe" to "hear" the cosmos. Someday we will sort out our metaphors. Right now, I am more interested in knowing what comes next. Until recently, few would have guessed we would see a binary black hole this soon. This discovery already promises to tell us much about how the biggest stars in the universe formed. When will we see binary neutron stars? Will our partners see a gamma-ray burst simultaneously? Or a supernova, and neutrinos? At the moment I am looking for neutron stars that continuously emit gravitational waves, a serene and steady tone, in contrast to the sudden chirp of an inspiral. Eventually, I hope we see the Big Bang's gravitational waves — directly. As we go through these firsts, something is bound to appear that we did not expect, and that will be even more wonderful. Whether out among the stars or amidst our equations, such strange novelties are welcome. I am only sad that, besides particles, there is not another fundamental force such as electromagnetism and gravity that can radiate waves across the universe. Perhaps, though, we will learn about those forces from seeing gravitational waves: what lies beyond Einstein? This discovery may be just the beginning.

SN: The discovery and seeing the actual gravitational wave strain in the detection paper is awe-inspiring, beautiful and mind-blowing. It is difficult to find the words to express the intense emotions that I have felt since last September — the scientific method relies on testing one's theories with measurements and observations, and for the first time in a hundred years and after enormous challenges and perseverance from so many folk, we have now reached this point of studying the universe in a truly unique way... and it is simply amazing!

MBW: Part of what drew me to LIGO was the fact that the goal seemed nearly impossible to me, but through the tenacious efforts of hundreds of scientists over several decades, the first detection of gravitational waves actually appeared to be just over the horizon. This discovery shows how much people can accomplish by working together, and it is only just the beginning, the dawn of a truly exciting era of astronomy.

CG: It's life-changing! I remember waking up the morning after the discovery (I had been on shift until midnight) and still feeling like I might be dreaming. After so many years of focusing microscopically on only pieces of LIGO (i.e. hardware and running the machine), everything changed in one fell swoop. Honestly, up until the discovery, my work was just a job; I really didn't think a lot about the potential of a discovery. But after the discovery, it really puts so many things in perspective. I can appreciate the broad strokes of humanity which led to this point starting a century ago with Einstein's general theory of relativity, to Rai Weiss' visions of a detector, to my turning of a bolt years ago, and to the mad rush of phone calls early in the morning on September 14, 2015. Everything changes, and this is only the beginning!