

## **First Light Lite**

June 1, 2021

Jim Lynch – Editor

### **Message from the CCAS President**

#### **1) Elections**

This month's meeting on June 3<sup>rd</sup> (which incidentally is my birthday) will be an important one - but not because of my birthday. Rather, we will be putting together a slate of officers for CCAS for 2021-22, along with a nomination for an at-large CCAF board member. The voting, which will be held at the July meeting, will be for President, Vice-President, Secretary, and Treasurer of CCAS as well as for the CCAF Board member. As you likely know, CCAS is the "Society Affairs" part of the club, whereas CCAF's charge is the equipment the club uses, including the Werner Schmidt Observatory.

We welcome nominations, which can be given to Christine Lynch via [roadracers@aol.com](mailto:roadracers@aol.com), or made directly at the June meeting after we hear from our Guest Speaker. If you send a nomination via email, please use the subject header "CCAS Elections."

#### **2) Membership and Dues**

Last year, CCAS suspended all dues requests, due to the fact that the pandemic greatly limited our activities and so we didn't think it fair to charge dues. This year, we will still be limited at first, but will be asking for \$20.00 in *voluntary* dues. These dues are used for speaker expenses, the "book program" for local high schools, and other such outside expenses. (The CCAF Foundation deals with our equipment costs, not CCAS.) We hope that you are enjoying the speaker program, and can be supportive of our book program for the schools, and so will chip in. But, if you can't, please still join us as a member. We will have a renewed menu of activities this year, which we hope will both attract your attention and maintain it.

#### **3) Committees**

The committees which we formed this February have been mostly quiet, again due to our inability to do much with because of the pandemic. To refresh people's memories, they were: 1) Membership/Outreach, 2) Programs/Content, 3) Communications, and 4) the Invited Speaker Program. Out of the four of these, only the fourth one really had much traction over the past fourteen months. Our membership stayed static at the mailing list for First Light (including interested students), our programs with the schools and star parties were curtailed, and our communications were limited to First Light and a few emails. Externally, we, like many other concerns, were close to dead in the water, except for the Invited Speaker program, which in many ways was our salvation. Internally, we held our usual officer and Foundation meetings over Zoom, but they were devoted mostly to "holding pattern" activities.

As of the day this is written (May 29<sup>th</sup>), Massachusetts is lifting many Covid restrictions, and we can see some light at the end of the tunnel that has a reasonable probability of not being a train. Thus, our committees will be ramping up again. I will contact the previous members to notify them, but I would also love to see some new people join as well. Contact me at [jlynch@whoi.edu](mailto:jlynch@whoi.edu) if you are interested.

Let me refresh your memories of what the committee's charters were, in a very brief form.

- a) Membership/Outreach – Recruiting new members Cape-wide, and making links to schools, organizations and clubs both on-Cape and off.
- b) Programs/Content – Star party organization, special events, school program offerings, offerings for club members.
- c) Communications – Website, Videos/podcasts, advertising of events and programs.
- d) Speaker Program – Finding invited speakers for CCAS meetings and also tracking other interesting talks that club members can access.

#### **4) Ramping Up After Covid**

As mentioned last month, we are working to ramp our in-person programs back up, gradually and safely, following local and state guidelines. Our (indoors) speaker program will “go live” when the schools and public facilities open up for events (probably next fall), although we will still keep the Zoom format available, as we can get some wonderful speakers “from afar” with Zoom! Our star parties are looking towards “socially distanced” but live events in early summer, transitioning to our usual format by fall. We already have a green light from DYHS to use WSO, and as soon as we have our paperwork and protocols in place, we should start again. And our school interactions should be live by next fall, with interaction directly in the classrooms and at our Observatory. The state has approved fully in-person classes, and we believe that we also can work with them in person, pending their approval.

In the meantime, we still have a *great* lineup of speakers on Zoom this spring and summer! I’ll describe them in our “Upcoming Speakers” section shortly. And we also have had some ongoing invitations from the Phoenix Astronomical Society to attend their Zoom events. Read on, if you’re interested!

#### **5) Book Program for Students**

Before getting to that list, however, let me mention to any Cape HS students (or teachers) reading this newsletter that our spring “book give-away” for HS student attendees is still going on, and will also be continued next fall. In January, we gave out laminated Moon maps to those who attended Jim Head’s talk; in February Jim Gates and Cathie Pelletier’s “Proving Einstein Right” was featured; and in March, Emily Levesque’s “The Last Stargazers” was the prize. This month, we will be giving away extra copies of all three of the above (one per customer... 😊) to those who attended Keith Thorne’s May talk on LIGO, along with copies of “Gravitational Waves” by Brian Clegg. Next fall (originally slated for June), we will award “Turn Left at Orion” (and some small astronomy gear) to those students who attend co-author Dan Davis’ talk. These are admittedly blatant enticements to get the students to listen to some STEM talks, but the worst that could happen to them is that they would get to listen to some first-rate professional scientists talking about fascinating research, and that they would start a rather nice

astronomy library! We'll risk that, in order to give the students something a little extra to encourage their interest in STEM.

## **6) Books available**

As you might remember from a previous newsletter, Mr. Jim Carlson, one of CCAS' founders, recently passed away. His family has generously offered to give his astronomy books to any members who might be interested. If you *are* interested, please just contact me at [jlynch@whoi.edu](mailto:jlynch@whoi.edu), and I will put you in contact with the family. (We don't post information about private individuals directly.)

## **Upcoming Speakers**

### **June 2021**

#### **Mr. George Silvis, CCAS and AAVSO**

During the club portion of our meeting (after the Guest Speaker), we often have presentations of club activities, observations, etc. George Silvis gave an extremely nice exoplanet observation talk in April, and he has more topics to talk about as our primary speaker this month. Specifically, George will give talks about 1) Sudden Ionospheric Disturbances (SIDs) monitoring - what they are, and how to observe and report them, 2) the Supernova Early Warning System (SNEWS) and how amateurs can participate, and 3) Photometry and how to prepare observations for the American Association of Variable Star Observer), AAVSO.

### **July 2021**

Thanks to CCAS member Paul Fucile, we have one his Stellafane colleagues talking to us in July, Dr. Tom Spirock. His talk will be on "Lucky Imaging Results Using the 13" Schupmann Telescope at Stellafane and the 6" Warner and Swasey Refractor at Mount Wilson." Anyone interested in planetary imaging should be sure to attend this talk!

## **August 2021**

Our Guest Speaker in March, Dr. Jim Gates, mentioned in passing and with more than a slight hint of pride, that his daughter Delihlah was finishing her PhD work in General Relativity (Black Holes) at Harvard this spring. Being a shameless opportunist, I cadged the link to her thesis defense and also asked her if she would be interested in giving a talk to our club. Happily, she agreed and so she will be speaking to us about Black Holes this August. She, and the speakers after August, will likely be live, and we will also see if there is a way to tape the talks, so that our faithful “remote audience (Zoomies?!)” can also enjoy hearing them. This is part of our transition plan. And it will be a joy to again host our speakers at our pre-talk dinner, and be able to chat with them “offline.”

## **September 2021**

Dr. Alyssa Goodman, whose work on the "Radcliffe Wave" discovery has been prominent in the news this last year, has also agreed to talk to CCAS this fall. Her exact topic/title is TBD.

## **October 2021**

Dr. Jim Head, who has given us two excellent talks on Lunar Exploration and the Chinese Space Program, has offered to talk this October about the latest news from Mars, which should be very exciting. Perseverance and a number of other rovers and orbiting craft are making Mars a busy place these days, and there should be plenty to relate and synthesize!

## **Last Month's Speaker**

### **Dr. Keith Thorne (Caltech and the LIGO Livingston Observatory)**

Thanks to CCAS member Marinna Martini, we had a LIGO project guest speaker in May, Dr. Keith Thorne (who is not related to Kip, but occasionally gets some of his mail...) Let me post parts of an email he sent me:

“Dr. Keith Thorne is a group leader at the LIGO Livingston Observatory. His duties include the real-time control and data acquisition systems for their laser interferometers. These are the most sensitive scientific instruments yet devised, making the first ever detections of gravitational waves from colliding black holes and neutron stars in 2015. He has been with the LIGO project since 2003 after his initial particle physics research at Fermilab.”

Keith mentioned “I even gave a TedEx talk back in the day at Corning Glass”  
<https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKewjzuJ2kutHuAhVDeKwKHRPgDAQQwqsBMAB6BAgFEAg&url=https://www.youtube.com/watch?v=oB0KYSluetw&usg=AOvVaw0NwZ9aY6z5J0DIvwFcqwA6>

PRECIS of “Listening for Bumps in the Ocean of Night: Discovering gravitational waves with LIGO”

NOTE: In the following, I use “gravitational wave” rather than “gravity wave.” The former is a general relativistic effect (as explained below), whereas the latter is used to describe non-relativistic waves where gravity is the restoring force, such as ocean waves. It may seem a silly distinction, but it avoids confusion!

At this point in time, the LIGO (Laser Interferometer Gravitational Wave Observatory) project is well known to most amateur astronomers, even if they can’t exactly gin up an inexpensive amateur version of the gear used. But for those that aren’t so familiar with gravity wave astronomy (and even those that are), Keith Thorne gave a nice introduction to the subject, both historically and physically.

Like pretty much everything that has its roots in General Relativity, gravitational waves stem from solutions of Einstein’s field equations, which date back to 1915. After deriving such waves in 1916, Einstein waffled on and off about whether they were real, but also knew that whatever the case, they were far too small in amplitude to be discovered by the technology of his time. That discovery would have to wait another hundred years from the derivation of his field equations.

Gravitational waves are produced by time varying “mass quadrupole distributions,” which means that they are not the product of simple spherical objects, but come from things like “compact object binaries” (neutron stars and black holes), core collapse supernovae, asymmetric neutron stars and the stochastic (random) background gravitational wave noise of the universe. While all of these astronomical mechanisms are possible, it is only the first category that has been observed to date. The others still remain as tantalizing possibilities.

After a review of the compact object sources (white dwarves, neutron stars, and black holes), Keith turned to the general properties of gravitational radiation. Expressed as a strain (i.e. a stretching or compressing) of spacetime, gravitational waves seen at earth due to compact binary mergers have amazingly small amplitudes, on the order of  $10^{-21}$ , meaning an object gets compressed in size by one part in  $10^{21}$ . This is due to both the weakness of the gravitational force and the “spherical spreading” (like light) of the energy as it propagates from distant sources. This also means that one wants as big an object (a “ruler”) for a detector as possible, so that this tiny fraction of the ruler is measurable, and is why the individual LIGO detectors have such long arms. The LIGO detectors are literally trying to measure a distortion of the arms one thousandth the diameter of a proton!

The speed of a gravitational wave is the speed of light, as was nicely confirmed in October 2017, when the LIGO and Virgo detectors received gravitational wave signals within 2 seconds of gamma ray satellites and optical telescopes seeing distant signals from the same direction. The wavelength, denoted by  $\lambda$ , is the distance along the wave between points of maximum stretch or squeeze. The speed, wavelength, and frequency of a gravitational wave are related by the equation  $c = \lambda f$ , just like the equation for a light wave. For the  $\sim 200$  Hz signals first detected by LIGO, this gives a  $\lambda$  of 1500 km, which is half of the 3002 km separation between the Hanover, WA detector and the Livingston, LA detector. This spatial separation of the detectors is done both to allow the detectors to be used as elements of a directional array, as well as to make sure that they are listening to different background noise signals, which allows the noise to be more effectively filtered out. Only a real signal should look the same at the two locations.

Keith then turned back to the history of LIGO, and specifically to the laser interferometer experiments that Rainer Weiss started at MIT in the early 1970’s.

(These followed some pioneering, but unsuccessful efforts with solid bars by Joseph Weber in the late 1960's). Weiss' setup closely mirrored the historical Michelson-Morley experiment, only with modern lasers and coherent light. Like Weber, the initial attempts were not sensitive enough, but the technique looked more promising overall, and Weiss at MIT and Kip Thorne at Caltech settled in with it.

Signal-to-noise ratio is the gold standard in signal processing, and perhaps the most impressive thing about LIGO is how it suppresses the myriad of noise sources that are strong enough to mask the ultra-weak gravitational wave signal. Noise and stray vibration signals varying from ungodly strong (earthquakes, anyone?!) to unbelievably weak and subtle (how about quantum zero-point vacuum fluctuations?), and stretching over a large range of frequencies, have to be dealt with. Keith devoted a few slides to showing the technically intricate solutions to eliminating some of the noise sources, while admitting that this was just the tip of the iceberg. The list of noise sources is extensive, and it would take several talks just to show all the clever solutions that have been implemented, even briefly.

At this point in time, LIGO is running routinely, with three major data collection runs and ~67 probable "events" recorded. It is now in full science mode, and even "statistical science" mode. Keith showed a "stellar graveyard" plot of coalesced compact binary systems that now has the power of a medium-large statistical sample behind it, which gives a whole new dimension to the science that can be done. And individual events can still hold their fascination, as an example of an "asymmetric collision" between a black hole and an unclassified (not in the military sense!) companion shows. The companion is either the lightest black hole ever measured or the heaviest neutron star!

LIGO is also in fully-three dimensional, "multi-messenger" astronomy mode. With the Virgo node in full operation, the LIGO array can precisely locate an event in the sky in right ascension and declination, and also pass that detection information along in a timely manner to optical, x-ray, neutrino, and other observing systems, both on earth and in space. With all these instruments in play, a full spectrum time series description of an astronomical event can be made, something that has been a goal for astronomy for many years.

And finally, the earth based LIGO system will not be the last word in gravitational wave detection. A space-based system called LISA is being developed by the European Space Agency (ESA) which will have a very long



baseline, and also not be plagued by many of the noise sources found on earth. Its baseline of a million miles (as opposed to a few kilometers for LIGO) will allow it to listen to much lower frequency gravitational waves, which in turn are due to different astronomical phenomena, including the Big Bang.

Gravitational wave detection has had an exciting past, and will have an exciting future as well. We thank Keith for explaining it, and bringing us up to date on the latest events.