First Light Lite

January 1, 2022 (Happy New Year!)

Jim Lynch – Editor

Message from the CCAS President

Last month, my lead paragraph stated: "The Covid pandemic is not over, but at least for a highly vaccinated and cautious area like the Cape, some normal activities are resuming." I then talked about an in-person star party CCAS held in November, and a public STEM event that CCAS participated in. Optimism ran high!

A month later, and a Covid strain that we had just barely heard about (Omicron) has run rampant in the USA, the Cape included. So, as a club, we are back to our remote existence for a few more months, until the winter cold/flu/Covid peak abates. As with the past 21 months, caution must be our guiding principle. Let me elaborate on details below.

1) Whither Goest Our Activities? (Et tu, Omicron?)

Lecture series

We have some more great speakers lined up (see below) and will be continuing our book give-away program for any students attending. But live lectures look increasingly unlikely any time soon (until after March at the earliest is now our guess). We generally use public venues for our talks, and these are still not opened. So, Zoom continues for now. We're hoping that *eventually* things will ease up, and we'll certainly keep you informed.

But, before leaving the topic of speakers, let me give a **huge** shout out to our Covid era Zoom speakers, who have kept our club active in at least one important area. I have attached a list of all of our recent guest speakers, noting those speakers, to the end of the email. We owe all of them a dinner and some sort of award for keeping the STEM efforts of clubs like ours (and we are not alone) going in the midst of some very crazy times.

Star Parties (updated)

Our WSO star parties were shut down for over a year and a half during the pandemic, but we temporarily got back into business. Our November 6th star party was held, and attracted numerous visitors. The large scope had problems that were only fixed towards the end of the party, but the images finally produced were quite nice, and were shown last month. The binocular and laser tour went quite well, with three planets, the Milky Way, and a plethora of constellations (and their attractions) showing up brightly. Late fall and winter occasionally have very clear skies!

As to the full resumption of Star Parties, the cold weather/Covid combo has now become a controlling factor. We can't allow people into the WSO to warm up yet, as January and February evening weather is very often 20-30 degrees (plus wind chill). We don't want to freeze our guests (or our staff), so instead we will work on getting our equipment and Observatory in great shape for the Spring. Additionally, we will post some winter sky attractions to look at in our newsletter and on the web. You can (like I do) duck in and out of your warm house to see these and/or photograph them. The dates for further 2021 Star Parties which were posted on the CCAS website, www.capecodastronomy.org, were removed and we will update that site with 2022 Star Party dates as soon as they become possible.

School Projects and Activities

At this point in time, we are still discussing with the local schools (DYHS, BHS, Sturgis) what is possible and what is not this winter and spring.

Public Outreach

As mentioned last month, we had a very successful CCAS booth at the Cape Cod Natural History Museum on November 13th, when the Museum hosted a "James Webb Space Telescope" event that concentrated on space science and astronomy. Jim Lynch, Chris Lynch and Charlie Burke staffed the booth, which had many visitors (picture shown below). We had many people sign our "interest" sheet, and also take our brochures, and so hopefully we will be seeing these people again in the future! We also heard a great lecture on the Webb telescope by Charles Law of the Harvard Smithsonian Center for Astrophysics, who also has agreed to give that talk to us in January! And, now that the JWST has successfully launched and is unfolding, that lecture becomes even more interesting to listen in to!

Fig. 2. Charlie Burke and Jim Lynch man the CCAS booth at the CCNHM "James Webb Space Telescope" event. The red glow is a neon gas discharge tube that we used to show spectroscopy (together with inexpensive diffraction grating slides). Photography by Chris Lynch.

We also have some very exciting possibilities together with the Camp Edwards base folks and the Upper Cape Cod Regional Technical School (and its adult education component), with whom we are also pursuing discussions.

Day of Astronomy

We are still planning a Day of Astronomy event at the Werner Schmidt Observatory (WSO) for the public and our club members and friends. However, it also will have to wait for the warmer weather because the outdoor component will just be too cold for a multi-hour event (as with our star parties.)

We will send out notices (email and other) when the date for this solidifies, as well as post it on our web calendar.

2) Speakers

Last Month's Speaker

December 2nd, 2021

Dr. Delilah Gates, Princeton University,

Our last speaker in 2021 was Dr. Delilah Gates, who spoke on one of the public's (and astronomer's) favorite topics, black holes. Her talk is described below.

Title: Observational Signatures of Black Holes: Learning from Light?

Abstract: Black holes are a prediction of Einstein's theory of general relativity and are the most extreme gravity regions of our universe. With experiments like the Event Horizon Telescope, imaging black holes has transformed from science fiction to science fact. What can we learn about black holes from imaging the light that bends around them? What signatures in black hole images tell us how big they are and how fast they rotate?

PRECIS:

Although scientific giants Albert Einstein and Arthur Eddington weren't convinced that one of general relativity's (GR's) predictions, black holes, made any sense at all, a century of work since then has in fact shown that they not only exist, but are in fact very common. Observations from LIGO and Virgo have displayed gravitational waves (another GR prediction Einstein distrusted) from black hole collisions, and the Event Horizon Telescope (EHT) has shown us compelling visual images. Other evidence also exists from indirect observations like star orbits, powerful jets, and the bright accretion disk. The case for their existence has been closed, and now the push is to understand them. That case may eventually take as much effort as the one for showing that they exist!

One of the scientific detectives who is on the case of understanding them is Dr. Delilah Gates of Princeton University, who was our speaker in December. Delilah started out with asking how we know we are looking at an "invisible" creature like a black hole, and if we are, what are the parameters of it that we should be looking to measure? The experimental evidence, as we said, is compelling. As to what to look at and what it can tell us, we first have to return (as always) to Einstein's GR field equations. These are intricate tensor equations that take no small amount of effort to understand and work with, but basically, they relate the curvature of spacetime to the matter/energy it encloses. Or, to quote yet another scientific giant, John Wheeler: "Matter tells Spacetime how to curve, and Spacetime tells matter how to move."

Given Einstein's GR field equations, researchers through the years have worked on solutions for various matter/energy configurations, and in particular have devoted a large share of effort to understanding black holes. One of the things that was discovered was a theorem by Hawking (and others) that "black holes have no hair," which was Wheeler's joking description of the theorem. In less "insider joke" terms, this referred to the result that a black hole could be fully described by just three parameters: its mass, its spin and its electrical charge. The latter is less of a concern, as charges tend to rearrange and cancel in the real world, so that really, a black hole's mass and spin are most of the story! Given that, Delilah showed a small table of the various possible black holes possible with that mixture of parameters. Of this group, the most interesting was the so-called "Kerr black hole" (named after Roy Kerr, a New Zealand mathematician who described their properties in 1963), which has spin (or rotation/angular momentum) as well as mass. This is the most likely scenario for a black hole.

Next up came the small bit of math that Delilah threw at the audience, namely the form of the Kerr metric, the "general answer" to Einstein's equations for a rotating black hole. The metric is physically what the local ruler looks like for any points in spacetime. (Remember that measures of space and time change in relativity. Your clock and ruler don't have to agree with mine, especially when talking about extreme regions like black holes. Go watch "Interstellar" if you want a fun reminder.)

Next, Delilah showed the basic setup for processing the optical signals that one gets from a black hole. The basic idea is to be able to infer the real position of a source of light from the apparent position that the refracted rays seem to come from. Gravity may be the lens here, but the basics of optics should be familiar to most of our members who intrepidly deal with telescope optics.

A nice thing about having a theory about what possible sources of light might be, combined with a theory of optics (in a curved spacetime, which is a complication, but a navigable one) is that you are then set up to do computer simulations, which nowadays are a common accompaniment to both prediction and data analysis. This is what Delilah did next, showing both the earliest simulation of a BH with an accretion disc (the stuff orbiting and falling in) made in 1979 (which for some of our members is "the late Jurassic") as well as a more modern movie.

Next came real and computer images of the M87 supermassive black hole, which the Event Horizon Telescope (EHT) famously imaged. Using GRMHD (general relativistic magnetohydrodynamic) simulations (GR plus magnetism and fluid dynamics), and blurring the image (hey, we all squint through telescopes – jk, it's a resolution factor), a very nice correspondence between theory (the simulation) and the image data is seen. So, we seemingly DO have a good first order idea of what a black hole is that can reproduce the EHT images!

Or do we? The mass and spin of a BH can have a wide range of values, and the accretion disc which is producing the light is also a rich source of variable parameters. So, are the models just being tuned to match the images using the wide possible variation in the parameters, or have we actually learned something about the BH (and the accretion disc)? The answer, happily, is that the calculations all show a dark center and bright ring, implying "universality." GR and the black hole give universally similar features, which can be exploited to learn about the BH. The BH and the accretion disc are not so strongly intertwined that one cannot separate one from the other, at least to first order.

Delilah then turned to the details of the trajectories of the photons that are released in the vicinity of the black hole. For some of the oceanographers in the audience (and CCAS has a few), the appearance of multiple paths connecting a (single) source position and a receiver will not come as a shock. Complicated refraction geometries invite such behavior. In a black hole, Delilah showed how photons can wind multiple times around the BH, and then proceed merrily to the receiver (us). Technically, this exercise was "tracing near critical orbits using the poloidal geodesic equations," but for most of us "ray tracing" will suffice.

Kerr black holes, being rotating objects, have some distinct personality traits, and data on the image screen position, intensity, polarization and red/blue shift have good potential to let us infer the determine the BH's parameters. For instance, the diameter of the photon ring around the black hole encodes the size of the BH. The maximum observable blueshift (MOB) encodes the BH spin and its orientation. One particular atomic line, the kα line of iron, is very useful for this. Its broadening, doppler shift from the emitter motion, and gravitational redshift all are exploitable data. Delilah spent some time showing how these "clues" vary as one varies the black hole's mass and rotation, and where they are sensitive and not so sensitive. This an SOP exercise when looking to see what can be squeezed out of data, and it appears that BH imaging will be a viable technique for studying these amazing (and ubiquitous, which would have floored Einstein) objects!

To conclude, we'd like to thank Delilah for showing us some of the "behind the scenes" looks at the famous BH images that were just pretty pictures to us before her talk. The old "one picture is worth ten thousand words" adage is more than true in this case.

On a personal note, I'd like to thank Delilah additionally for inspiring me to finish reading my copy of "Spacetime and Geometry" by Sean Carroll. GR is a beautiful subject, and Sean Carroll is (like Delilah) a wonderful science communicator. (And yes, he has written many popular books, all of which are worth reading by our CCAS members and friends.)

January 2022 Speaker

Mr. Charles Law, Harvard Smithsonian Center for Astrophysics

Title:
A New View on the Universe: the James Webb Space Telescope

Abstract:
The launch of the James Webb Space Telescope (JWST) will herald a new era of astronomical discovery. Astronomers will see the very first galaxies and stars formed in the universe, detect molecules in the atmospheres of planets around other stars, reveal supernovae explosions in unprecedented detail, and much more.

In this talk, I will provide some historical context to how JWST was conceived, designed, and built, and what exactly makes it so uniquely powerful for modern astronomy. I will outline a few of the major science goals that JWST will address in the coming years, with a particular focus on what JWST will be able to tell us about the chemistry of planet formation and what we will soon learn about how our own solar system came to be and the origins of life as we know it.

Spring/Summer 2022

Dr. Alyssa Goodman of Harvard University, whose work on the "Radcliffe Wave" discovery has been prominent in the news, has agreed to talk to CCAS this coming year. We had promised Dr. Goodman some direct contact with the local students, but until the delta and omicron variants are under control, that is not yet possible. Her exact topic/title is TBD.

Dr. Francesca Fornasini of Stonehill College has also agreed to talk to us. She specializes in early star and galaxy formation, and her exact topic will be announced in the near future. Her husband, Dr. Garrett Keating, is also interested in visiting and talking to us. Now, if we could just get rid of bleeding Covid!

5) Star Parties - Information

We are again posting our older "usual information," but please note that given the resurgence of the pandemic via the Delta and Omicron variants, combined with the cold weather, we are not planning any Star Parties until the weather warms some or until we can allow people into WSO to warm up. The website will post our 2022 Star Party dates as soon as we have them.

Star Party Information:

A Star Party is a scheduled event "at the WSO Dome" usually starting at 7:30pm in the fall, winter, and spring (8:30 in the summer because the sun sets later.) Our EAA setup will be available for ~2-4 hours from when the sun sets.

Not just telescopes will be available: a CCAS member who knows the groupings of stars in the night sky (constellations) and how those move with season and time, will point to various stars, planets, and constellations with a laser pointer, describe what is being pointed out, and invite binocular observation.

When at our website, please click on:" Meetings & Events" on the Home Page and then,
...for Schedule of Meetings and Star Parties and anything else scheduled, click on " Calendar". If you need to see a month later than the current month, click on the arrow pointing to the right... to see more info on each item in the calendar, click on each item.

If you can, please visit the calendar at our website once a month to track us "opening back up to normal," especially as we start scheduling Star Parties again.

If in doubt about the weather, call 508-398-4765 15 minutes or less before the event starts — no answer means the event has been cancelled. Cancellations may also be reflected on the calendar.

All our scheduled Star Parties are free of charge and open to the public. One of the main missions of CCAS is to invite folks to enjoy the night sky and learn something about it.

For more info about The Schmidt Observatory click on " Observatory" from the home page and look thru the items listed, particularly "Mission" and "Facility." At "Facility," please click on the underlined "Werner Schmidt Observatory" at the top of the page to go to a map showing the location of the observatory behind Dennis-Yarmouth High School.

Directions:
To get to a WSO Star Party, exit from the Mid-Cape Highway, Rt 6, at Exit 8 and turn left (toward the south) at the end of the ramp. Drive down Station Avenue a mile or so, and, when you reach it, on the left, drive into the northernmost road leading onto the Dennis-Yarmouth High School campus. Then go all the way thru the gate until you see the Dome and parking spots. Don't worry about a sign on the fence near the open gate which suggests "authorized" folks only. If the Dome is open, you are authorized.

To get to the Library at Dennis-Yarmouth Regional High School where our monthly meetings are usually held (again, check for updates), drive into the southernmost road leading onto the campus, drive along the football field until you can turn left behind the main HS building, and park near and go into the first "back door" you can see. Directions to the Library are posted in the hallways when we have meetings there.