Student questions: Nathaniel Butler colloquium on "Gamma Ray Bursts: Past, Present, and Future"

10/12/22

What are some potential research about the gamma ray bursts?
NB: I outlined two key questions in my talk. Actual work on these topics involves nightly observations of GRBs, reduction of data, and science analysis (writing papers).

What kind of material that would survive a gamma ray burst?
NB: Material survives, but anything nearby is ionized and cools.

How do you eliminate background gamma ray radiation from the sun, especially during solar storms?
NB: Don't point at the sun.

What Earth or space-based factors would most disrupt your measurements?
NB: Satellites typically need to turn off when passing through radiation belts in the Earth's atmosphere.

What were the challenges of maintaining the telescopes in the mountains of Baja California?
NB: Old telescopes take a lot of work! Instruments eventually break and need repair or parts replacement. Staff can be minimal in the case of robotic facilities.

What other sounds, such as the click caused by merger events, can be associated with other types of events? Do other astronomical events cause a sound at some frequency?
NB: Likely yes. However, few events have sufficient energies as compared to mergers of nature's most extreme neutron stars and black holes.

What does it mean for the classical observations of GRB being pointed towards us?
NB: The GRB emission goes out in a cone. If earth is in that cone, we observe the bright (classical) GRB.

Does JWST aide in any of the GRB observations? If so, how?
NB: It will be interesting to observe high redshift GRB host galaxies with JWST. It may be possible, although difficult, to observe such a burst while it is bright due to JWST pointing constraints.

What instruments are used for the gamma ray burst detection?
NB: Gamma-ray and X-ray detectors use materials (gas, crystals, solid state detectors) which interact with the photons and allow for some position-based measurements.

Is the after-glow observation important to the research done in this area?
NB: Absolutely. This is how we obtain constraints on energetics, beaming. We also get spectra from the afterglow which allow us to measure redshift (i.e., distance).

What might ESA's upcoming LISA (Laser Interferometer Space Antenna) mission be able to tell us about the objects that produce gamma ray bursts?
NB: Probably not a lot. LISA, as far as I understand, will focus on galaxy mass black hole systems.

Does the current data we have on the distribution of gamma ray bursts suggest whether or not they were more common earlier in the universe's history than they are today?
NB: They are more common than massive star formation beyond redshift 2 (Universe at 1/3 of it's current size).

Do gamma ray bursts have any profound gravitational effect at long distances from the merger event or do they only affect celestial bodies nearby the event?
NB: The latter.

How sensitive do telescopes need to be to detect gamma ray bursts, and for ground-based telescopes, do they need to be in isolated locations with low light pollution like most other telescopes?
NB: Absolutely! GRBs and their afterglows tend to be quite faint after tens of seconds.

What exactly is a bh-bh (blackhole blackhole) event?
NB: A merger of two black holes.

What causes the jetting in GRBs?
NB: We don't really know. It likely has to do with spin in the original system and possibly magnetic fields channeling the radiation.

What was the hardest part of learning to code new software?
NB: It just takes time.

Is there ever 'too much' data to have to go through and analyze when collecting it over large areas of the night sky?
NB: There is often too much data for traditional approaches. And we have to develop more systematic approaches that are automatic instead of manual.

What other kind of science could come from using LIGO?
NB: LIGO has detected far more massive black holes than we would have likely predicted in advance. It is telling us a lot about the stellar graveyard.

What resolution does the Colibri mission camera have?
NB: It does photometry (10% spectral resolution). There are plans for an R=1000 spectrograph (0.1% resolution) as well.

How are the locations for ground-based interferometers, such as LIGO, determined/selected?
NB: I don't know. I imagine they need to be well separated. There would be a lot of politics involved.

How can you correct for the strong observational biases predicted by the simulations?
NB: I don't believe you can.

How do you pick a location for a good telescope, and have there ever been placements that ended up being problematic/were not ideal?
NB: Most of last centuries (and older) telescopes are now in regions too polluted by light.

What was the transition like into fully automated software?
NB: Gradual.

What would be a more sophisticated version of LIGO (that you mentioned) that would help the detection of GRBs?
NB: I don't know what path they will take. It could get larger, have more powerful lasers, or involve more detectors.

Is there any way you could harness amateur astronomy for the detection of GRBs? (in the same way that some networks of amateurs are helping for exoplanet ephemerides or galaxy classification)
NB: Yes, but it is challenging with small telescopes. The AAVSO works on such things.

You can always find people on the internet worried about it, but what would it actually take for humanity to be wiped out by a gamma ray burst?
NB: It would have to be in our galaxy and pointed toward us. There are 1 or 2 known stars that could do such a thing, but we wouldn't know the jet pointing. It is a very very rare possibility, except perhaps over the whole timespan of the earth.

Forgive me if I missed it, but what was the actual specific subject/title of your PhD thesis?
NB: I did not discuss it. My thesis was related to the HETE-2 GRB satellite.

Why did Hanford and Livingston measure slightly different sinusoidal patterns but the same "chirp"?
NB: Good question. I don't know.

Why are small telescopes used to hone in on sources rather than larger ones which would logically have a better angular resolution?
NB: Large telescopes have narrow fields of view and are very expensive to use. There is not enough time available.

Why GRBs are very very rare in our Milky Way galaxy?
NB: They are very very rare. One has to look over vast volumes to see one. Supernova happen about once per century per galaxy. GRBs are probably a million times more rare because they require much more massive stars, which are in turn much more rare.

You said that simulations are strongly observational biased. So, what can be the possible way out to reduce these biases and simulate in a more realistic way?

NB: I don't believe they can be reduced. Other observation methods may suffer from different biases.

Do you think there is any utility to launching a constellation of cubesats to detect gamma ray bursts and supplement existing observations (e.g., from FERMI)?
NB: It is one way to observe the whole sky (or nearly the whole sky), which is important for LIGO follow-up. But it can be hard to have such a small satellite with sufficient sensitivity.

Is it worthwhile exploring the creation of small-scale gamma ray bursts in a laboratory environment?
NB: No. I don't think so.

It's my understanding that GRBs happen at least once per day, but GRBs are caused by events such as neutron star collisions and black hole mergers. Do those events really happen with such frequency, or is there another theory that explains the frequency of GRBs?
NB: Absolutely, if one observes enough of the universe.

At the end of the talk you had mentioned that understanding more about GRBs will change the way we do astronomy. Can you elaborate on how?
NB: I discussed the way different sorts of transients will be detected in the future at very high rates. That will require a very different approach to large data masses and using robotic telescopes to try to follow up as many detections as possible.

Do gamma ray bursts indicate gravitational waves might have occurred?
NB: Most likely.

How many near earth sources produce these gamma ray bursts and how concerned should we be if one is too close?
NB: Basically 0 and no.

You mentioned reionization is a random process - is it truly random or is there a way to model it using initial conditions?
NB: It can be modeled, but the prediction along a given direction into space would be a random sample of the simulation.

When you're observing, how do the lights you can see from one side of the mountain impact your data?
NB: If you can see lights, the data are often poor.

What causes certain types of merges to produce their own specific vibrations?
NB: The main difference is the mass of each object in the merger. The more mass there is, the faster the merger happens.

You spoke about how Gamma rays from Gamma ray bursts can't penetrate our atmosphere and are absorbed instead. Even though they can't penetrate the atmosphere, do they have any effect on our planet?
NB: A bright GRB last week (one of the brightest ever) produced some ionospheric disturbances above Inda. That is rare.

I am not sure if I missed it, but what type of detectors are used in telescopes for gamma rays?
NB: I discussed this a bit. See above.

Are there expected to be efforts to develop more LIGO-like experiments given its success?
NB: Hopefully.

Do gamma rays disappear as they travel through the universe, and why?
NB: Yes, they can interact with matter along the way if there are far enough away.

Are gravitational waves and light the same type of wave?
NB: No.

Is there a measurable difference in the gamma ray bursts and gravitational waves from merging black holes compared to merging neutron stars?
NB: Yes, see above.

I saw that there was a gamma ray burst that had energy levels up to 18 TeV recently, why do some bursts have significantly more energy than others?
NB: Presumably, the initial explosions are larger. It can also depend on the magnetic field strength in the vicinity of the GRB.

Are the GRBs you observe wavelength -dependent in term of their arrival time (i.e., having passed through some medium), and does this affect your ability to measure them and classify their sources?
NB: There is no evidence for this that I am aware of.

What justifies that the speed of gravity is different from the speed of light, even if only by 10^15 which is the factor LIGO found?
NB: The general theory of relativity predicts that they are the same. A different theory may not.

Why did you choose to study GRBs?
NB: It was the main topic of interest in my group at graduate school. I was interested in working on detectors.

Do amateur astronomers make any contribution to GRB science?
NB: Sometimes they get detections. It's quite rare.

I found the problem of having to be in the jet path in order to observe GRBs interesting -- would we able to obtain substantially more data by putting telescopes on the Moon or another planet, or are they not far enough away to affect our "coverage," so to speak?
NB: Correct.

What is used as a "standard" GRB spectrum when studying the transmission spectra of distant bursts?
NB: There is no standard spectrum, but a simple model is usually sufficient to allow one to study emission and absorption features in the spectrum.

How far must LIGOs sensitivity be pushed in order to make new discoveries?
NB: Even small improvements can have a large impact, since they allow the observable volume to increase.

Looking towards the future, how can the buggiest uncertainty, jetting, be resolved?
NB: It will likely require just a lot more observations.

In the beginning when the satellite first detected a GRB (when we were looking for bomb tests), how did we know that what we were seeing was a GRB and not something else?
NB: No one knew what they were, although it was soon realized that they were from outer space.

Could you explain in a little more detail the automated software you used in the telescopes to collect data of the GRB?
NB: The software must receive a GRB position, point a telescope there, capture data, reduce the data, compare sources found to catalog positions, identify new sources, and monitor and fit the time development of the source flux.

How do gamma rays interact with gravitational waves?
NB: They do not.

What processes lead to the formation of gamma ray bursts, and does one process dominate in particular?
NB: Two mechanisms (gravitational collapse of a high mass star to black hole and mergers of compact objects) were discussed in my talk. After that, the physical emission processes that allow the explosion energy to be transferred into electromagnetic radiation are important.