**Student questions: Sanchayeeta Borthakur colloquium on "Understanding How Galaxies Reionized the Universe"**

1/24/18

Question 1: If the black parts of space are gas, does that mean space is not a vacuum?
Yes. It contains low density gas.
Question 2: If the hydrogen in the universe gets reionized, will it cause another big bang?
No. Big Bang is the beginning of the universe and even though hydrogen is ionized in today's universe, the conditions (density, temperature etc.) are quite different.

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Question 1: Do you believe that humans may be able to utilize black holes for their own purposes?
Maybe. Not sure of any specific plans though!
Question 2: Would it be possible to predict the future or past black holes in our own galaxy or other galaxies?
One can probabilistically predict/estimate their growth based on their feeding pattern and the stellar population around them. As galaxies grow (especially the bulges of galaxies) so should the central super-massive black hole.

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Question 1: Given that you only had about a day's notice, how did you prepare for this talk differently than you might given advanced time to plan/practice?
I could have certainly worked on my delivery. I was also trying to put more visualiations of the concepts into my talk. Those need a lot of time to create or even find from the web.
Question 2: You said that dust and gas have different structures in the data, so that you can essentially subtract out any effects from the dust to get a proxy for an early galaxy that is only gaseous, but are there any other important corrections that must be made to get accurate proxy data from a much younger nearby galaxy?
Very good question! Dust is one of the primary aspect. Other relevant things would be the mass of the galaxy – the gravitation potential. Winds in massive galaxies need more momentum to escape or do significant damage. The other thing will be distribution of neutral gas in the "halos" of galaxies that may eat up significant fraction of ionizing flux. All these things will be different in young galaxies.

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Question 1: How do feeding black holes produce highly radiative accretion disks?
Friction from material in the rotating/infalling disks around black holes makes them extremely hot. The hot disk in turn radiate in all wavelengths based on their temperature profile.
Question 2: Does size, number or density of developing stars play more of a role in the production of ionizing photons?
It's the number density of most massive stars (O-stars) as these are the stars that produce the vast majority of ionizing photons and generate the winds necessary to make the tunnels.

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Question 1: When using known models of absorption spectra to determine the orientation of a newly observed galaxy, is there a certain deviation from the standard model that is allowed, or are there parameters within the spectra that are unique to certain galaxy types?
Most of these galaxies are face-on. We wouldn't detect outflows in edge-on galaxies. Also most of the light from the stars will be eaten up by the dense disk. So only certain orientations are favored for our study. No correction to orientation was made.

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Question 1: What does the "z" represent that was presented in this presentation?
z generally denotes redshift.
Question 2: Why are the ions impossible to detect after they have been impacted by a photon?
Certain ions (ex – Si+) still have electrons that can jump between orbitals.

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Question 1: You mentioned quasars as a potential source of ionizing photons (albeit not enough to see using Hubble). Does this mean that using the absorption profile method on DCO's (where there is enough ionization to be detectable) will allow us to uncover more about the still mysterious nature of quasars?
DCOs are purely star-forming system. They might later (at unknown time) harbor a black-hole, which may feed and go to quasar mode.
Question 2: You mentioned sulfur-2 production and retention could be used as another indirect indicator to determine holes in the cocoons around young star clusters. It sounded like this process was another way to create holes, but the detection method - the absorption profile method - could still be the same. Can you explain the relation between an indirect indicator and the detection method a little more?
Good question! S II line is an emission-line and is easier to detect than absorption-line for faint galaxies. S II is produced when the star's ionizing radiation interacts with cool cloud. The idea is that if radiation is not surrounded by cool clouds i.e. there are tunnels/gaps in the cool gas coverage, then S II production will be less. Hence weaker emission-line than expected.

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Question 1: What are the implications of discovering more about reionization for the rest of the field of astronomy?
Tells us about early galaxies and what impact they had on the universe. Also neutral gas is essentail for star-formation and heating most of the gas in the universe would strongly impact star-formation history of the universe.
Question 2: As a non-astronomer, what is solar/galactic wind and what drives it?
Sun produces winds constantly, which contains fast moving charged particles. Auroras are produced which these charged particles hit our atmosphere near the magnetic poles. Similarly, young stars produce stellar winds. The combined effect is called galactic winds.

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Question 1: Given that when we look through the telescope at a galaxy to watch its happenings, we are looking back in time theoretically, does this play into how you examen the properties of how galaxies release the materials you are studying?
Yes. Different distances translate to different times. The galaxy properties varies. So we try to understand the physics and them relate it to galaxies from a different time accordingly.
Question 2: What new phenomena will the GMT (Giant Magellan Telescope) allow astronomers to view and to follow that up, how do you expect it to change the future of astronomy and astro-physics?
We can probe the physical/chemical state of the gas for many many galaxies. We can also trace out regions of "ionized bubbles" and connect them to nearby galaxies with GMT.

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Question 1: As a Computer Science Major, I am interested to know what type of software did you use to compute the escape of Lyman continuum radiation?
We wrote our own code to find the best fit model. Simple chi-squre fit will work in principle. To identify lines one could use neural network or other machine learning techniques.
Question 2: Using the large data set provided previous; the leaking of the 17 galaxies in the 198 star forming galaxies and the 1 galaxy leaking 102 LGB, how have these contributions and your current research, affect the future success of detecting LGB candidates?
Excellent question. We are refining the set of properties that indicate escape of iopning flux. More importantly, with successful candidates – especially in the nearby univese- we can study the physics of gas and stars in such galaxies.

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Question 1: For the research that you do and the instruments you use, what kind of instrument does it take to see the edge of the universe and how much does it cost?
I use spectrogragh most in the ultraviolet. To see galaxies at the edge of the universe you'd need a infrared space telescope. One such is coming up soon – JWST. It cost billions of dollars!
Question 2: Have you noticed any patterns to the subjects you observe? Is there any distinct characteristics for each Different celestial body?
We noticed that they produce a lot of stars in a very small area. Such densities are unimaginable in regular galaxies.

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Question 1: Why does it matter if the universe is being reionized? What question does it answer?
Tells us about early galaxies and what impact they had on the universe. Also neutral gas is essentail for star-formation and heating most of the gas in the universe would strongly impact star-formation history of the universe.
Question 2: Do you think that the universe will stop being reionized, and if so, when and why?
It's already being reionized.

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Question 1: The only evidence I understood for re-ionization was that as time continues less neutral gas is present. How is this evidence that RE-ionization occurred? Is there any other evidence for re-ionization?
This is called reionoization – the fact that earlier there was neutral gas then there wasn't any. All of it was ionized. One of see indirect evidance in other wavelnegths such as CMB, HI 21cm topology etc.
Question 2: Sanchayeeta kept mentioning radiation being removed. What does this have to do with re-ionization?
Ionization from galaxies that could get out of galaxies reionized the gas between galaxies. This process is called reionization.

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Question 1: As the cluster of stars leave the main sequence, how would this affect the galactic winds and cocoon as energy diminished?
Great question. Massive stars go supernovae and can really disrupt their cocoons. Red giants also generate winds that can disrupt the cocoon for future young stars, although they don't produce significant ionizing flux themselves.
Question 2: When you are attempting to look so far away from us using a land-based telescope like the Magellan, what efforts are made to diminish atmospheric turbulence and is it possible to use SOFIA to help with images?
SOFIA works in a different frequency. But one could use adaptive options for get better resolution!

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Question 1: At the start of your talk, you spoke about the different stages the Universe has gone through where there was a ton of gas between the galaxies, then as the energy dislodged the Hydrogen molecules there was no gas between the galaxies and we have what we have now.Is there a chance that we will return to this stage of gas between the galaxies despite the Universe currently expanding?
It's unlikely. The denisties are very low now – as universe expanded – and lots of ionizing photons from QSOs remain today.
Question 2: Near the end of your talk you spoke about how the James Webb Space Telescope and Giant Magellan Telescope will contribute to your studies. To what capacity will something like the SOFIA aircraft make on your studies given its ability to fly at high altitudes and thus reduce the amount of atmospheric interference?
SOFIA is an IR observatory. JWST will also be an IR intrument and much more powerful than any we have so far! So for my science JWST (higher redshift ~6+), GMT (lower redshift ~3), and HST (lowest redshift ~0) will be the best instruments.