WEBVTT

1
00:00:14.549 --> 00:00:15.360
loeb: Okay, Morgan.

2
00:00:15.780 --> 00:00:16.980
Morgan Elowe MacLeod: I can introduce our first

3
00:00:16.980 --> 00:00:17.369
Speaker

4
00:00:20.190 --> 00:00:22.350
Morgan Elowe MacLeod: You like that, it's good to have to post

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00:00:23.760 --> 00:00:24.180
Morgan Elowe MacLeod: Some

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00:00:24.540 --> 00:00:26.130
Morgan Elowe MacLeod: Slightly less prepared than others.

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00:00:27.300 --> 00:00:29.310
Ana Bonaca: It's okay, I think, I think I can do.

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00:00:29.490 --> 00:00:30.060
Morgan Elowe MacLeod: About it.

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00:00:31.950 --> 00:00:42.180
Ana Bonaca: So it's a great pleasure to introduce and, uh, how cool is currently a miller fellow in Berkeley and she was an undergrad at MIT, where she worked

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00:00:47.790 --> 00:00:48.030
Ana Bonaca: Back.

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00:00:49.320 --> 00:00:50.280
Ana Bonaca: Then she

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00:00:51.780 --> 00:01:05.070
Ana Bonaca: Moved to conflict as a grad student, but before that she took a year off as a Fulbright Fellow at MPa and there she is really important work extending the cannot code or measuring stellar abundances

13
00:01:06.420 --> 00:01:20.670
Ana Bonaca: From the kind of domain has been trained on SPSS equity data into hundreds of thousands available and most spectra. So I feel like many people in our community expected

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00:01:21.750 --> 00:01:31.950
Ana Bonaca: To come back and then use care can like just continue along this this line of research. However, she she surprised us all by getting involved.

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00:01:32.760 --> 00:01:49.200
Ana Bonaca: With the CTF and starting to savvy transients and finding like really opening up this new landscape of so many different types of events. We now know and we'll hear about in the next 20 minutes. So thanks. Thank you. I

16
00:01:50.460 --> 00:02:05.460
Anna Ho: Thank you for the very kind introduction. Can you all hear me and see my slides. Okay, great. So I'm going to tell you about some of my recent work studying extreme cosmic explosions and I thought I would start by explaining what I mean by extreme

17
00:02:06.540 --> 00:02:12.750
Anna Ho: This is a cartoon showing the landscape of optical transients or cosmic explosions in the year 2005

18
00:02:13.230 --> 00:02:25.590
Anna Ho: The x axis shows the time scale of the transients from one day to 100 days and the y axis shows the peak luminosity in the bed absolute mag on the left hand side and herbs per second on the right hand side.

19
00:02:26.790 --> 00:02:42.390
Anna Ho: So at the time, there were basically three major established classes of transients but a few years later, thanks to white fields and targeted optical surveys we filled in many of the so called gaps in them and also the space and began to push to faster time skills.

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00:02:43.470 --> 00:02:48.750
Anna Ho: But I've been doing for my work is trying to push to even faster time skills and hire people who have in our cities.

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00:02:49.140 --> 00:03:01.770
Anna Ho: For a long time, this was exclusively the realm of after glows too long duration gamma ray bursts, which we would find in targeted

follow up observations to discoveries by high energy satellites like for me or swift

22
00:03:02.160 --> 00:03:09.510
Anna Ho: But today, we can find routinely optical transients without relying on a GRB trigger that live in this part of phase space.

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00:03:09.840 --> 00:03:22.830
Anna Ho: And that's because we live in an era where every night, a whole suite of high cadence surveys are patrolling the sky looking for transients so the one that I've been particularly heavily involved with. Is this a key transient facility or is ETF

24
00:03:24.060 --> 00:03:28.740
Anna Ho: They thought I would give you a sort of window into the transit astronomer life.

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00:03:29.310 --> 00:03:39.420
Anna Ho: With an example of why it's sort of challenging to do astronomy in the top left part of face space here. So this is an example. This is an event that I discovered earlier this year.

26
00:03:39.930 --> 00:03:46.950
Anna Ho: This is a transient. It looked very much like an Africa to a GRB but it was not picked up by high energy satellites so walk you through the timeline.

27
00:03:47.370 --> 00:03:54.840
Anna Ho: In observer frame estimated time since explosion in the observer frame on the bottom and then in the rest frame on the top because this isn't a redshift of 2.9

28
00:03:56.040 --> 00:04:02.610
Anna Ho: We discovered this event with ETF at 19.5 mag. This was it. But it was quite read and that's what

29
00:04:03.300 --> 00:04:09.660
Anna Ho: tipped me off. So I immediately triggered of atomic tree and we show that this was feeding quite quickly.

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00:04:10.500 --> 00:04:18.690
Anna Ho: We triggered to on kecks I got a structure with elevators and that's how we measure the redshift of 2.9 I triggered swift and measured X rays.

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00:04:19.500 --> 00:04:27.390
Anna Ho: I got another epic photography with Gemini which show that this was a broken power law light curves and finally triggered the VLA and also got a radio detection.

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00:04:27.990 --> 00:04:37.380
Anna Ho: So this was all the data that we got for this object. It was all obtained in the first 10 days observer frame since the explosion. And that's why this kind of work is challenging.

33
00:04:37.860 --> 00:04:45.630
Anna Ho: But it's worthwhile because it teaches you about the extremes of how massive stars can end their lives. So we have this

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00:04:46.200 --> 00:04:57.930
Anna Ho: Traditional story where massive stars and their lives by developing an iron core they collapse and explode into core collapse supernova and leave behind a neutron star or a black hole.

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00:04:58.710 --> 00:05:06.570
Anna Ho: But today, and I think especially in the last few years, we think we've come to appreciate that this the real story is far more complicated.

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00:05:06.930 --> 00:05:19.470
Anna Ho: Than that. And there are two complications that I'm particularly interested in one of those is that some stars seem to launch relativistic jets when they collapse, you know, via some kind of contact object phenomenon.

37
00:05:19.980 --> 00:05:29.130
Anna Ho: And then the other is that some stars seem to undergo very intense mass loss of some kind of just in the final days, two weeks of their lives, which I like to call death omens

38
00:05:29.430 --> 00:05:37.800
Anna Ho: And then when the star explodes it collides with this dense material and produces a fast and luminous optical transient from circumstance or interaction.

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00:05:38.760 --> 00:05:45.360
Anna Ho: So the question is why this these phenomena are probably quite rare. But then the question is why do some stars do this while others don't.

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00:05:45.810 --> 00:05:56.100
Anna Ho: And in trying to answer that I think is interesting as we get to revisit some of the basics of stellar evolution. So the importance of factors like rotation multiplicity multiplicity and mass loss.

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00:05:56.400 --> 00:06:09.840
Anna Ho: As well as the basics of how stars explode in the first place. And then the physics of how jets are launched and propagate through matter. That's what I think is astrophysics interesting about this top left part of optical transients space.

42
00:06:11.310 --> 00:06:17.040
Anna Ho: When I first started working in this field, I was particularly focused on this phenomenon of relativistic jets.

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00:06:17.400 --> 00:06:24.060
Anna Ho: The canonical example of this is long duration gamma ray bursts, which we believe are associated with core collapse supernovae.

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00:06:24.570 --> 00:06:31.950
Anna Ho: And have all the GRB is close enough where we could actually spectroscopic we classify the supernova. It's always have the same type. So the spectrum.

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00:06:32.250 --> 00:06:44.400
Anna Ho: Is a one CBL so that means the one see means that there's no hydrogen, helium and then be L stands for broad lines, which means that are very broad absorption features which presumably come from high velocity in the rejected.

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00:06:45.480 --> 00:06:53.730
Anna Ho: That that I'd show an animation, just to bring everyone on to the same page. So this shows a GRB progenitor the course collapse into some contact object and launched a jet.

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00:06:54.150 --> 00:06:59.310
Anna Ho: Jet tunnels through the star breaks it up the surface and then escapes into interstellar space.

48
00:07:00.060 --> 00:07:07.260
Anna Ho: it collides with ambient gas and dust and this produces synchrotron radiation all across the electromagnetic spectrum.

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00:07:07.740 --> 00:07:17.220

Anna Ho: Which we call the afterglow and which we can observe with our optical telescopes and radio telescopes on the ground, and we believe out to, you know, large viewing angles away from the jet.

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00:07:18.510 --> 00:07:27.480
Anna Ho: But in order to see the prompt burst of gamma ray emission with a satellite like for me or Swift. We think that you have to be looking directly down the barrel of the jet.

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00:07:28.650 --> 00:07:38.550
Anna Ho: So that's the basic model of GR BS. But what I think is a little bit troubling is that the circumstances required to produce a GRB are quite contrived. So the jet has to get out of the star.

52
00:07:38.730 --> 00:07:51.180
Anna Ho: I would just collapsing in the jet has to accelerate materials ultra relativistic speeds. So it actually seems more natural to think that GR bees are just the extreme of a whole continuum of phenomena that extend all the way down to even ordinary supernovae.

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00:07:51.930 --> 00:08:03.150
Anna Ho: So there's, you know, perhaps there are dirty fireballs, these would be low Lorenz factor jets that might produce an afterglow but no GRB there might be chokes jets. The Jets choked either inside the star itself, or in some kind of surrounding CSM

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00:08:04.230 --> 00:08:10.740
Anna Ho: So I set out to look for some of these things. And the problem is you can't rely on a GRB satellite because they weren't necessarily produced your BS.

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00:08:10.980 --> 00:08:17.820
Anna Ho: So my approach was to search for fast and luminous optical transients and that's what brought me to this line of work.

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00:08:18.210 --> 00:08:27.660
Anna Ho: Along the way, I also became very interested in this phenomenon of stars exploding and dense CSM which presumably got there via some late stage mass loss.

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00:08:28.260 --> 00:08:34.500
Anna Ho: We have now with CTF been able to find these on triggered after blues to gamma ray bursts, which is very exciting.

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00:08:34.920 --> 00:08:42.120

Anna Ho: And then also I become interested in other phenomena and colo luminosity gamma ray bursts and trying to find them using optical surveys, as well.

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00:08:43.020 --> 00:08:58.710
Anna Ho: So I don't obviously I can't talk about all of this today. And so I thought I would do is just focus on this detour actually that I took, which is also related to relativistic explosions and then I'm happy to talk about any of these things later on slacker one on one, if you're interested.

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00:09:00.300 --> 00:09:12.840
Anna Ho: Okay, so the beginning of my detour, was on the 16th of june 2018 when the Atlas survey, which is another Wide Field optical transients survey reported this transient that just coincidentally got the name 2018 co w

61
00:09:13.470 --> 00:09:21.150
Anna Ho: Very nearby. It only 60 mega parsecs. And it was immediately interesting because it was one of the fastest rising was movement as transients ever discovered.

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00:09:21.420 --> 00:09:29.820
Anna Ho: And I was particularly interested because they were early reports of broad lines and x ray emission, which is kind of what you would expect from a relativistic explosion.

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00:09:30.960 --> 00:09:35.550
Anna Ho: So immediately trigger radio observations which is a basic expectation for these kinds of explosions.

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00:09:36.000 --> 00:09:42.720
Anna Ho: To put my observations into context. Here's a collage of radio light curves of various stellar explosions low frequency observation. So

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00:09:43.230 --> 00:09:52.410
Anna Ho: With with facilities like the VLA on the right hand side and then high frequency observations submillimeter wavelengths with facilities like the SME and Alma on the left hand side.

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00:09:53.340 --> 00:10:01.650
Anna Ho: And you can immediately see the left hand side as much emptier than the right hand side that's, you know, historically, it's been much less common to follow up solar explosions that millimeter wavelengths

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00:10:02.250 --> 00:10:07.350
Anna Ho: But he was very nearby and discovered early so this seemed like a good opportunity to try and

68
00:10:07.890 --> 00:10:16.020
Anna Ho: Sure enough, with some Millimeter Array, we found really quite an unprecedented millimeter light curve. So it was sort of double peaked at this very steep drop

69
00:10:16.530 --> 00:10:24.660
Anna Ho: We actually resolve the rise. We actually detected nearly a terahertz with bad night at Alma in a to sort of follow up DDT observation.

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00:10:25.350 --> 00:10:34.200
Anna Ho: This was really surprising. And then the next task was to try and interpret the strange emission that we observed and I'll talk about that.

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00:10:34.950 --> 00:10:42.240
Anna Ho: There's this classic diagram from radio supernova astronomy, where you plot on the X axis, the time of your observation types of frequency

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00:10:42.480 --> 00:10:50.130
Anna Ho: And on the y axis you plot the peak radio luminosity. And so I'm throwing on here a bunch of different stellar explosions and eating cow is just way up here.

73
00:10:50.640 --> 00:10:57.990
Anna Ho: From our alma observation. So observational II. The question is in what does it mean to be on the upper right hand side of this diagram.

74
00:10:58.590 --> 00:11:02.520
Anna Ho: You can draw lines of constant velocity. So the relativistic explosions are here.

75
00:11:03.480 --> 00:11:09.570
Anna Ho: At and cow the object to speed was point one. See, so actually nothing really spectacular. So that's not the answer.

76
00:11:10.200 --> 00:11:20.010
Anna Ho: You can draw lines of constant CSM density which correspond to a mass loss rate and so clearly that's part of the story. And I think

that's usually what people think of when they think of high frequency observations.

77
00:11:20.340 --> 00:11:23.520
Anna Ho: But that's not the whole story because you have to explain the y axis.

78
00:11:23.820 --> 00:11:35.550
Anna Ho: And so in our paper we show that the peak radio luminosity is directly proportional to the energy formalized by the shock divided by the shock radius. So the way to say, sort of, what is luminous millimeter and mission mean

79
00:11:35.940 --> 00:11:48.780
Anna Ho: Is that this is what you get when you have an energetic explosion and a dense medium and then millimeter observations are actually essential if you want to study the innermost CSM which corresponds to the most recent mass loss. History of the progenitor

80
00:11:49.950 --> 00:11:57.750
Anna Ho: So that was our conclusion. And I think what's promising for millimeter observatories is that 18 cow is probably not unique, and having these properties.

81
00:11:58.230 --> 00:12:00.180
Anna Ho: That I'm showing the low frequency light curve as well.

82
00:12:00.780 --> 00:12:07.770
Anna Ho: And it early times, you know, so he was doing strange things in late times that early times though, it looked actually kind of similar to other supernovae that we've seen.

83
00:12:08.100 --> 00:12:21.420
Anna Ho: And looking back at some of the data for these other events here, you know, to hints here. I think it's actually quite likely that a number of these were also bright millimeter transients at early times. It's just that nobody conducted those observations.

84
00:12:22.740 --> 00:12:27.510
Anna Ho: So I think, yeah, I think the future is bright for for millimeter time domain astronomy.

85
00:12:28.890 --> 00:12:39.960
Anna Ho: Okay, so that's the focus of my what what I wanted to focus on was my millimeter observations, but just to conclude, I want to go

through some of the other properties of this transit your many people have

86
00:12:40.320 --> 00:12:49.170
Anna Ho: Have worked on this. So just to speculate as to what it might be. So we observed very luminous variable x ray mission which i and then other groups.

87
00:12:49.710 --> 00:12:57.750
Anna Ho: Have attributed to some kind of newborn compact object. There was obviously the fastest luminous optical emission, which tells you something about the structure of the CSM

88
00:12:58.230 --> 00:13:05.610
Anna Ho: There was hydrogen and helium and a mission and the optical spectra, which you know so clearly to some presented or different distinct from from Dr. B's

89
00:13:06.210 --> 00:13:14.580
Anna Ho: There was all this fast forward shock, which I just talked about. We know that is must be somehow. And I said tropic. This is showing jets, but that's probably not the only possibility.

90
00:13:15.030 --> 00:13:23.640
Anna Ho: And then finally, the host galaxy was a dwarf galaxy, kind of like GRB. So that suggests that these progenitors have some something in common in terms of their, their pathways.

91
00:13:24.900 --> 00:13:30.540
Anna Ho: But since then, I think the consensus has become that these types of transients are rare. I worked very hard in CTF

92
00:13:30.870 --> 00:13:43.500
Anna Ho: And others have looked with other surveys, the rate is probably, you know, certainly less than a percent of the core collapse rate, maybe even closer 2.1% of the rate we have found two other of these events. So we found one in CTF

93
00:13:44.310 --> 00:13:53.400
Anna Ho: But so what I'm showing here as they were kind of filling things in the upper right hand side of the space. I want to, I also drew the second point here. This is a late time radio observation.

94
00:13:53.850 --> 00:14:04.710

Anna Ho: So if you only observed with radio telescopes when it's spreading the radio. You can see would look actually quite normal. And so this is just an example of why it's important to observe at high frequencies at early times

95
00:14:06.360 --> 00:14:14.520
Anna Ho: Okay, so I think all I'll have time to say about 18 cow, as I mentioned, I looked quite hard to find more of these and CTF

96
00:14:14.850 --> 00:14:25.650
Anna Ho: And a few months actually. After 18 cow. I found what I thought was going to be another 18 cow in the CTF high cadence survey, but which actually turned out to not be that it turned out to be a one. See broad line supernova.

97
00:14:26.070 --> 00:14:33.750
Anna Ho: So this just to remind you, is the special type of supernova associated with Dr views. So kind of by accident was brought back to what I was originally looking for

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00:14:34.350 --> 00:14:42.120
Anna Ho: This is the beautiful light curve from the CTF high cadence survey and I'll just highlight a few, few of the most important features.

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00:14:42.810 --> 00:14:52.620
Anna Ho: To resolve this amazing rise of over a magnitude per hour and the optical. It was very luminous and blue at peak, which is why I thought it might become another transient like a team cow.

100
00:14:52.920 --> 00:15:01.860
Anna Ho: We actually were able to detect this event. Prior to the explosion by stacking images, which I think is the first time that's been done at least for once the broad line supernova.

101
00:15:02.250 --> 00:15:08.280
Anna Ho: And after around eight days the spectrum. That's when the specs are really started to look like ordinary once the broad line supernovae.

102
00:15:09.510 --> 00:15:13.590
Anna Ho: So in my talk, I'll focus on interpreting this very strange light curve.

103
00:15:14.040 --> 00:15:26.340
Anna Ho: But I do want to mention that we have an enormous amount of data on this object which is enabled by the fact that we discovered it

basically right at the beginning when it was rising, including what I think is the earliest spectral sequence of any stepped on globe supernova.

104
00:15:28.140 --> 00:15:38.880
Anna Ho: Okay, how do we explain this light curve so ordinary once the broad line supernovae. These are a few from the literature we attribute their light curves to the radioactive decay of nickel 56

105
00:15:39.510 --> 00:15:45.780
Anna Ho: That mechanism really doesn't work for this one was rising way too quickly and too much too high a peak luminosity.

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00:15:46.350 --> 00:15:59.280
Anna Ho: And so what I want to suggest is that instead the mechanism powering the peak was shocked interaction with a dense shell of CSM that is confined so it does not, it just drops off abruptly and density, kind of at the edge.

107
00:16:00.000 --> 00:16:06.030
Anna Ho: So the structure of this, the of a star tend to the 10 centimeters or so. Put the shell at 10 to the 14 centimeters.

108
00:16:06.630 --> 00:16:22.050
Anna Ho: The star explodes with some objective velocity collides with the CSM and then you get this shock moving at V shock photons are able to escape when the optical density of the optical depth drops to see overview shock and so you get this. You can think of as a CSM breakout

109
00:16:23.250 --> 00:16:25.020
Anna Ho: Then the time scale of the transient

110
00:16:25.560 --> 00:16:36.090
Anna Ho: Is depends on the kind of width of this layer. So it's the width of the layer divided by the shop velocity and with these this kind of setup you can get a transient peaks in the optical UV on the time scale of a day.

111
00:16:36.660 --> 00:16:46.110
Anna Ho: And the peak luminosity of that transition is the energy deposited in this layer divided by the crossing time. As you can see that I think nicely explained the properties that we observed

112
00:16:46.830 --> 00:17:02.550

Anna Ho: So to test this in more detail. I worked with David Khatami and Dan case in at Berkeley to run a 1D a simulation and Castro. So the parameters that David put in, you know, once the broad line supernova energy so tend to the 52 earths, and then a shock velocity of point one seat.

113
00:17:03.720 --> 00:17:10.110
Anna Ho: This is the shell properties. And this is a showing the simulation results compared to our data.

114
00:17:10.560 --> 00:17:12.660
Anna Ho: The clock kind of shows the evolution of the Photo Sphere.

115
00:17:12.720 --> 00:17:17.220
Anna Ho: Radius and then the bottom panel shows the evolution of the effect of temperature up to

116
00:17:17.280 --> 00:17:18.510
Anna Ho: 50,000 Kelvin.

117
00:17:19.140 --> 00:17:25.590
Anna Ho: This is just the CSM interaction. And this is just adding in some once the broad lined data from the literature.

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00:17:26.310 --> 00:17:30.330
Anna Ho: So I think this picture nicely explains what we saw. I want to mention

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00:17:30.930 --> 00:17:38.490
Anna Ho: Something that initially got me kind of confused. So 18 GP has one analog of the literature. This is a one CBL at higher redshift.

120
00:17:38.910 --> 00:17:47.130
Anna Ho: And they also attributed this to some kind of CSM interaction. But when I compared our shell properties, I realized they were quite different. So I was getting something two orders of magnitude higher

121
00:17:47.430 --> 00:17:51.300
Anna Ho: And an order of magnitude smaller for the shell mass, despite the light curves being quite similar.

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00:17:51.840 --> 00:17:59.220
Anna Ho: And so the reason for this as a word of warning is that I'm assuming shop breakout they assumed that the shop breakout was over.

123
00:17:59.430 --> 00:18:10.410
Anna Ho: And at the optical admission was dominated by the post shot cooling emissions, you just have this hot expanding all of gas, basically. And there are relations in the literature that people commonly used to do this kind of modeling, but

124
00:18:10.860 --> 00:18:25.320
Anna Ho: You get quite different answers. And you can reconcile this if you make the same set of assumptions. But yet, so just warning if you're trying to use shell masses and radio from the literature is you have to see what exactly people were assuming power. The, the optical emission

125
00:18:26.760 --> 00:18:34.800
Anna Ho: Okay. So in summary, this event. I think we have a couple of lines of evidence that this was some kind of once the broad line with enhanced end of life mass loss.

126
00:18:35.100 --> 00:18:44.340
Anna Ho: There was the direct detection of some kind of pre explosion and mission and then indirectly, we saw the interaction of the director with this pre shared admission.

127
00:18:45.300 --> 00:18:50.850
Anna Ho: I think this is quite unexpected and strip stars as far as I know, there are some ideas for how this might come about.

128
00:18:51.540 --> 00:18:54.870
Anna Ho: But I think this is something, there's something I'm interested in in learning more about

129
00:18:55.260 --> 00:19:05.490
Anna Ho: I think it's particularly unexpected in these GRB types of supernovae. I think there have been some predictions that you might get mass loss from Rapid Rotation kind of along along the equator.

130
00:19:06.240 --> 00:19:08.460
Anna Ho: There's also made me interested about whether

131
00:19:08.970 --> 00:19:19.260
Anna Ho: A CSM like this, how this would actually affect the propagation of a jet. This is something I've worked with pulled up over here about I think there's some disagreement. It's been argued that a job would be completely choked.

132
00:19:19.740 --> 00:19:22.440
Anna Ho: But I think in our work, we found that that's actually not the case.

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00:19:23.970 --> 00:19:35.970
Anna Ho: And finally, I think in the future we'll be able to establish what fraction and type of stars exhibit this behavior, instead of two different ways, you know, the fast luminous transients are well suited to a shallow high cadence survey like CTF

134
00:19:36.240 --> 00:19:44.160
Anna Ho: And I think the study of this pre explosion of mission is basically perfect for a facility like like the Reuben Observatory. That's something I'm excited about now.

135
00:19:45.330 --> 00:19:59.400
Anna Ho: Okay, so I think that's all the time I have, I obviously to talk about everything that I've been thinking about in the last few years. So I thought I would just leave a list up here and that way you know what you can ask me about on Slack or individually later. So thank you.

136
00:20:02.430 --> 00:20:03.240
Morgan Elowe MacLeod: Thank you so much.

137
00:20:22.830 --> 00:20:37.560
Morgan Elowe MacLeod: Thank you very much for really beautiful talk and and yeah let's let's open for some questions on starting from the slack floor has a question about at a

138
00:20:40.920 --> 00:20:41.340
Morgan Elowe MacLeod: Cow.

139
00:20:42.240 --> 00:20:42.720
There we go.

140
00:20:43.860 --> 00:20:46.650
Morgan Elowe MacLeod: You all get really good at reeling off these numbers.

141
00:20:47.280 --> 00:20:54.030
Morgan Elowe MacLeod: And so looking at the millimeter versus longer wavelength slide. Yeah.

142

00:20:55.590 --> 00:21:01.980
Morgan Elowe MacLeod: Flores asking it looks like the 18 cow has a steeper decline.

143
00:21:02.160 --> 00:21:05.100
Morgan Elowe MacLeod: Yeah, and and could you tell us more about this.

144
00:21:05.430 --> 00:21:09.750
Anna Ho: Yeah, I don't think we really so when we first saw steep decline actually in the millimeter

145
00:21:10.020 --> 00:21:21.750
Anna Ho: And we attributed this to a drop off in the density of the CSM so the idea was that this you had 10 to the minus two solar masses of material confined to tend to the 16 centimeters or so.

146
00:21:21.960 --> 00:21:27.420
Anna Ho: So that explain the drop off, but then seeing this in the low frequencies. I don't think we really know there's

147
00:21:27.840 --> 00:21:36.030
Anna Ho: Because I can think of two explanations for why you would get something like this, you know, either you run out of stuff to interact with. So, it reflects the structure of the CSM

148
00:21:36.330 --> 00:21:45.960
Anna Ho: Or your energy input is actually dropping off. So maybe this engine, whatever it was ended or shut off somehow. But I think we're not sure

149
00:21:47.370 --> 00:21:48.900
Morgan Elowe MacLeod: Floor. Do you want to add to that at all.

150
00:21:54.870 --> 00:22:00.030
Morgan Elowe MacLeod: I guess I have another related question which comes from Paul duffel and that's

151
00:22:02.010 --> 00:22:21.720
Morgan Elowe MacLeod: So his direct I'll read his question, but could you get this from a jet CSM interaction. This being the second transit, you were talking about and kind of related Lee to what you were just saying, how do we, can we use the multi wavelength observations to disentangle like geometry vs.

152

00:22:23.460 --> 00:22:35.160
Morgan Elowe MacLeod: Vs energetics sort of like can you combine, for example, millimeter observations and the longer wavelength radio and even the optical and say something about

153
00:22:36.690 --> 00:22:44.340
Morgan Elowe MacLeod: Like whether it's a shell, for example, or a continuous distribution or if it's a conical outflow versus a spirit.

154
00:22:44.400 --> 00:22:45.120
Anna Ho: Yeah trick.

155
00:22:45.150 --> 00:22:47.550
Morgan Elowe MacLeod: Like what are the limits of what we can do.

156
00:22:47.880 --> 00:22:52.590
Anna Ho: Yeah. Um, so I guess the first question I think was whether there could have been a jet.

157
00:22:53.070 --> 00:23:10.200
Anna Ho: So we have no evidence for a jet. So the radio was not detection in the radio not detection, the millimeter non detection and the x ray and I follow this up with radio out quite late times in case there were some late rising but successful jet. So at this point, that seems unlikely.

158
00:23:11.340 --> 00:23:28.170
Anna Ho: I don't think we I'm reluctant to kind of invoke a jet unless one is actually needed. And so I think what we saw can be explained by the CSM interaction model. And so I'm reluctant to invoke some hidden choked jet of some kind. I guess the energy would be

159
00:23:28.470 --> 00:23:33.690
Anna Ho: The thing that sort of is hard to explain but that's the case for all the ones who brought line supernova. They're all

160
00:23:33.870 --> 00:23:41.040
Anna Ho: Tend to the 52 arrays and that's difficult to explain with just a simple neutrino powered explosion, but observational, I think we don't have evidence

161
00:23:41.640 --> 00:23:47.580
Anna Ho: For a jet, then I think the other question was how you can disentangle how to talk about the geometry. So,

162
00:23:47.970 --> 00:23:54.810
Anna Ho: This you know when people think of CSM interaction. I think they usually think of emission lines and optical spectra.

163
00:23:55.350 --> 00:24:01.230
Anna Ho: Radio mission x ray mission but we didn't have any of that. So the spectra should know emission lines at any point

164
00:24:01.560 --> 00:24:13.020
Anna Ho: We have spectrum throughout the evolution of this transient. But I think that is naturally explained. If it's just a shell where it's very confined and there's no kind of extended material going out to larger radio

165
00:24:13.620 --> 00:24:22.920
Anna Ho: Because then by the time you get to peek light, the ideas, the shock has swept up the shell. There's nothing more to sort of interact with and produce emission lines. And then after this. You're just sort of done

166
00:24:23.640 --> 00:24:28.440
Anna Ho: So I think from the lack of admission lines, we can actually say that the shell seems

167
00:24:29.520 --> 00:24:39.030
Anna Ho: That supports this shell confined idea whether it's to royal or sort of actual shell. I think we have no way to disentangle that at this point. Interesting.

168
00:24:39.060 --> 00:24:52.830
Morgan Elowe MacLeod: So Josh Grindley asks whether this could be an effects this GRB, in which case, one is seeing a structured jet that might appear as a soft x ray outburst. And maybe that relates to what you actually were just raising about

169
00:24:53.880 --> 00:25:05.820
Anna Ho: Constraints. Yeah, I guess we saw no yeah I you know from my work with Paul, it seems like this kind of CSM IF THERE WAS A JET. JET would have just gone sailing into it. Maybe it would have been decelerated but it would not have been stopped.

170
00:25:06.120 --> 00:25:17.940
Anna Ho: So I didn't look for an off axis jet and found none with our radio observations, even at quite late times. So it seems, at least not a jet like a classical GRB jet interesting

171
00:25:18.060 --> 00:25:25.740
Morgan Elowe MacLeod: And can I interrupt you there with my own question. Is it the case that the CSM density is high enough that it would be radio luminous kind of thing.

172
00:25:27.120 --> 00:25:36.510
Anna Ho: Oh, right. That's a good question. I guess so. Right. When I say that I didn't detect a jet. What I really mean, as I put some constraints on sort of what could the density have been and what what

173
00:25:36.810 --> 00:25:43.470
Anna Ho: Could what could the jet energy have been I don't I'll top my head. I don't remember what the CSM density is constrained to being

174
00:25:43.740 --> 00:25:53.400
Anna Ho: But I think for typical for sort of normal GRB properties we didn't see what one would expect. I see interesting and

175
00:25:53.550 --> 00:26:09.390
Morgan Elowe MacLeod: Avi low Basques whether a shell and it sounds like, really, that is kind of what's going on here is that could that be a result of a precursor ejecting a fraction of the envelope or what are we, do we have a sense of the physical origin of that.

176
00:26:09.510 --> 00:26:11.790
Anna Ho: Yeah. Yeah, so the so the two

177
00:26:13.440 --> 00:26:20.310
Anna Ho: Kind of contenders that I think are most promising for this. So, you know, there are, there's some

178
00:26:20.550 --> 00:26:28.260
Anna Ho: Ideas that in the very late cedars nuclear burning when the temperatures in the core get extremely high. You get these instabilities that are able to

179
00:26:28.530 --> 00:26:35.130
Anna Ho: Propagate to the surface and then you kind of shed. So for the for one CBL progenitor you're shutting a little carbon oxygen layer.

180
00:26:35.760 --> 00:26:43.800

Anna Ho: Out and that is what we observed. So in the spectra of the transient we saw carbon, oxygen and absorption. So that's presumably the composition of this layer.

181
00:26:44.370 --> 00:26:49.170
Anna Ho: So I guess that's the sort of wave driven mass loss as one possibility. And then I've also read

182
00:26:49.680 --> 00:27:00.780
Anna Ho: Ideas that also because of sort of the late stages of nuclear burning, you might get a rapid spin up of the progenitor and that might cause equatorial mass loss. And so perhaps that's

183
00:27:01.500 --> 00:27:08.190
Anna Ho: That's the way that this kind of material got there. So those are those are two possibilities that I'm aware of at least

184
00:27:09.750 --> 00:27:17.250
Morgan Elowe MacLeod: Can I ask a sort of follow up question and I'll be a few follow up questions or anyone if you have follow up questions, feel free to chime in.

185
00:27:20.160 --> 00:27:30.840
Morgan Elowe MacLeod: Say there's equity boreal mass loss, does that, in a sense, presumably, that's the same equator that a jet would go out through the poles of

186
00:27:31.080 --> 00:27:46.080
Morgan Elowe MacLeod: Right. Um, so does the fact that we're seeing the strong interaction really kind of point towards the spherical story that you're raising in the sense that, you know, a jet might escape through the polls, where there isn't much CSN

187
00:27:46.500 --> 00:27:46.860
And right

188
00:27:49.290 --> 00:27:49.770
Anna Ho: Um,

189
00:27:49.800 --> 00:27:51.420
Morgan Elowe MacLeod: Does that make sense or do I need to

190
00:27:52.740 --> 00:27:53.850
Morgan Elowe MacLeod: I know I wasn't very clear.

191
00:27:54.000 --> 00:27:58.320
Anna Ho: And no, no, that's fine. Sorry. Are you asking if the materials just along the equator.

192
00:27:58.500 --> 00:27:58.860
Morgan Elowe MacLeod: Yeah.

193
00:27:59.070 --> 00:28:01.050
Anna Ho: See the strong interaction will

194
00:28:01.080 --> 00:28:03.240
Morgan Elowe MacLeod: Say there were then a jet in the pole.

195
00:28:03.480 --> 00:28:08.160
Morgan Elowe MacLeod: Yeah, you might have a relatively evacuated pole, but a dense. Yeah.

196
00:28:08.220 --> 00:28:08.580
Anna Ho: Yeah.

197
00:28:08.610 --> 00:28:20.430
Morgan Elowe MacLeod: But the ROI Taurus and the fact that you do see the interaction and some of these cases, it ends up being an equatorial mass loss sort of way driven in a rotating star.

198
00:28:21.630 --> 00:28:27.900
Morgan Elowe MacLeod: Maybe that would point towards, towards the geometry being not that have a sort of polar jet.

199
00:28:28.290 --> 00:28:37.830
Anna Ho: Oh, I see. Also, I think maybe, maybe I wasn't clear. So I think that the mission that we saw was not anything to do with a jet. I think it was the spherical supernova explosion.

200
00:28:39.030 --> 00:28:41.220
Anna Ho: Supernovae ejecta hitting the shell.

201
00:28:42.060 --> 00:28:43.650
Morgan Elowe MacLeod: I see, I see. I see, I see.

202
00:28:43.800 --> 00:28:50.220

Anna Ho: So no jet right just by this thing i want CBL and I looked very hard for a jet. I don't think we basically

203
00:28:50.310 --> 00:28:50.910
Anna Ho: I'm not good.

204
00:28:51.120 --> 00:28:51.870
Morgan Elowe MacLeod: At all. Okay.

205
00:28:52.170 --> 00:28:53.520
Anna Ho: In the model for this object.

206
00:28:54.000 --> 00:28:55.830
Morgan Elowe MacLeod: Yeah. Interesting, interesting.

207
00:28:57.600 --> 00:29:02.730
Anna Ho: I will say my personal opinion on one CBS at this point is that not all of them have debts, so

208
00:29:04.200 --> 00:29:04.530
Anna Ho: Yeah, we

209
00:29:04.680 --> 00:29:15.000
loeb: Could I just followed up with Morgan was saying. And so if there was a binary companion clause in could that imitate the shell for you.

210
00:29:16.440 --> 00:29:21.750
Anna Ho: That's a good question. I don't that I do not have not looked into that. I don't know why.

211
00:29:24.090 --> 00:29:26.580
Anna Ho: I would have to, I don't know off the top of my head.

212
00:29:26.820 --> 00:29:32.010
loeb: Because, in principle, the collision of the ejector with a companion could lead to some kind of a shocking.

213
00:29:32.310 --> 00:29:36.630
Anna Ho: Yeah. And yeah, I just, I don't know how one would tell the difference.

214
00:29:38.670 --> 00:29:41.130

Anna Ho: Between those scenarios, I would have to think more about

215
00:29:45.150 --> 00:29:57.660
Morgan Elowe MacLeod: Let's close with one last question. I think taking us back to almost some of your final slides, thinking about you know what the constellation of facilities that we have available. And how do we make progresses.

216
00:29:58.830 --> 00:30:08.040
Morgan Elowe MacLeod: From from summer dimming do we expect to SST to contribute to finding more of these fast rise events or are they too fast to find their with the

217
00:30:09.480 --> 00:30:11.130
Morgan Elowe MacLeod: Reuben Observatory cadence.

218
00:30:11.280 --> 00:30:12.660
Morgan Elowe MacLeod: And you need to

219
00:30:12.930 --> 00:30:15.570
Morgan Elowe MacLeod: You know, use that only for the progenitors or something.

220
00:30:15.990 --> 00:30:23.940
Anna Ho: Yeah, I mean, yeah, so the nominal LS st cadence, the sort of what it spending most of its time doing is not well suited to this kind of thing at all.

221
00:30:25.050 --> 00:30:36.870
Anna Ho: Be I think Alice's t is trying to make plans for sort of smaller scale high cadence surveys. And I don't think that I don't think a final decision has been made about that. So I think the green, the sort of ideal.

222
00:30:37.560 --> 00:30:53.190
Anna Ho: Combination is you have a shallow survey kind of running alongside LS st were with your shallow high cadence survey you pick up all these past luminous things in the relatively nearby universe out to redshift point one or point two.

223
00:30:53.610 --> 00:31:00.540
Anna Ho: And then with LM s t you do the pre explosion studies and maybe even post explosion studies.

224

00:31:00.810 --> 00:31:06.630
demink: So thanks, thanks. And if I can, especially i guess i know it's pretty bad. So it was kind of a set of question.

225
00:31:08.520 --> 00:31:23.970
demink: But the interest of illiteracy is also for rare events, especially if you can find them for their way and this seems to be something exotic and the further way, we can see things we get a very interesting constraints and if there is some sort of evolution with time when

226
00:31:24.000 --> 00:31:24.600
Anna Ho: Right, but

227
00:31:24.750 --> 00:31:30.210
demink: At least the etc. So I'm hoping into direction, do you think that is hopeless with it because we can only do with nearby.

228
00:31:31.980 --> 00:31:36.060
Anna Ho: So I think that what would help. So something I've been thinking about

229
00:31:36.990 --> 00:31:47.310
Anna Ho: And trying to get involved with at Berkeley and LPL is whether you could avoid some of these cadence requirements by knowing the luminosity of the transient a priority.

230
00:31:47.670 --> 00:31:51.630
Anna Ho: So what's distinctive about these events is not just that they're fast, but also that they're

231
00:31:52.140 --> 00:32:02.220
Anna Ho: Quite more luminous than ordinary supernova. And so if one had a very extensive galaxy catalog catalog galaxy Redshirts you could select these perhaps without requiring the same

232
00:32:02.550 --> 00:32:08.910
Anna Ho: High cadence. And so then with something like Ellis team. Maybe you could increase your yield of these types of events.

233
00:32:10.170 --> 00:32:11.700
Anna Ho: I need to work out this election.

234
00:32:11.700 --> 00:32:13.710

demink: Effects later and understand what population.

235
00:32:13.830 --> 00:32:24.300
Anna Ho: Yes. Yeah. Yeah. And then there's the issue of you'd have to confirm what they are. If they're too high redshift. Maybe the radio mission wouldn't even be or hips are talking about thinking about eating cow what I was saying that but

236
00:32:24.900 --> 00:32:34.590
Anna Ho: If you wanted to get spectra logic and from this is a one CBL than at higher redshift that would, that could be extremely difficult. So there is the issue of spectroscopic confirmation as well.

237
00:32:35.580 --> 00:32:40.830
demink: And if I may, on the predictive analytics and then maybe depending on what the rate of these events are

238
00:32:41.160 --> 00:32:49.200
demink: There's also an interesting progenitor where you have a lead time merger of two stars that either already stripped or have gotten lost most of their events in previous interactions.

239
00:32:49.860 --> 00:32:56.070
demink: That could lead to injection at a time and merging. Not too long after the question is written material still around.

240
00:32:57.390 --> 00:33:05.820
demink: We haven't worked this out in great detail have discussed it in context of this, but with it in mandibles apart as we make estimates for such events and where they would occur.

241
00:33:06.150 --> 00:33:08.400
demink: Oh yeah, it gets maybe one I'll send you a reference

242
00:33:08.460 --> 00:33:11.100
demink: It specifically addressed to the system, but it's

243
00:33:12.180 --> 00:33:14.220
demink: Depending on the radio could be relevant or not.

244
00:33:14.670 --> 00:33:17.010
Anna Ho: Okay. Yeah, it'd be great to talk about that more later. Thank you.

245
00:33:18.360 --> 00:33:23.640
Morgan Elowe MacLeod: And I thank you so much for a really wonderful talk and

246
00:33:24.870 --> 00:33:35.370
Morgan Elowe MacLeod: Those of you who posted questions in the in the chat window I copied them into the slack. And so, and, for example, the link that you were just mentioning Selma, that's a great place for it.

247
00:33:35.910 --> 00:33:46.530
Morgan Elowe MacLeod: So we can continue to congregate there. And we're so grateful for your taking the time to to meet with us, despite the challenges of life these days. So thank you so much for giving me the chance to be here.

248
00:33:48.270 --> 00:33:49.740
Ana Bonaca: Thanks. Okay.

249
00:33:50.160 --> 00:33:52.500
Anna Ho: Talk to you all on to go. Yeah.

250
00:33:54.660 --> 00:34:02.010
Ana Bonaca: So yeah, it's I think it's far and I stock in respect to move on our next speaker. Today's excellent Bowman, who

251
00:34:03.150 --> 00:34:10.950
Ana Bonaca: Got his integrated master's degree in physics from University of Mumbai and then move to Carnegie Mellon.

252
00:34:11.610 --> 00:34:24.930
Ana Bonaca: For for PhD and this or physical oriented background really shows in some of the work is done at CMU where he applied group theory to flashlight and Ericsson morphology.

253
00:34:25.470 --> 00:34:36.000
Ana Bonaca: Of the topic of his you see thesis was actually measuring clustering in the early universities in the blue tides simulations.

254
00:34:37.080 --> 00:34:43.590
Ana Bonaca: He has since moved the University of Florida where he's working with a familiar person through the ITC Laura Flicka

255
00:34:44.700 --> 00:34:52.050

Ana Bonaca: And actually studying relations of supermassive black holes and illustrious which will hear about today. So take it away.

256
00:34:54.870 --> 00:34:55.020
Ana Bonaca: I

257
00:34:55.050 --> 00:34:56.820
Aklant Bhowmick: Thanks for the kind introduction.

258
00:34:57.360 --> 00:35:07.620
Aklant Bhowmick: And thank you so much for letting me be here and talk about my work. So I'll be presenting some results from a very recent four hours, which I did with Laura blocker and her students. Hello, Thomas

259
00:35:08.040 --> 00:35:16.020
Aklant Bhowmick: On the impact of environment on Supermassive black and fueling or he and activity in the illustrious THC. Can you guys see the slides. Okay.

260
00:35:17.250 --> 00:35:17.550
Aklant Bhowmick: Awesome.

261
00:35:18.660 --> 00:35:18.960
Aklant Bhowmick: Alright.

262
00:35:20.070 --> 00:35:27.870
Aklant Bhowmick: So the fundamental question that we try to ask with these kinds of works is, essentially, what are the key physics that drives agent activity in galaxies.

263
00:35:28.620 --> 00:35:34.020
Aklant Bhowmick: So for the physical process to drive Ag and activity. There are two key requirements that need to be satisfied.

264
00:35:34.380 --> 00:35:40.680
Aklant Bhowmick: First is that we need a steady supply of coal, gas, and then we need some mechanism for the gas to lose its angular momentum.

265
00:35:41.340 --> 00:35:45.270
Aklant Bhowmick: There are two broad categories of processes that can satisfy the requirements.

266
00:35:45.660 --> 00:35:55.020

Aklant Bhowmick: On one hand, one can have secular processes that can occur within the galaxies and these include stellar wins a gas accretion or hydrodynamic instability, such as the bar instability.

267
00:35:55.770 --> 00:36:09.720
Aklant Bhowmick: On the other hand, one can also have galaxies being subjected to external disturbances such as major mergers of interactions and that can also trigger potentially trigger Ag and activity and this is going to be the focus of this particular work and talk

268
00:36:10.860 --> 00:36:16.230
Aklant Bhowmick: So galaxy mergers or interacting systems are also very interesting because they are precursors to what would

269
00:36:16.530 --> 00:36:29.790
Aklant Bhowmick: eventually go on to form gravitationally bound that could wineries, which are going to be sources of gravitational wave detections in upcoming facilities such as Liza, and this offers very exciting prospect in the light of the upcoming of my time messenger astronomy.

270
00:36:31.350 --> 00:36:39.240
Aklant Bhowmick: So in terms of the role of galaxy mergers or interactions in driving agent activity. And so there are two key fundamental questions that need to be answered.

271
00:36:39.660 --> 00:36:46.500
Aklant Bhowmick: The first is whether a merger region connection exists in our universe. And second is, if it does exist. What is its relative importance.

272
00:36:46.770 --> 00:36:55.680
Aklant Bhowmick: Compared to secular processes and driving Ag and activity and whether there's a dependence on luminosity or redshift of the agents in terms of the answers to these questions.

273
00:36:56.700 --> 00:37:12.450
Aklant Bhowmick: So observation levy find actually that a vast majority of aging hosts do not show any signatures of recent emerges in their morphology and here are some examples of aging hosts, which have been analyzed in some recent works and even visually. You can see that these hosts.

274
00:37:12.660 --> 00:37:15.420
Aklant Bhowmick: Do not have any kind of external disturbances that would

275
00:37:15.600 --> 00:37:19.170
Aklant Bhowmick: Be typically characteristic of mergers or interactions.

276
00:37:20.640 --> 00:37:28.080
Aklant Bhowmick: On the other hand, galaxies that are indeed found to be merging or interacting. They do tend to have a higher fraction of aging host and he are

277
00:37:28.740 --> 00:37:35.580
Aklant Bhowmick: Isn't recent work which shows some images of such interacting systems. And here's the result from as an adult 2013

278
00:37:35.850 --> 00:37:45.540
Aklant Bhowmick: Where they essentially looked at the agent access defined as the ag inflection of merging of interacting systems, divided by the agent fraction of a master catalog of

279
00:37:46.320 --> 00:38:00.750
Aklant Bhowmick: Isolated galaxies or non merging galaxies as a function of the project of separation between the interacting galaxies. And what they found was that a decreased projected separations. This increased Ag and access would could which could be a potential signature of

280
00:38:00.780 --> 00:38:01.980
Merger alien connection.

281
00:38:03.150 --> 00:38:13.830
Aklant Bhowmick: So in terms of like what are the potential reasons for what are the these conflicting results that can possibly explain this conflicting results on the merger region connection and its importance in

282
00:38:14.340 --> 00:38:18.510
Aklant Bhowmick: Driving Aegean activity. So first, there could be like selection effects.

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00:38:18.930 --> 00:38:30.360
Aklant Bhowmick: For example, different observation groups use different selection criteria to select a GNC you could select agents in the x ray band or the mid infrared or the optical band and the point is that these different selection criteria could

284
00:38:31.470 --> 00:38:36.120
Aklant Bhowmick: prob galaxy merges at different stages which could lead to different results.

285
00:38:37.320 --> 00:38:43.950
Aklant Bhowmick: And then the second is that mergers can potentially trigger Quasar obscuration and this has been established.

286
00:38:44.640 --> 00:38:51.060
Aklant Bhowmick: In various works on simulations, as well as observations. And here's an example result from black hat and 2018

287
00:38:51.570 --> 00:38:57.300
Aklant Bhowmick: Where they looked at idealized simulations of galaxy mergers, which is shown here. And they essentially have

288
00:38:57.870 --> 00:39:09.060
Aklant Bhowmick: investigated the ag and luminosity and hydrogen column density as a function of time and around the time of merger, which is here, we find that the ag and luminosity peaks, but so does the hydrogen column density, which could

289
00:39:09.540 --> 00:39:23.070
Aklant Bhowmick: Potentially obscured equation. So, this essentially tells us that there is a significant portion of quasars, that could be triggered by galaxy mojo interactions, but they because obscuration they may not be available for detections in various bands.

290
00:39:24.540 --> 00:39:28.230
Aklant Bhowmick: So overall what we see, that is that is the

291
00:39:28.890 --> 00:39:37.230
Aklant Bhowmick: About the merger region connection. There's very mixed results from the observational side. So there's a body of work that serve as evidence against meridian connection and its importance.

292
00:39:37.590 --> 00:39:47.910
Aklant Bhowmick: And there's another body of work that serve as evidence for merger region connection. But this essentially tells us that this is a very active field. And it's a matter of considerable debate and but

293
00:39:48.780 --> 00:39:55.020
Aklant Bhowmick: There's a lot of progress going on, but not for the work needs to be done before we attain a much more complete picture.

294
00:39:56.130 --> 00:40:05.730

Aklant Bhowmick: So the question that we asked in this work is whether we see enhanced activity Aegean activity associated with galaxy mergers and cosmological hydrodynamic simulations.

295
00:40:06.120 --> 00:40:17.580
Aklant Bhowmick: And we essentially looked at the last E and G simulation, which a lot of people in this session are very closely involved with. And these are essentially a suit of simulations, which run all the way to redshift zero

296
00:40:18.000 --> 00:40:23.700
Aklant Bhowmick: Using the repo hydrodynamic code. The code has a wide area of physics, which include gravity.

297
00:40:24.120 --> 00:40:32.970
Aklant Bhowmick: Gas money to Hydra dynamics star formation Blackhole route and stellar and he and feedback here. I'm going to be focusing on results from the D amp D 100 box.

298
00:40:33.480 --> 00:40:37.530
Aklant Bhowmick: Which has a box size of about hundred meg apostates and about 10 billion particles.

299
00:40:37.830 --> 00:40:51.180
Aklant Bhowmick: And with such a combination of volume and resolution we are able to resolve, not just the overall large scale structure which has shown in terms of the dark matter density field over here, but also individual galaxies and black holes which are represented by these insert panels.

300
00:40:53.130 --> 00:41:03.150
Aklant Bhowmick: So in this world, we essentially exploit the fact that galaxy mergers would organically lead to formation of closed systems of black holes within various separation distances.

301
00:41:03.480 --> 00:41:09.420
Aklant Bhowmick: And we essentially identify these black hole systems in the simulation and analyze their agent activity.

302
00:41:10.170 --> 00:41:22.680
Aklant Bhowmick: So here's a schematic, which kind of demonstrates the our approach. So this black dots over here represent the spatial distribution of a very small example set of black holes that would be formed in the illustrious TNT box.

303

00:41:23.160 --> 00:41:31.980
Aklant Bhowmick: And what we do here is basically linked together these black holes using a maximum distance criterion. So, which is denoted by the max on the horizontal line over here.

304
00:41:32.520 --> 00:41:35.880
Aklant Bhowmick: So if you were to, for example, apply this criteria into this particular

305
00:41:36.510 --> 00:41:49.980
Aklant Bhowmick: Set of black holes, it would lead to the identification of this black hole triple system over here at the center, such that each member of the system is links to at least one of the member of the system within the separation distance the max.

306
00:41:51.060 --> 00:41:57.150
Aklant Bhowmick: So we apply this criterion and identify black holes in the 2100 bucks at various Richard snapshots.

307
00:41:58.050 --> 00:42:10.650
Aklant Bhowmick: And we prob different separation scales, which are meant to be proxies for different stages of galaxy. The Halo mergers. So here we considered separation scales of one mega 6.1 mega parsecs and point 01 mega parsecs.

308
00:42:10.890 --> 00:42:15.180
Aklant Bhowmick: So, for example, one mega plastic separation scales would correspond to typical distances.

309
00:42:15.600 --> 00:42:29.520
Aklant Bhowmick: Between black holes living in two different healers that have just merged or are close to merging. So this represents a very, very early stages of galaxy mergers, where the galaxies are still the wholesalers are merged, but they're still too far apart to be considered as interacting

310
00:42:30.600 --> 00:42:37.590
Aklant Bhowmick: And here's an example of such a system in the same age over here where the background panel shows a gas entity field were going from

311
00:42:37.950 --> 00:42:54.600
Aklant Bhowmick: Right, right, dark red too bright yellow implies increasing gas sensitivity and these green circles correspond to the positions of Black Codes which here we see it forms a trickle system

within one mega pack scales, but the host galaxies are still to fall apart to be interacting

312
00:42:55.950 --> 00:43:05.550
Aklant Bhowmick: And then we also consider scales of point one mega politics which corresponds to typical distances between black holes hosted by interacting galaxies. So here's another example.

313
00:43:05.910 --> 00:43:19.260
Aklant Bhowmick: Of a triple system where one of the black holes is hosted by a very massive central galaxy and the other two are hosted by satellite galaxies, and you can see that the central galaxies kind of tightly stripping the to satellite galaxies.

314
00:43:20.190 --> 00:43:31.620
Aklant Bhowmick: And lastly, we also consider separation. So point 01 mega politics which corresponds to typical distances between black holes hosted by merging galaxies. So galaxies have already emerged, but the black holes are in the process.

315
00:43:31.950 --> 00:43:36.180
Aklant Bhowmick: Of merging. So, but with the separation scale, I have to mention the caveat to that.

316
00:43:36.480 --> 00:43:42.450
Aklant Bhowmick: The sample is highly incomplete because a lot of vast majority of these systems because of the financial solution of the simulation.

317
00:43:42.750 --> 00:43:53.400
Aklant Bhowmick: And the black hole repositioning scheme applied within the simulation, they would promptly merge. So it's a very incomplete sample, but nevertheless it is worthwhile to look at the agent activity of these systems as well.

318
00:43:54.360 --> 00:44:01.590
Aklant Bhowmick: And the other thing I want to note is the separation scales are much, much larger than what would be associated with gravitationally bound

319
00:44:02.100 --> 00:44:09.900
Aklant Bhowmick: Blackwood binary. So again, due to the resolution limits of the simulation, we are unable to prove scales, much smaller than this directly from the simulation snapshots.

320

00:44:10.170 --> 00:44:25.110
Aklant Bhowmick: But on that note, I must also mentioned that there are various members of the group who work on pro specific models which trace take the systems and trace the late time evolution of the systems using these some analytic post processing models, all the way down to scale subpar sex.

321
00:44:27.090 --> 00:44:32.520
Aklant Bhowmick: OK, so now let's look at the overall statistics of these black hole systems and the D amp D 100 bucks.

322
00:44:32.790 --> 00:44:39.960
Aklant Bhowmick: So here we are essentially showing what we call the black hole multiplicity functions. So in the y axis we have the number of black hole systems.

323
00:44:40.320 --> 00:44:49.680
Aklant Bhowmick: Part of it as a function of the so called black hole multiplicity, where the multiplicity of one represents a black hole single to is a pair three is a by on to the triple and so on and so forth.

324
00:44:50.640 --> 00:44:59.520
Aklant Bhowmick: When we go from left to right panels. It represents decreasing separation scales from one mega parsecs 2.01 mega six and as you can see that

325
00:44:59.910 --> 00:45:12.870
Aklant Bhowmick: As we decrease the separation scale, the total abundance of these rich black hole systems of pairs triples and quadruples the decrease as what you would expect. And this leads to an overall steepening of these multiplicity functioning profiles, but

326
00:45:14.130 --> 00:45:22.080
Aklant Bhowmick: Decreased separation scales. Now if we did have the numbers at for example redshift zero shown by this blue curve over here this

327
00:45:22.740 --> 00:45:29.340
Aklant Bhowmick: At one mega plastic separations. You have about 3000 pairs 700 troubles and hundred quadruples

328
00:45:29.880 --> 00:45:39.870
Aklant Bhowmick: At point one mega pack six operations we have 600 pairs hundred triples and 20 quadruples and at point to one megapixel separation scales we have 60 pairs. But again, remember that these

329
00:45:40.500 --> 00:45:46.740
Aklant Bhowmick: The sample is highly incomplete because of the prompt mergers happening YouTube equity positioning and financial solution.

330
00:45:48.270 --> 00:45:57.780
Aklant Bhowmick: Okay, so now let's look at the agent activity of these black hole systems. Here we quantify the agent activity in various ways. So first we look at the so called Ag and fractions.

331
00:45:58.020 --> 00:46:05.580
Aklant Bhowmick: Which is the fraction of black hole systems at various multiple cities which have at least one activity and above a certain

332
00:46:05.940 --> 00:46:13.830
Aklant Bhowmick: Critical Eddington ratio. So here I'm presenting to you Eddington ratio is greater than point seven. And again, Potter is a functional multiplicity.

333
00:46:14.400 --> 00:46:17.400
Aklant Bhowmick: So if you look at the dashed lines and accompanied by the

334
00:46:18.030 --> 00:46:23.670
Aklant Bhowmick: green dots. These essentially represent the ag and fractions of randomly selected sets of black holes.

335
00:46:23.940 --> 00:46:31.410
Aklant Bhowmick: And that fact that that increases with the call multiplicity is a simple reflection of cognitively experiencing that if we select larger and larger.

336
00:46:31.650 --> 00:46:40.560
Aklant Bhowmick: Subsets of black holes than the probability of at least one black hole, even if you randomly selected at least one black hole will have a higher will be in it will increase.

337
00:46:41.730 --> 00:46:47.100
Aklant Bhowmick: It has little have increased probability to have at least one number at integration is greater than point seven

338
00:46:47.970 --> 00:47:02.130
Aklant Bhowmick: However, if you compare these rather trivial increase to that of the solid lines which corresponds to agent fractions of true true

Blackwood systems, we see that, particularly at scale. So point one and point 01 mega parsecs which

339
00:47:02.610 --> 00:47:16.290
Aklant Bhowmick: If you look at the ratio plots, which shows the agent fractions of to backup systems divided by that of the randomly selected sets. There's enhanced Adrian fractions for these local systems by up to factors of two to six at these separation scales.

340
00:47:17.340 --> 00:47:23.820
Aklant Bhowmick: However, if we look at the same effect at one mega six operations, we do not see any enhancements.

341
00:47:25.410 --> 00:47:34.980
Aklant Bhowmick: Conversely, we can also start with a sample of agents that high enough Eddington ratios and ask the question of what fraction of this sample of agents has

342
00:47:36.090 --> 00:47:44.730
Aklant Bhowmick: Are associated with companions within media separation scales. So here we plot this quantity in the y axis, which shows the fractional regions with at least one companion.

343
00:47:45.510 --> 00:47:48.150
Aklant Bhowmick: Product as a function of the Eddington ratio threshold.

344
00:47:48.480 --> 00:47:57.420
Aklant Bhowmick: And again, we are comparing the solid and the dashed lines where the solid lines are true Blackwood systems and the dashed lines are randomly selected sets of black holes in the ratio plot over here.

345
00:47:57.810 --> 00:48:15.720
Aklant Bhowmick: And again, we see that at scale of point 1.01 mega parsecs exclusively. If we look at the highest Eddington ratios, these, these agents have enhanced likelihood of being associated with companions by two factors or four compared to what you would expect from a simple random selection.

346
00:48:16.950 --> 00:48:23.100
Aklant Bhowmick: However, if, if we look at the overall fractions we we must also note that while there is enhancement, but

347
00:48:23.430 --> 00:48:35.520

Aklant Bhowmick: The overall fraction of agents that have companions that point one megapixel still 40% which means about 60% of them are still not associated with companion. So they are aging and activities likely driven by secular processes.

348
00:48:37.350 --> 00:48:45.750
Aklant Bhowmick: The same enhancements. If you try to look for them at one mega six operations, we do not see any enhancements that you can see here, similar to what we found for the Asian fractions.

349
00:48:47.700 --> 00:48:58.320
Aklant Bhowmick: From an observational perspective, it is also interesting to infer as to what fraction of what fraction of observable agents have companions. So these are so I'll start with

350
00:48:58.770 --> 00:49:02.790
Aklant Bhowmick: Showing some results at for local agents. So these are results at redshift zero

351
00:49:03.270 --> 00:49:18.330
Aklant Bhowmick: Snapshot. So here we are essentially plotting the fraction of agents with at least one companion. Again, but as a function of the flux threshold of the in the 14 to 195 kilo electron volts band. So essentially the Ultra hard x ray G and band.

352
00:49:19.470 --> 00:49:28.500
Aklant Bhowmick: And the blue and the orange lines correspond to the point one mega plastic and point 01 mega six operations, respectively, where we did see eg and enhancements.

353
00:49:29.040 --> 00:49:43.890
Aklant Bhowmick: And if we infer the results at the swift be at flux limit we find that about 20% of 50 agents have companions within point one mega politics and about 2% of this 50 agents of components within point 01 mega parsecs.

354
00:49:45.150 --> 00:49:48.060
Aklant Bhowmick: And if we move to higher chips or there's the

355
00:49:49.260 --> 00:50:03.780
Aklant Bhowmick: And so the agents that to faint to be detected within the survey at survey, but in the heart x ray ban are some surveys, where which can potentially detect AG. And so here, our results are the same quantity but plot of now as a function of the flux threshold of

356

00:50:06.120 --> 00:50:07.860
Aklant Bhowmick: Which is for the heart x ray band.

357
00:50:08.190 --> 00:50:14.760
Aklant Bhowmick: And these vertical lines show the various flux limits of the various surveys and the heart X Ray Bans so the extent that Chandra X.

358
00:50:14.820 --> 00:50:24.780
Aklant Bhowmick: Deep Field, the channel, the feel and the stripe ready to sex and if we infer the results numbers for the stripe stripe. We did. We sex survey which is the widest of all the surveys

359
00:50:25.620 --> 00:50:35.820
Aklant Bhowmick: We have about 30% of the stripy to agents that have companions than point one mega prospects and less than 1% of these agents have companions within point 016

360
00:50:37.980 --> 00:50:47.670
Aklant Bhowmick: Okay. So, lastly, I would also like to quantify the impact of these merger driven enhancements on the overall Eddington ratios. So here are we showing the

361
00:50:48.180 --> 00:50:59.850
Aklant Bhowmick: Median Eddington ratios as a function of the redshift were for black hole singles shown by the black lines black hole binary shown by the moon lines and the black hole triples shown by the

362
00:51:00.450 --> 00:51:09.780
Aklant Bhowmick: Purple lines. And again, if we focus on the comparison in the solid and dashed lines, which is to Blackboard systems and and and sets of black holes, respectively.

363
00:51:10.440 --> 00:51:23.640
Aklant Bhowmick: We see that the median adding to ratios for the true black hole systems are enhanced by two factors of two to three at scale. So point one and point. You don't want to make our sex, but there's no such enhancements at scale. So one mega sex.

364
00:51:25.020 --> 00:51:37.440
Aklant Bhowmick: And then additionally, we also find that these enhancements are more prevalent at higher redshift compared to lower it shifts and this is naturally occurring because there's higher availability of gas to fuel. These mergers that higher ed shifts

365

00:51:39.270 --> 00:51:51.570
Aklant Bhowmick: So overall, to summarize my talk, we investigated the agent activity or Blackboard systems and 2100 and we found enhanced Adrian activity which manifests in the form of

366
00:51:52.260 --> 00:52:00.840
Aklant Bhowmick: Enhanced Adrian fractions by a factor of three to six for these very high Arrington ratio agents at scales of point one and point 01 mega parsecs.

367
00:52:01.200 --> 00:52:05.670
Aklant Bhowmick: Conversely, if we also start with a sample of agents and look at what fraction of them have

368
00:52:06.240 --> 00:52:18.480
Aklant Bhowmick: Companions within point one and point 01 mega 650 enhancements in that likelihood by a factor of four. And then, given the fact that no such enhancements are found at scale soft one mega per sec

369
00:52:19.170 --> 00:52:32.280
Aklant Bhowmick: This tense that these enhancements unlikely driven by mergers galaxy mergers or interactions. However, we also find that despite these enhancements only about 40% of agents actually have companions had point one.

370
00:52:33.360 --> 00:52:39.870
Aklant Bhowmick: Make a pass sex and even less so 4.1 mega parsecs. And this tells us that the vast majority of these agents are still

371
00:52:40.470 --> 00:52:47.520
Aklant Bhowmick: Driven by like the they don't have companions, and they are likely driven by a secular processes. And then we also find that these overall

372
00:52:48.240 --> 00:53:01.380
Aklant Bhowmick: Enhancements and Eddington ratios in these local systems are at best of two factors of two to three and this finally tells us that while merger region connection definitely exists in the system. Angie simulations.

373
00:53:02.190 --> 00:53:12.240
Aklant Bhowmick: The player relatively minor role in driving overall Ag and activity and Blackwell growth as compared to secular processes. And with that, I conclude my talk. Thank you again for the invitation.

374

00:53:12.840 --> 00:53:16.860
Aklant Bhowmick: In addition to these works. I also work on. I'm currently working on black hole seeds.

375
00:53:17.760 --> 00:53:29.010
Aklant Bhowmick: I implementing Blackwood seed models realistic luck. We'll see models in cosmological hydrodynamic simulations on currently running simulations to investigate that. So if anyone is interested and would like to discuss more on that topic. In addition to

376
00:53:29.670 --> 00:53:33.930
Aklant Bhowmick: This particular one, feel free to ask any questions. Thank you so much.

377
00:53:45.960 --> 00:54:02.850
Morgan Elowe MacLeod: Thank you for really wonderful talk. So I want to open with two questions from Martin Elvis, who asks, have you considered or tried the new star 8024 k, the band because there would be less obscuration there.

378
00:54:03.480 --> 00:54:07.020
Aklant Bhowmick: Okay, so I haven't tried that. But one reason why I

379
00:54:07.020 --> 00:54:09.000
Morgan Elowe MacLeod: Thought to 24 sorry

380
00:54:10.410 --> 00:54:17.820
Aklant Bhowmick: Eight to 24 no idea, particularly, look at that. Yet I wasn't aware of that as well. But one reason why we one

381
00:54:18.630 --> 00:54:25.560
Aklant Bhowmick: Reason why we looked at the ultra high extra bandwidth that was least protocol obscuration and that's also where we looked at

382
00:54:25.950 --> 00:54:32.430
Aklant Bhowmick: compared our results with observations from Costa del 2012 and they were numbers were consistent

383
00:54:32.880 --> 00:54:42.960
Aklant Bhowmick: But of course for the hard x ray ban the significant leave much more prone to obscuration so we could not but yeah that's a very interesting point, we should look at that the new band that you consider interesting

384

00:54:43.440 --> 00:54:45.300
Morgan Elowe MacLeod: And second, in

385
00:54:46.800 --> 00:55:04.170
Morgan Elowe MacLeod: Number in number medalists at like in that relationship there seemed to be no evolution for redshift less than 1.5 and this seem surprising as there are a lot of age, and there's a lot of Ag and evolution from redshift zero to

386
00:55:04.170 --> 00:55:08.730
Morgan Elowe MacLeod: 1.50 and maybe mergers aren't responsible

387
00:55:11.220 --> 00:55:12.120
Aklant Bhowmick: So,

388
00:55:13.380 --> 00:55:16.200
Aklant Bhowmick: So you mean the overall abundance of black hole systems here.

389
00:55:17.820 --> 00:55:20.070
Morgan Elowe MacLeod: And Martin. If you'd like to unmute yourself and

390
00:55:20.070 --> 00:55:21.120
Morgan Elowe MacLeod: chime in. Yes.

391
00:55:22.080 --> 00:55:23.640
Aklant Bhowmick: Okay, awesome. So

392
00:55:23.850 --> 00:55:28.830
Martin Elvis: The color red, blue, red and green are all on top of each other. So there's no change.

393
00:55:29.790 --> 00:55:38.820
Aklant Bhowmick: Yes. I mean, they decrease, but not to such an extent between redshift zero to 1.5 but if you look at the overall Ag and activity.

394
00:55:39.600 --> 00:55:50.940
Aklant Bhowmick: They are so if you were to make the same plot for the abundance of agents, then at various flux limits, then we would see an evolution. So the agent activated significantly decreases between

395
00:55:51.210 --> 00:55:56.550

Martin Elvis: The left suggests that the connection with the multiplicity is not that strong right

396
00:55:57.690 --> 00:56:11.100
Aklant Bhowmick: A that simply is a consequence of the overall decrease in the gene activity but but it merges can still be triggered, but because of the ability to have less gas. What will left an extent compared to

397
00:56:12.210 --> 00:56:15.570
Aklant Bhowmick: Redshift higher chips, where you have more. Yes.

398
00:56:18.690 --> 00:56:35.490
Morgan Elowe MacLeod: Interesting from below. What is the fraction of pairs that produce a gravitational waves signal that's detectable by Lisa which show AGM activity in tertiary or higher order multiple companion so

399
00:56:36.510 --> 00:56:41.100
Morgan Elowe MacLeod: Pairs that producer gravitational wave signal which has a GN activity in a third

400
00:56:41.700 --> 00:56:51.780
Aklant Bhowmick: Yeah. That is an interesting question. I haven't looked at that yet. So they are post processing models that student of Laura blacker Muhammad's is working on which does predict

401
00:56:53.520 --> 00:57:01.200
Aklant Bhowmick: make predictions for gravitation to make detections for these kinds of sources. And yeah, I mean, I think that's really interesting Avenue, where we can actually collaborate

402
00:57:01.350 --> 00:57:01.920
Morgan Elowe MacLeod: Together and

403
00:57:02.220 --> 00:57:04.950
Aklant Bhowmick: Figured out. I can look at the agent activity and

404
00:57:05.040 --> 00:57:06.510
Aklant Bhowmick: You can look at the gravitational wave but

405
00:57:06.930 --> 00:57:13.560
Aklant Bhowmick: At this point, I haven't looked at that, because we have to look at. We have to apply these models to smaller scale and prefer evolution to smaller scales.

406
00:57:16.290 --> 00:57:18.930
Morgan Elowe MacLeod: So I was wondering along those lines.

407
00:57:19.950 --> 00:57:21.900
Morgan Elowe MacLeod: Obviously there is

408
00:57:23.310 --> 00:57:28.470
Morgan Elowe MacLeod: A resolution limit to any simulation, but can we say something about

409
00:57:30.120 --> 00:57:47.040
Morgan Elowe MacLeod: Could one apply essentially a sub grid model of the in spiral and perhaps merger by basically asking if there is a single black hole, which was multiple but merged at time X in the past in the simulation.

410
00:57:47.340 --> 00:57:58.290
Morgan Elowe MacLeod: So in a sense, like, can we get some information about what may be a sub grid pair by asking about singles that are previous mergers.

411
00:57:59.250 --> 00:58:05.700
Aklant Bhowmick: So you mean that we start with a sample of in what in the simulation because of outmoded repeating a single, single black holes but

412
00:58:05.910 --> 00:58:15.300
Aklant Bhowmick: Yes, but actually the actually they are like if you were to have an infinite presentation simulation, for instance, they would be merging lot and

413
00:58:15.780 --> 00:58:16.140
Aklant Bhowmick: I mean,

414
00:58:16.170 --> 00:58:24.030
Aklant Bhowmick: It's somewhere along those lines that these pros processing model that's I eat at 2020 years trying to apply. So they're basically taking

415
00:58:24.030 --> 00:58:24.750
Morgan Elowe MacLeod: These accolades.

416

00:58:25.410 --> 00:58:37.860
Aklant Bhowmick: And trying to trace. So one, one thing that they do is incorporate the LA Times in the modules. So one one aspect of the model. And yeah, it's definitely possible to do that and and yeah I

417
00:58:37.890 --> 00:58:43.020
Aklant Bhowmick: Mean we can move forward that discussion would say even look at that avenue for sure.

418
00:58:44.610 --> 00:58:49.230
Morgan Elowe MacLeod: Great. And we have time for one last question here in China asks

419
00:58:50.250 --> 00:58:51.450
Morgan Elowe MacLeod: What kind of

420
00:58:52.950 --> 00:59:00.000
Morgan Elowe MacLeod: Black Hole feeding model, are you considering to implement in the cosmological simulation and then

421
00:59:00.300 --> 00:59:01.470
Morgan Elowe MacLeod: Assuming a rapper.

422
00:59:01.830 --> 00:59:02.610
Morgan Elowe MacLeod: Will you

423
00:59:02.670 --> 00:59:05.160
Morgan Elowe MacLeod: Will be abandoning the Bondi Hoyle model.

424
00:59:05.250 --> 00:59:06.480
Morgan Elowe MacLeod: Or what's your plan.

425
00:59:06.660 --> 00:59:17.010
Aklant Bhowmick: So currently we are running a whole bunch of tests just to determine that. So we initially started off with a very simple model where we replace the FBS seating where you just see

426
00:59:18.240 --> 00:59:19.980
Aklant Bhowmick: In fo groups at

427
00:59:21.150 --> 00:59:24.390
Aklant Bhowmick: above a certain mass we have replaced that by

428
00:59:25.410 --> 00:59:40.620
Aklant Bhowmick: Sitting at FOS where the densest gas sell his house just becomes our farming, but the multiplicity of that specific style is less than a specific value. So we have considered various central PA negative four times negative five and you run some initial tests and

429
00:59:41.670 --> 00:59:55.320
Aklant Bhowmick: And then we're also considering various other models, for example, like the star forming gas mass of that specific Halo is greater than a certain factor times the seed mass, for instance, or the multiplicity of that stuff. Having the access

430
00:59:56.010 --> 01:00:10.860
Aklant Bhowmick: Less than a certain value. So we are trying to do various possible tests to investigate that and see whether the key problem here is that different. We have we achieved in some sense of resolution convergence, because what we are really trying to do is

431
01:00:12.270 --> 01:00:18.600
Aklant Bhowmick: Try to because we cannot resolve the seats at these limited visitation simulations we have trying to

432
01:00:19.770 --> 01:00:20.460
Aklant Bhowmick: Infer

433
01:00:21.990 --> 01:00:27.510
Aklant Bhowmick: We're trying to seed these simulations, with the resolution of the simulation, which is limited.

434
01:00:27.810 --> 01:00:38.160
Aklant Bhowmick: And we are trying to infer the evolution from by running higher resolution zoom simulations as to what would happen if the seed, which would have otherwise been seeded lot earlier. Try to involve

435
01:00:38.520 --> 01:00:54.330
Aklant Bhowmick: Would have evolved to a much larger mass. And we would have me then, we can see that larger black hole Muslim to a lower resolution simulation. And that's a very tricky problem because there's so many different environmental factors that affect these and evolution of the seeds like

436
01:00:55.410 --> 01:01:06.780
Aklant Bhowmick: Hey, Tomas metal cities that affirmation is reason all of that. So you die like no be undergoing a lot of tests and we have

absolutely narrowed down on which industrial model, we want to use, but we are doing that.

437
01:01:09.000 --> 01:01:10.080
It's really interesting.

438
01:01:11.130 --> 01:01:25.080
Morgan Elowe MacLeod: Um, well, I think we are at our time. So let me thank both of you. Excellent. And, and, and for really wonderful talks today and we all want to express our gratitude for your joining us

439
01:01:26.100 --> 01:01:26.850
Morgan Elowe MacLeod: And

440
01:01:28.140 --> 01:01:31.560
Morgan Elowe MacLeod: And and convening in this virtual space. So thank you all.

441
01:01:33.270 --> 01:01:35.280
Ana Bonaca: And thank you for tuning in.

442
01:01:37.110 --> 01:01:43.650
Ana Bonaca: It's really nice to actually see the the handles are more than 60 people from from the CFA and IDC

443
01:01:43.950 --> 01:01:44.670
Exactly.

444
01:01:46.290 --> 01:01:48.870
Morgan Elowe MacLeod: Wonderful. Well, we'll see you all soon. Bye bye.

445
01:01:49.020 --> 01:01:49.320
Aklant Bhowmick: Thank you.

446
01:01:49.410 --> 01:01:50.910
Ana Bonaca: Thanks doing fine.