

WEBVTT

1

00:00:03.090 --> 00:00:13.769

Ana Bonaca: So Hello everyone, welcome to the IDC colloquium this week, we have a pleasure of welcoming a shower, who is a humble fellow at ut Austin.

2

00:00:14.549 --> 00:00:30.930

Ana Bonaca: Before that, and I got a bachelor's degree in physics and master's degree in astrophysics at the elites Maximilian your recipe and Munich and, at the time she studied merger is the signatures of mergers and elliptical galaxies and fine if you can actually.

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00:00:32.130 --> 00:00:43.050

Ana Bonaca: see them in the are at the signatures remain the velocities version of stars cover when she moved for her PhD incredible break she also switch that topic and then started.

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00:00:43.950 --> 00:00:50.550

Ana Bonaca: simulating physical conditions in the very early universe, and like the formation of the very first galaxies.

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00:00:50.940 --> 00:01:03.420

Ana Bonaca: And what she moved to as a hubble fellow through ut Austin she kind of continued along this line of research, but are you focusing on what these conditions mean and how they affect the formation of the very first stars.

6

00:01:04.050 --> 00:01:18.060

Ana Bonaca: In the universe so we'll hear about both very theoretical work and also some very interesting for guessing by that I suffered serious to hear about, because who wouldn't want a telescope on them so.

7

00:01:18.090 --> 00:01:18.570

Ana Bonaca: You should.

8

00:01:19.140 --> 00:01:20.310

Ana Bonaca: All make a case for that.

9

00:01:21.360 --> 00:01:23.700

Ana Bonaca: So please take it away.

10

00:01:24.300 --> 00:01:30.690

Anna Schauer: Thank you so much it's a pleasure to speak virtually in Boston thanks a lot for having me so.

11

00:01:31.200 --> 00:01:44.940

Anna Schauer: As I said, I will talk today about the formation regions of the first stars, and for that I would like to start with giving this time evolution of the universe overview, so we have the big bang on the left and we have.

12

00:01:45.960 --> 00:01:54.630

Anna Schauer: Our present day universe, and the right and after the cosmic microwave background emerged everything was more in this dark and.

13

00:01:55.200 --> 00:02:05.580

Anna Schauer: Not Ionized in the universe, and then was really the first stars that formed roughly between redshift and 30 and 10 that started to light up this universe.

14

00:02:06.030 --> 00:02:18.330

Anna Schauer: When we now look for observational traces we can prob some very only galaxies with our current instruments to record the galaxy is at the moment at redshift 11 and the record holder.

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00:02:19.200 --> 00:02:30.330

Anna Schauer: supermassive black holes at redshift seven and we hope to push this a little bit further out to ratchet 1415 with James webb but those.

16

00:02:30.870 --> 00:02:36.060

Anna Schauer: galaxies that we will be observed, will be biased towards the very massive and.

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00:02:36.720 --> 00:02:50.400

Anna Schauer: So, in order to really understand how does individual staff emission regions, how does very first galaxies source so called mini halos work and rely on an American simulations or semi analytic models.

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00:02:50.850 --> 00:03:03.270

Anna Schauer: And this is what I studied most of my time so I have this nice set of cosmological simulations you can see here a density slice through my entire simulation box it's.

19

00:03:03.630 --> 00:03:13.680

Anna Schauer: One cool moving megapixel cubed and size and the nice thing about those simulations is twofold one is that we have a primordial chemistry included.

20

00:03:14.250 --> 00:03:25.260

Anna Schauer: So I will talk about it in a second but it's important to treat the formation of molecular hydrogen corrective and you talk about the universe, because that's your main coolant at high redshift.

21

00:03:25.740 --> 00:03:37.620

Anna Schauer: And the other nice thing is that we have a high resolution, and you have this high resolution uniform you throughout our whole simulation box, so we don't only assume into a few objects, but we can treat all those.

22

00:03:38.820 --> 00:03:52.800

Anna Schauer: tiny galaxies that are forming with the same high resolution and our resolution is roughly 100 solar masses and back Meta and 20 solar masses in gas and because we don't form stuff directly in the simulations and don't have any.

23

00:03:54.000 --> 00:04:11.790

Anna Schauer: supernova explosion metal enrichment and we count randall simulations for very long, long and we stopped our simulations at the redshift of 14 or 14 and a half, in some cases, so the redshift range recovers from 200 down to 1415.

24

00:04:13.170 --> 00:04:18.810

Anna Schauer: So, as I said, those very first galaxies are so called mini halos form.

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00:04:19.980 --> 00:04:32.280

Anna Schauer: massively in the simulation and i'm zooming in here into one of those regions, and you can see that those form at the intersection of those filaments that we start to see.

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00:04:33.420 --> 00:04:43.710

Anna Schauer: And let's talk a little bit more about this, so the physical properties of those mini halos you can see here is more density slice of a small region of my simulation.

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00:04:44.940 --> 00:04:50.910

Anna Schauer: We have a very elementary structure that the gases mostly following the black metal.

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00:04:51.990 --> 00:05:01.950

Anna Schauer: It sits in those filaments and, of course, our stars form out of the most dense gas that's in the Center so that's indicated by the dark green here, and this plot.

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00:05:02.400 --> 00:05:12.540

Anna Schauer: And the mass of those extended objects of those mini halos is in the mass range of a few tend to the five to 10 to seven solar masses.

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00:05:13.170 --> 00:05:30.690

Anna Schauer: When we look at the temperature of exactly the same part of the simulation he can see that the temperature is relatively low and those low density regions, just because the universe expanded, and we have a diabatic cooling, so to say, and then whenever we have a high density region.

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00:05:31.890 --> 00:05:36.630

Anna Schauer: We have shock heating, so the shocks heat up the gas to temperatures of.

32

00:05:37.890 --> 00:05:47.790

Anna Schauer: yeah depends on the mass of the object, but a few thousand to 10,000 Kelvin However, at the very Center where the gas was very dense.

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00:05:48.450 --> 00:05:57.630

Anna Schauer: We can do the comparison so here you have like a little bit of a lower temperature region here you have a bit of a lower temperature recharge here, and that is.

34

00:05:58.770 --> 00:06:10.530

Anna Schauer: At the same position as our higher density gas, and if you look at another property of the molecule hydrogen is exactly where we find our molecular hydrogen, so it does is just a conceptual view.

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00:06:11.040 --> 00:06:18.810

Anna Schauer: That shows that molecular hydrogen really drives the cooling in those high density regions because we don't have any metals.

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00:06:19.860 --> 00:06:31.920

Anna Schauer: At atomic hydrogen can only get you to 1000 Kelvin so with molecular hydrogen, you can cool to those lower temperatures effort to drive to lower mass down and therefore you can start to form stars.

37

00:06:33.630 --> 00:06:50.400

Anna Schauer: However, information it's not just hydrogen hydrogen needs to go via and formation channel I don't have a χ minus Plus, so this is why it's important to include a full network of a primordial chemistry and awesome illusions simulations and luckily, we can do that.

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00:06:52.170 --> 00:06:58.740

Anna Schauer: So now let's make the picture, a little bit more complicated, apart from just hydrogen of molecular hydrogen.

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00:06:59.940 --> 00:07:10.350

Anna Schauer: When we look at a very early universe there's one effect that really matters and that's the so quite streaming velocities so again here, I have my time evolution slide and then.

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00:07:10.950 --> 00:07:22.200

Anna Schauer: going to before recombination we had this tight coupling of gas for photons, and this is what the streaming velocity is ultimately origin from.

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00:07:22.650 --> 00:07:41.310

Anna Schauer: So on the right, I have a very conceptual view only after gas and back Meta structure, so we see that we have a little bit of an over density in the dark matter in the Center of my conceptual view that matters indicated by those dark.

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00:07:42.870 --> 00:07:54.210

Anna Schauer: Big blocks here and then what happens, instead of that mccullough implications can increase, so the dark matter is falling towards gravitational Center ever.

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00:07:55.320 --> 00:08:05.640

Anna Schauer: Because of this tight coupling the gas can be pushed out what's in some regions of the universe, so when we look at this, we have here and over density.

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00:08:07.140 --> 00:08:15.000

Anna Schauer: The gas CAP coupled to the photons we have too much pressure so actually what happens is that the gas is pushed out words from this.

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00:08:16.200 --> 00:08:17.550

Anna Schauer: From this over density.

46

00:08:18.750 --> 00:08:26.100

Anna Schauer: And then, when we look at us and some regions of the universe, we then have exactly the opposite velocity of the gas at the dark matter.

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00:08:27.540 --> 00:08:32.850

Anna Schauer: Whereas in other regions of the universe, we are moving with a similar velocity.

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00:08:34.410 --> 00:08:53.310

Anna Schauer: So does it basically periodic acoustic oscillations and when we now look at this does have an effect that happens on very, very large scales of the universe so here I show you a conceptual plot with a side length of 400 comoving megaparsecs.

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00:08:54.960 --> 00:09:08.130

Anna Schauer: We have this velocity difference imprinted in the universe and it's a very large scale effect, this means that we have some single boxes that have roughly the same.

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00:09:09.090 --> 00:09:22.500

Anna Schauer: offset velocity and we can run simulations of roughly the same offset velocity just by taking small boxes and just simulating one region of the universe that has no relative velocity between.

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00:09:22.980 --> 00:09:31.770

Anna Schauer: Gas and that matter, and we can run another simulation as a That was a fraction of the universe that has a high offset velocity.

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00:09:32.760 --> 00:09:41.700

Anna Schauer: And those velocities are distributed like like a multiverse gaussian and another important thing is how big are those so.

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00:09:42.240 --> 00:09:50.910

Anna Schauer: The recruitment square velocity of that is 30 kilometers per second at recombination and as the universe expands.

54

00:09:51.270 --> 00:09:58.110

Anna Schauer: This velocity the case so does this also seeing why it is important to tie redshift because there's velocities of.

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00:09:58.620 --> 00:10:11.310

Anna Schauer: A larger and also because our galaxy galaxies that are forming they are smaller so, relatively speaking, the velocity offset between the gas and that matter in some regions of the universe.

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00:10:12.120 --> 00:10:18.540

Anna Schauer: is quite significant compared to, for example, to escape velocity of the galaxies that are forming.

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00:10:19.350 --> 00:10:35.340

Anna Schauer: So I run those different simulations I don't only have this relation with know streaming velocity I really pick out for different regions of the universe, with different streaming velocities and around those four different simulations.

58

00:10:36.360 --> 00:10:42.090

Anna Schauer: They also have the same properties so it's one cool moving mega classic so sightings.

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00:10:42.870 --> 00:10:52.980

Anna Schauer: And I shown you this picture before disaster density slide of my whole simulation box at Russia 15 and as the simulation with no streaming velocity and i'm going to show you.

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00:10:53.400 --> 00:11:12.000

Anna Schauer: The simulations that will have a non zero streaming velocity, so it is no streaming velocity as as as live streaming velocity at increases and assistant are just one I simulate so what you can see here immediately, is that we kind of have a structure washing out.

61

00:11:13.650 --> 00:11:31.920

Anna Schauer: So we can really see are ready on this large scale that streaming velocities have an important in fact on those higher higher redshift times for the density, distribution and because i'm in high density gas regions if i'm stars, also for the star formation.

62

00:11:33.030 --> 00:11:39.450

Anna Schauer: So I have the same plots again here in the top row, so the top row was the last four slides.

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00:11:40.500 --> 00:11:49.020

Anna Schauer: And then, when you zoom into one region, I show you again the density slice here now just with a slightly different color scale.

64

00:11:49.890 --> 00:12:05.460

Anna Schauer: And you can see, here again, that the structures washed out because we have this large scale offset velocity I choose to be in X direction that's completely arbitrary, but you can see that it's washed out and X direction.

65

00:12:06.480 --> 00:12:11.670

Anna Schauer: And what you can also see us the high density region decreases so we have.

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00:12:13.110 --> 00:12:26.010

Anna Schauer: The gas and highest density to region and high streaming velocity case as much lower than the know streaming velocity case, and if you zoom in even more intimate simulation.

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00:12:26.700 --> 00:12:34.470

Anna Schauer: Then we can see that even more clearly, so the conclusion of that is that the streaming velocity is washed out or structures.

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00:12:35.700 --> 00:12:40.080

Anna Schauer: And then the density decreases when you go to higher streaming velocity regions.

69

00:12:42.090 --> 00:13:01.200

Anna Schauer: And then you can see that this HALO if you can call it a halo not just a filament doesn't have high density gas anymore, so of course it can't form a Stein down so we move to different or just a couple of healers can steal from stars in those streaming velocity regions.

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00:13:03.150 --> 00:13:11.490

Anna Schauer: Stepping back from that, I would like to consider the second important affected that prevent star formation at very high redshift.

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00:13:12.060 --> 00:13:18.780

Anna Schauer: And that comes from the first ask themselves so as the first is start to emit light they start to emerge.

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00:13:19.710 --> 00:13:41.550

Anna Schauer: Also light in the so called lamb and verna bands and those provide negative feedback as well, so quickly talk includes lemon runner radiation as UV UV radiation between 11.2 and 13.6 ev roughly at some indiscreet energies and this UV radiation canvas try molecular hydrogen.

73

00:13:42.870 --> 00:13:48.060

Anna Schauer: It can destroy it by a two step process it's a molecule.

74

00:13:49.770 --> 00:14:00.150

Anna Schauer: You can enhance the rotational energy, then it starts to vibrate and then it can eventually break up and fall down to a state.

75

00:14:00.960 --> 00:14:11.340

Anna Schauer: Where it's broken apart the socket laminar radiation and we cut it off at the ionizing numbers and therefore our we are in our universe.

76

00:14:11.610 --> 00:14:24.720

Anna Schauer: That is neutral and lemon vanek radiation can mostly freely travels through the universe, unless you have a lot of wonderful hydrogen and you start our self seeding process so molecular hydrogen is emitted by the first.

77

00:14:25.650 --> 00:14:35.520

Anna Schauer: lemon runner radiation is emitted by the first is and can destroy molecular hydrogen and molecular hydrogen is critical for forming those first eyes and therefore.

78

00:14:36.510 --> 00:14:55.620

Anna Schauer: It makes it harder to film fast starts as soon as you have lemon runner radiation looking at same similar set of simulations I have the same simulations and now I turn on progressively higher level on our backgrounds so here, you can see again a full slice of my simulations at redshift.

79

00:14:56.670 --> 00:15:01.650

Anna Schauer: This time I show you the Monica hydrogen abundance and in the case, but I don't have a.

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00:15:02.820 --> 00:15:12.960

Anna Schauer: lemon run a background, you can see that the just average value in the universe is much higher than when I have even a small Amazon account.

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00:15:13.470 --> 00:15:23.520

Anna Schauer: And then i'm zooming into the same halos again, and when I zoom into the same HALO you can see that also the molecular hydrogen fraction indoors halos.

82

00:15:24.450 --> 00:15:35.010

Anna Schauer: In the case of know lemon my background is higher than when you have 11 background ever swimming and even more he can see it even better.

83

00:15:35.610 --> 00:15:45.480

Anna Schauer: yeah even able to retain some of the molecular hydrogen, even if you have a strong lemon run a background, because of the self shielding effect from the molecular hydrogen.

84

00:15:48.780 --> 00:16:02.430

Anna Schauer: And then, what I really do with all those data, so I have a set of total of simulations where I turn on different streaming velocity values different lemon backgrounds and that run all those combinations of them.

85

00:16:03.450 --> 00:16:20.010

Anna Schauer: And this is Those are two of my main resolve plots and then search for how massive other galaxies that are able to have high density gas and therefore what master the galaxies and mini halos have.

86

00:16:21.060 --> 00:16:30.570

Anna Schauer: In order to form styles and I show you here, and the least massive galaxy as a function of redshift folders combination of.

87

00:16:31.410 --> 00:16:44.400

Anna Schauer: lemon runner backgrounds and streaming velocity values when I don't have an in fact my minimum HALO masks or at least most of HALO that passes a certain density criteria, but I say it's enough to form stars.

88

00:16:45.870 --> 00:16:51.240

Anna Schauer: As read our constant and it said at a few times 10 to the five soda masses.

89

00:16:52.440 --> 00:17:10.320

Anna Schauer: Then, when I put lemon on a background, but no streaming velocity it goes up to this a dark Gray lines and increases just a little bit and including a strong alignment runner background increases it quite a bit, and then I moved to this whole set of new color.

90

00:17:11.400 --> 00:17:18.930

Anna Schauer: Here in my plot as soon as that include streaming velocities So if I don't have a streaming velocity.

91

00:17:19.860 --> 00:17:28.860

Anna Schauer: I do find those halos with a few times 10 to the five solar masses that can form stars as soon as i'm in the regime where I have streaming velocities.

92

00:17:29.490 --> 00:17:48.000

Anna Schauer: This stuff from Washington mass threshold moves to attend to the six solar masses and higher and then the lemon or no background in addition increases this mouse, because then the galaxies that don't only form later, but they also have to have.

93

00:17:49.500 --> 00:17:55.620

Anna Schauer: A higher mass so they have more gas that can shield itself sheer done against the landowner background.

94

00:17:56.970 --> 00:18:06.180

Anna Schauer: And when I moved to my outlier region where I have a really high screaming velocity of three secrets and alignment verner background.

95

00:18:07.260 --> 00:18:16.050

Anna Schauer: I reached the atomic cooling regime so a really high mass threshold for star formation, to take place.

96

00:18:17.130 --> 00:18:29.490

Anna Schauer: And on the bottom panel it's it's a very similar picture, but here I search for the average HALO, most of all, my staff forming object at redshift so.

97

00:18:30.570 --> 00:18:35.190

Anna Schauer: The top panel shows the minimum HALO mass and.

98

00:18:36.210 --> 00:18:49.440

Anna Schauer: button shows the ever changing last because we are when we want to transform those results into semi energetic models that are maybe important for 21 centimeter radiation.

99

00:18:50.400 --> 00:18:57.060

Anna Schauer: and think similar like that we're not only interested in the outlier object, but we're interested to what the average.

100

00:18:57.720 --> 00:19:14.730

Anna Schauer: mini HALO in the universe does and, of course, when you move to away from the least massive object to just take the average object you masses generally increase, but overall pictures that both effects lemon verner radiation and streaming velocity increase.

101

00:19:16.230 --> 00:19:24.150

Anna Schauer: The mask special for star formation, we don't see direct redshift dependence it's all very stochastic and.

102

00:19:25.440 --> 00:19:31.290

Anna Schauer: To to the relatively low numbers of mini halos that we have even though you have quite a few.

103

00:19:33.060 --> 00:19:45.810

Anna Schauer: So we can see a clear retro of dependence and then, when you compare the two effects which one is stronger you see that streaming velocities have a stronger effect, but that those two effects ultimately end up.

104

00:19:48.060 --> 00:19:56.550

Anna Schauer: So now i'd like to go back to my first slide and talk about the observational prospect.

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00:19:57.780 --> 00:20:13.380

Anna Schauer: So we talked about that we need mostly numerical simulations and semi energetic models to probe the formation of the first is that those are the redshift you can actually reach some of those first star formation regions.

106

00:20:14.550 --> 00:20:26.220

Anna Schauer: With 21 centimeter radiation, but for that you proper global signal, so if you want to really observe or get information of what a single objects.

107

00:20:27.810 --> 00:20:31.500

Anna Schauer: 21 centimeter radiation can't do that can't do that yet.

108

00:20:33.390 --> 00:20:49.170

Anna Schauer: But now for like those last few minutes of my talk, I wanted to turn the question around and ask what kind of telescope which you actually need in order to observe those first the HALO stores first star formation regions.

109

00:20:50.430 --> 00:20:51.150

Anna Schauer: And for that.

110

00:20:52.260 --> 00:20:52.410

Ana Bonaca: We.

111

00:20:53.910 --> 00:20:54.480

Anna Schauer: played a.

112

00:20:55.140 --> 00:21:05.160

Anna Schauer: quite simple game, so what kind of telescope do you need and we defined a three criteria that such a telescope needs to fulfill one is it needs to.

113

00:21:06.840 --> 00:21:19.140

Anna Schauer: observe enough sources in the sky, we don't want to just point on very expensive telescope somewhere not pick up any sources, so the number density of sources and this guy needs to be sufficiently high.

114

00:21:19.890 --> 00:21:28.560

Anna Schauer: Of course, we need to be able to see those first objects, so we need to design the telescope that we can pick up those.

115

00:21:29.220 --> 00:21:46.500

Anna Schauer: Very dumb galaxies that are not filled with a lot of stars, so the brightness of those populations, we clap population three star clusters is important, and then, if you see one we want to be sure that we see one and we don't accidentally see a brown dwarf.

116

00:21:48.120 --> 00:22:01.020

Anna Schauer: So just walking quickly through it we took different models for the brightness of the population three star clusters and we took three different models, there are many more.

117

00:22:02.130 --> 00:22:05.310

Anna Schauer: But we kind of wanted to spend a model range.

118

00:22:06.570 --> 00:22:18.540

Anna Schauer: And to show you we have single population three stars without nebula emission and then we have here a time evolving population three sad.

119

00:22:19.500 --> 00:22:33.420

Anna Schauer: That considers nebula emission and both of those are taken from the literature, we choose the dresser model from zach rosen 2011 and also my.

120

00:22:34.230 --> 00:22:50.130

Anna Schauer: postdoc advisors model for a single massive population three stars here, and when you now put the light of a typical population three classes, which we take to be 1000 solar masses St Lucia mass.

121

00:22:51.360 --> 00:22:56.100

Anna Schauer: Through your jam swept filters which was the James webb folders because.

122

00:22:57.150 --> 00:22:59.850

Anna Schauer: They prob nice wavelength ranges.

123

00:23:01.620 --> 00:23:20.850

Anna Schauer: You can see here the flux on the sky also translated into the Abbey magnitude and, if you want to observe those first star clusters what you can see, is that you need to roughly probe a 39th ap magnitude So if you establish that limit.

124

00:23:22.080 --> 00:23:30.180

Anna Schauer: What does leads as that we need that we need roughly a 100 meter mirror and because we need to probe.

125

00:23:31.290 --> 00:23:51.240

Anna Schauer: The wavelength regime that is not observable from earth, we need to go into space, this can either be done in space, directly or another possibility is on the moon, and for that we are very happy that there is a project proposed more than a decade ago by Roger angel.

126

00:23:52.350 --> 00:23:59.490

Anna Schauer: and his collaborators to put a liquid mirror telescope on the moon, and if we compare what we need.

127

00:24:00.720 --> 00:24:03.900

Anna Schauer: From our paper to what is telescope has.

128

00:24:05.520 --> 00:24:16.470

Anna Schauer: It would be a very good telescope to do this worth and the choice for liquid mirror is because he would need to transport less material into space and therefore.

129

00:24:17.340 --> 00:24:30.540

Anna Schauer: Even though building 100 meter telescope or no one can of course never be cheap, but it would hopefully reduce the cost to have a rotating mirror that can then be coated.

130

00:24:32.190 --> 00:24:34.200

Anna Schauer: and moving it to the moon.

131

00:24:35.280 --> 00:24:52.170

Anna Schauer: would be cheaper than having it directly in space, so this is why we say that telescope proposed by Roger angel would probably fulfill those three criteria and to be a good way to observe the first stars directly.

132

00:24:54.300 --> 00:24:56.040

Anna Schauer: I live with my conclusions.

133

00:24:58.200 --> 00:25:00.090

Anna Schauer: I studied many halos.

134

00:25:01.260 --> 00:25:11.670

Anna Schauer: In that I have this mass of a few times 10 to the five to attend to the seven solar masses in mind america's Malaysians it's important to include.

135

00:25:12.420 --> 00:25:18.630

Anna Schauer: The effects at high redshift streaming velocities and mammoth vela radiation, if you want to study a typical.

136

00:25:19.080 --> 00:25:36.360

Anna Schauer: star formation regions that does only redshift it's currently out of observation and reach, but we could have served us with, for example, 100 meter telescope windows phone, so I look forward to the extended discussion around thanks a lot for your attention.

137

00:25:38.250 --> 00:25:38.730

Ana Bonaca: Thank you.

138

00:25:40.200 --> 00:25:41.790

Ana Bonaca: Very thought provoking.

139

00:25:43.740 --> 00:25:56.790

Ana Bonaca: As a as a general reminder on your questions, send me a direct message chat so they can kind of guided or group questions on on the same topic this way.

140

00:25:57.870 --> 00:26:02.250

Ana Bonaca: And we have a first question from obviously Please go ahead.

141

00:26:03.720 --> 00:26:06.210

Abraham Loeb: Oh yeah excellent token.

142

00:26:08.010 --> 00:26:23.640

Abraham Loeb: them at what flux limit do we expect their sources to cover the entire sky so overcrowding, will be an issue of course if you if you know where he is you can separate them in the third dimension but they're just in two dimensions, at what flux limit, do you know.

143

00:26:24.660 --> 00:26:25.920

Abraham Loeb: We get overcrowding.

144

00:26:27.750 --> 00:26:33.000

Anna Schauer: I don't think that overcrowding, will be a big problem.

145

00:26:34.920 --> 00:26:47.010

Anna Schauer: Like at some redshift the population three star formation density dies down again I don't think that we nowadays have store those very tiny galaxies forming.

146

00:26:48.660 --> 00:26:58.140

Anna Schauer: So you basically then lose the many galaxies that many small mass galaxies they.

147

00:26:59.910 --> 00:27:06.240

Anna Schauer: Like after some time, everything has either already from stars, so I will never from stars I guess.

148

00:27:08.340 --> 00:27:11.730

Abraham Loeb: Which fraction of the skies covered, you know by galaxies.

149

00:27:12.000 --> 00:27:14.310

Abraham Loeb: And Richard 2030.

150

00:27:15.450 --> 00:27:19.320

Anna Schauer: So, if you look at the accumulator number.

151

00:27:20.640 --> 00:27:23.310

Abraham Loeb: Reflection each each galaxy has a size right so.

152

00:27:23.550 --> 00:27:24.510

Anna Schauer: yeah we.

153

00:27:25.050 --> 00:27:26.040

Abraham Loeb: Use guys covered.

154

00:27:27.030 --> 00:27:35.130

Anna Schauer: I would say it's a small fraction at the moment, we have to telescope designed in a way that those first galaxies will be point sources.

155

00:27:38.610 --> 00:27:58.950

Anna Schauer: yeah and, if you look at the cumulative number of those galaxies between just redshift 10, which is the lowest we go down to it, to make the highest redshift and we expect first stars, we expect like even with our most optimistic model we expect them like 1000 per.

156

00:28:00.210 --> 00:28:01.710

Anna Schauer: square our Community.

157

00:28:03.030 --> 00:28:04.920

Anna Schauer: And i'm pretty sure that you will always.

158

00:28:06.060 --> 00:28:14.160

Anna Schauer: Like any detector will have many, many more pixels than that, so I don't expect that we will just stick have a bright.

159

00:28:16.230 --> 00:28:16.770

Anna Schauer: bright.

160

00:28:18.180 --> 00:28:23.100

Anna Schauer: image and therefore we can probably pick out those sources.

161

00:28:26.970 --> 00:28:40.860

Ana Bonaca: Just as a follow ups are imagining you mentioned with your simulations looking at the star clusters of revision three stars and as this one, cluster for many HALO or.

162

00:28:40.890 --> 00:28:46.200

Anna Schauer: yeah Okay, so we assume that we have one star cluster forming.

163

00:28:47.280 --> 00:29:01.080

Anna Schauer: Make the pub three IMF is not yet known it's not yet known, if it's one star or if it's a couple of stars but slowly the literature most words it's probably one class of stars.

164

00:29:03.030 --> 00:29:04.440

Anna Schauer: So we assume.

165

00:29:05.490 --> 00:29:11.370

Anna Schauer: In our model that we only have one because those stars also very long and as soon as they explode.

166

00:29:12.390 --> 00:29:16.650

Anna Schauer: We have metal enrichment and with, then we have population to stocks instead.

167

00:29:18.930 --> 00:29:24.570

Ana Bonaca: Thanks and who we are, yes I think ever seen a question along similar lines, so please go ahead.

168

00:29:24.840 --> 00:29:30.090

Julian Munoz: yeah so thanks for the talk that was that was really great, this is a topic that is close and dear to my heart.

169

00:29:31.440 --> 00:29:45.000

Julian Munoz: So so yeah I had a couple questions about the first is kind of similar like do you have enough that the sticks to figure it out some like stellar permission efficiency for the mini halos or are they just burst D they form once and they stop can we figure this out.

170

00:29:46.980 --> 00:29:54.510

Anna Schauer: So for my simulations because I want to resolve many healers I don't do this very high.

171

00:29:55.140 --> 00:30:09.660

Anna Schauer: I don't do the highest resolution right at the Center of the mini halos so I actually don't form stars direct in my simulation so I don't have statistics about the stars, because the stars don't really form in my simulations.

172

00:30:12.420 --> 00:30:13.590

Anna Schauer: assess your question.

173

00:30:13.860 --> 00:30:26.040

Julian Munoz: Well, I guess, my question is is like once once that you're supporting the stars and they start admitting lemon burner photons you only get one burst of popular stars, or are there, more than one burst by this by the same Taylor.

174

00:30:27.300 --> 00:30:39.480

Anna Schauer: And as soon as I have a second burst and the HALO it wouldn't be population twisters anymore, because they massive dashboard lift just a few mega years.

175

00:30:40.620 --> 00:30:41.730

Anna Schauer: yeah but.

176

00:30:41.760 --> 00:30:51.960

Anna Schauer: I don't form star static in isolation is check for density criteria within SAP this is enough if you had this whole stuff permission prescription that you would form size.

177

00:30:52.770 --> 00:30:55.740

Julian Munoz: cool and the other question related to this, and I have more but a little bit.

178

00:30:55.770 --> 00:30:57.330

Julian Munoz: yeah, but this is.

179

00:30:57.540 --> 00:31:08.550

Julian Munoz: The second related question is what you should have this density smooth plot when you have larger velocity just within that is that he wrote down the Krishna data and essentially like a beach effect.

180

00:31:09.000 --> 00:31:10.110

Anna Schauer: Yes, yes, yes, yes.

181

00:31:10.260 --> 00:31:17.250

Julian Munoz: Do you also see a decrease in the number of HALO is this like include this is kind of like orthogonal to the question you're answering right.

182

00:31:17.520 --> 00:31:19.980

Anna Schauer: yeah yeah so then.

183

00:31:21.450 --> 00:31:22.830

Anna Schauer: What happens is that.

184

00:31:24.090 --> 00:31:27.840

Anna Schauer: Because the gas has a harder time to settle into dark matter halos.

185

00:31:28.830 --> 00:31:45.450

Anna Schauer: Then one thing that happens immediately is the gas fraction
Linda that matter halos decreases the Stan means that those halos and
little bit less massive so we all know that that matter as much more
method and gas, so the gas doesn't play a major role.

186

00:31:46.620 --> 00:31:49.290

Anna Schauer: But if you have a little bit less gas in this halos.

187

00:31:50.790 --> 00:31:57.870

Anna Schauer: Your mass as a little bit less and therefore your HALO
machine function shifts just a tiny bit, but that's not a big effect.

188

00:32:01.680 --> 00:32:03.450

Julian Munoz: You do find you agree with those.

189

00:32:03.750 --> 00:32:05.460

Julian Munoz: Your shorts as well okay yeah thanks.

190

00:32:06.990 --> 00:32:09.480

Ana Bonaca: So we have some questions about.

191

00:32:10.740 --> 00:32:23.520

Ana Bonaca: kind of generational signatures like flourishes, but but
let's just stick a little bit about the the condition of the high
interest and itself those questions for so so Morgan, please go ahead.

192

00:32:25.650 --> 00:32:31.260

Morgan Elowe MacLeod: Sure yeah Thank you so much um so I was wondering
you're talking about you know whether these.

193

00:32:32.430 --> 00:32:40.800

Morgan Elowe MacLeod: clouds fragments and form a cluster versus ferment
single Star and can you talk a little bit more about that in the context
of your.

194

00:32:41.370 --> 00:32:48.000

Morgan Elowe MacLeod: simulations with varying levels of sort of
ionization in the background, like does.

195

00:32:48.600 --> 00:33:01.950

Morgan Elowe MacLeod: Does the cumulative effect of a cluster with the
same mass produce like where does that fall on that sequence So can I
understand, though, that series, in the context of that question or are
those really separate.

196

00:33:04.320 --> 00:33:05.310

Anna Schauer: So you mean.

197

00:33:06.810 --> 00:33:09.360

Morgan Elowe MacLeod: i'm not sure if I understood, let me try again sorry.

198

00:33:10.530 --> 00:33:16.740

Morgan Elowe MacLeod: So you were showing us a really beautiful sequence with different amounts of.

199

00:33:17.070 --> 00:33:18.060

Anna Schauer: Time and vendor background.

200

00:33:18.420 --> 00:33:18.600

Morgan Elowe MacLeod: My.

201

00:33:18.960 --> 00:33:22.320

Morgan Elowe MacLeod: background and then different amounts of H2 as a result, so.

202

00:33:22.590 --> 00:33:24.300

Morgan Elowe MacLeod: I was wondering does.

203

00:33:26.130 --> 00:33:26.850

Morgan Elowe MacLeod: When.

204

00:33:28.140 --> 00:33:33.030

Morgan Elowe MacLeod: pop three stars form do they contribute to that or is that really negligible.

205

00:33:35.010 --> 00:33:43.320

Anna Schauer: So in my simulations because I don't form the stars directly I treat the Lambda background as an external background.

206

00:33:43.410 --> 00:33:50.400

Anna Schauer: right, of course, the lemon when a background is build out of the radiation, that is coming from those first stars.

207

00:33:50.640 --> 00:33:50.970

Morgan Elowe MacLeod: Yes.

208

00:33:51.420 --> 00:34:01.320

Anna Schauer: So, yes it's it's, so to say, a circle if you're considered a large scales, then you prevent some stars from forming.

209

00:34:02.520 --> 00:34:09.060

Anna Schauer: Therefore, I saw your lamanna background doesn't grow that much because those stars don't admit in an advantage radiation.

210

00:34:10.080 --> 00:34:27.480

Morgan Elowe MacLeod: yeah So then, when I was wondering if you were talking a little bit about whether clouds fragment and form a cluster versus a single large star How does that affect like for a given amount of star formation what the alignment Boomer background would.

211

00:34:27.510 --> 00:34:28.320

Anna Schauer: be like.

212

00:34:28.530 --> 00:34:44.250

Morgan Elowe MacLeod: Can we understand those two as linked and and think about you know your sort of I understand that there's simplifications in that sequence of some simulations but can we understand those as a sort of along some continuum.

213

00:34:46.800 --> 00:34:55.170

Anna Schauer: So if you have a very different I am F here, the amount of.

214

00:34:56.550 --> 00:35:03.900

Anna Schauer: lemon verna photons emitted per soda mass formed into stars changes.

215

00:35:05.010 --> 00:35:05.490

Anna Schauer: So.

216

00:35:07.380 --> 00:35:11.100

Anna Schauer: If you want to simulate this very self consistently.

217

00:35:12.660 --> 00:35:22.560

Anna Schauer: You need to then also do a model of population three stars and consider that if I ever do simulations I don't think.

218

00:35:24.360 --> 00:35:24.990

Anna Schauer: will be.

219

00:35:26.580 --> 00:35:30.120

Anna Schauer: very feasible if you have both the background produced by your stars.

220

00:35:31.350 --> 00:35:35.400

Anna Schauer: And the same vicinity regions.

221

00:35:37.110 --> 00:35:43.710

Anna Schauer: Where did I move on a background is the lemon vendor radiation from the neighboring HALO is, of course, stronger because.

222

00:35:44.700 --> 00:35:56.580

Anna Schauer: After really, really large regions of the university talking about so this lemon irrigation can travel roughly at mega are sick before that has moved towards other bands.

223

00:35:58.410 --> 00:35:59.430

Morgan Elowe MacLeod: yeah okay.

224

00:35:59.460 --> 00:36:10.350

Anna Schauer: yeah if you were interested a vector neighboring halos and take into account that if you're sitting close to HALO that formed a lot of stories the slammer runner radiation.

225

00:36:12.270 --> 00:36:24.960

Anna Schauer: Then will inhibit stuff mission and a neighboring HALO and then depends on what spectrum, from the population three star in this first HALO the film stars look back interesting.

226

00:36:25.590 --> 00:36:26.460

Morgan Elowe MacLeod: Thanks so much.

227

00:36:26.700 --> 00:36:27.030

yeah.

228

00:36:29.250 --> 00:36:35.460

Ana Bonaca: So I think now is the a good time to serve, what can we.

229

00:36:36.660 --> 00:36:38.580

Ana Bonaca: Learn it for lowering usher's.

230

00:36:39.600 --> 00:36:41.460
Ana Bonaca: By these prestigious so Sarah.

231
00:36:42.780 --> 00:36:43.680
Ana Bonaca: Please go ahead.

232
00:36:45.330 --> 00:36:49.530
Rohan Naidu: I mean, do we care, the lower edge of them asked me about it gotcha so 15 ish right so.

233
00:36:50.970 --> 00:36:52.440
Rohan Naidu: yeah so I was curious like.

234
00:36:54.840 --> 00:37:02.700
Rohan Naidu: Is there, like any hope whatsoever that like these redshift 10 to 15 ish maybe i'll start galaxies.

235
00:37:03.360 --> 00:37:09.780
Rohan Naidu: off placing constraints on your models like are likely the models like divergent any observable there.

236
00:37:10.260 --> 00:37:16.200
Rohan Naidu: And, and in a similar context, I was curious what he made off like in our helium do like there's a lot of people like.

237
00:37:16.770 --> 00:37:30.450
Rohan Naidu: A blind for gobs and gobs of dance the time to measure helium do to constrain like Bob three populations that these riches so like I surmise you're not very optimistic about helium do either then.

238
00:37:31.020 --> 00:37:42.780
Anna Schauer: yeah so it's helium too, because this is a message right so they're pretty so a lot of him to and and I think you're talking about seo seven and what follows from that.

239
00:37:42.870 --> 00:37:52.140
Rohan Naidu: I mean not just your seven, but like you know, like it hi Richard now people want to like spend one or 100 hours with their spec do I measure helium do I, like it already.

240
00:37:53.490 --> 00:38:11.370
Anna Schauer: yeah i'm sure dad more massive outlier galaxies and those might still have like a surviving population three star, we see that star

formation shifts an average to lower he lives if you're in those streaming velocity regions.

241

00:38:12.420 --> 00:38:14.070

Anna Schauer: So you could very well have.

242

00:38:15.840 --> 00:38:16.320

Anna Schauer: Nick.

243

00:38:17.730 --> 00:38:30.360

Anna Schauer: galaxy me Hello Tom equally Hello Hello that formed populations, we started and still lives and has merged within a larger object and then still emitting some of the helium to.

244

00:38:31.800 --> 00:38:36.450

Anna Schauer: But if you look at how much flaps is produced.

245

00:38:37.470 --> 00:38:46.170

Anna Schauer: By just a small region small number of population three stars this fax criterium cannot be met, because.

246

00:38:47.370 --> 00:38:51.900

Anna Schauer: You only have MAC mini halos a small and therefore you don't have many stars.

247

00:38:53.640 --> 00:38:57.000

Anna Schauer: Even if you move to a star formation efficiency of 1%.

248

00:38:58.140 --> 00:39:01.470

Anna Schauer: Of the gas it's hard to observe that.

249

00:39:03.000 --> 00:39:23.670

Anna Schauer: Just because, like it's we say with James webb you can't observe those populations twisters those mini halos because the amount of nason stars in such a typical mini HALO atomic cooling, a lot of small that's the biggest enduring to.

250

00:39:24.750 --> 00:39:27.300

Anna Schauer: observe those mini haters directly.

251

00:39:28.860 --> 00:39:35.580

Anna Schauer: You can very well have an exceptional object, but that's very rare and we won't be able to probe the typical me HALO.

252

00:39:40.590 --> 00:39:41.910

Ana Bonaca: Does this answer your question.

253

00:39:43.320 --> 00:39:44.730

Rohan Naidu: yeah thanks.

254

00:39:45.780 --> 00:39:45.990

Rohan Naidu: Okay.

255

00:39:46.020 --> 00:39:50.310

Ana Bonaca: Thank you, Julian had a comment related so let's go from deafness.

256

00:39:51.720 --> 00:39:58.530

Julian Munoz: Like I think if he wasn't wretched 15 I think there's hope to the deck these things, indirectly, and I don't know about to be like good enough.

257

00:40:00.060 --> 00:40:10.200

Julian Munoz: For most people, but like these, these things definitely do matter like in terms of service is wrong with saying that like disagree, or like diverged with different prescriptions the 21 centimeter line will leverage a lot.

258

00:40:11.430 --> 00:40:11.760

Julian Munoz: Like.

259

00:40:11.820 --> 00:40:24.300

Julian Munoz: yeah go early early enough where these things are the main halos forming then it does matter a lot, but then again that is indirect you're not seeing the subjects, you know one, at a time, but I think there's some hope there.

260

00:40:25.410 --> 00:40:34.200

Anna Schauer: yeah if you, for example, look at the 21 centimeter signals already know, important for the global signal to include streaming velocities.

261

00:40:35.490 --> 00:40:38.220

Anna Schauer: Otherwise, your properties just change.

262

00:40:39.450 --> 00:40:50.490

Anna Schauer: Anything I don't know if it's the V spa paper from 2012 or the fiasco of paper from 2014 we had the differences for the 21 centimeter.

263

00:40:51.060 --> 00:41:03.540

Anna Schauer: Global signal included if you have streaming velocities included in your prescription or not, and you see that the global signal has a different profile and as a function of redshift.

264

00:41:04.410 --> 00:41:15.270

Julian Munoz: Right, so not only can we detect the top three stars, we can actually tell the effect of velocities of the effect the lemon verner feedback of these stars again indirectly, but I think there's a lot of a distinguishing power.

265

00:41:16.110 --> 00:41:24.210

Anna Schauer: yeah and I think for really nice 20 centimeter signal measurements, it was also be good to move to the moon so.

266

00:41:26.220 --> 00:41:29.250

Anna Schauer: We should yeah it would be amazing if that happens.

267

00:41:33.750 --> 00:41:38.520

Ana Bonaca: But speaking up maybe in the less direct.

268

00:41:40.020 --> 00:41:43.620

Ana Bonaca: probs I think josh heather had another question.

269

00:41:47.370 --> 00:41:56.310

josh: it's the old question that many, including Avi and poker and others have thought about, namely GR bs at high redshift.

270

00:41:58.020 --> 00:42:04.230

josh: almost certainly first week nobody's proven, as are going to result from pop three stars, which are massive.

271

00:42:05.430 --> 00:42:17.790

josh: And so, this is something that would tell us you know something about the epic of first up three star formation, you know because.

272

00:42:18.870 --> 00:42:34.290

josh: that's that's something that future facilities that are being proposed now in fact have been proposed and the current teakettle survey

could could really do it would not be nearly as expensive as 100 meter telescope on the moon, much as that might be interesting.

273

00:42:35.460 --> 00:42:37.860

josh: So I just wanted to point that out which.

274

00:42:39.060 --> 00:42:53.100

josh: Will not you know it will only tell us about the redshift dependence it won't tell us anything about structure of many halos there's no way, but neither would the hundred meter telescope on the moon right.

275

00:42:54.330 --> 00:42:55.860

josh: you're not going to solve anything.

276

00:42:57.150 --> 00:43:08.460

Anna Schauer: yeah it wouldn't resolve those many haters but I learned from the colors you could infer some properties yeah yeah how how frequent address gbs.

277

00:43:09.840 --> 00:43:28.320

josh: Well, we could be very frequent we have very incomplete knowledge, not because of the grb detection problem, although that can be greatly improved and that's also being proposed, but the lack of prompt follow up infrared imaging and spectroscopy.

278

00:43:29.460 --> 00:43:40.350

josh: As I pointed out to you know others here before there's a very large fraction I mean it's not a negligible fractions of Dr b's that are optically dark.

279

00:43:41.250 --> 00:43:57.990

josh: And that you know, is not then followed up in a systematic way with prompt JFK imaging and then spectroscopy, which is, of course, the only way to resolve, whether these things are high redshift and therefore optically dark.

280

00:43:59.550 --> 00:44:11.700

josh: So that's The biggest challenge and that there's a there's a very easy quote unquote solution for that 1.5 meter or even 1.3 meter telescope at El to.

281

00:44:12.270 --> 00:44:20.700

josh: That cannot play flute which we propose to the kettle survey, something we call the time domain spectroscopic observatory to so.

282

00:44:21.690 --> 00:44:34.980

josh: That would do it with with existing swift first, but if you can go faster than swift and it will cover more of the sky, like all the sky, then you have the ultimate package and you could really trace.

283

00:44:36.240 --> 00:44:38.940

josh: Part Three formation back to the very beginning.

284

00:44:42.270 --> 00:44:43.710

josh: So I hope this happens.

285

00:44:45.480 --> 00:44:45.750

Anna Schauer: yeah.

286

00:44:47.970 --> 00:44:48.750

josh: very nice talk.

287

00:44:49.590 --> 00:44:50.010

Thanks.

288

00:44:51.030 --> 00:45:01.050

Ana Bonaca: frickin or just follow up on this, what do you think it would take from them or simulation perspective to to produce.

289

00:45:02.400 --> 00:45:08.490

Ana Bonaca: Realistic forecast of how many jeremy's you would expect in from these top three stars and.

290

00:45:09.780 --> 00:45:11.970

Ana Bonaca: You see, like this theoretically happening.

291

00:45:14.100 --> 00:45:15.630

Ana Bonaca: In the next say five years.

292

00:45:16.680 --> 00:45:23.880

Anna Schauer: yeah i'm really not an expert on GPS I don't think I can really comment on that, unfortunately.

293

00:45:27.000 --> 00:45:27.900

Ana Bonaca: i've even had.

294

00:45:29.370 --> 00:45:44.040

Abraham Loeb: There was a recent flash that was argued to have existed recently and, and that is still being debated and there were a couple of papers on the archive, one of which claiming that it's actually just the satellite the.

295

00:45:45.630 --> 00:45:46.230

Abraham Loeb: terrestrial.

296

00:45:47.400 --> 00:45:48.780

Abraham Loeb: for granted, but but.

297

00:45:49.740 --> 00:46:01.080

Abraham Loeb: One could potentially with sensitive enough instrumentalists Josh was talking about the the tech not only Dr B's but also supernova cause massive if indeed the mass function is tilted towards massive stars with.

298

00:46:01.380 --> 00:46:06.120

Abraham Loeb: The supernova rate is quite substantial, given the star formation rate at those redshift so.

299

00:46:06.720 --> 00:46:15.810

Abraham Loeb: We could potentially see parent stability supernovae we sensitive enough telescopes and they will overwhelm the luminosity of the galaxy in which are embedded so that would be a very nice.

300

00:46:16.650 --> 00:46:23.430

Abraham Loeb: way of probing those galaxies because you would see the supernova and then you will know that there is a galaxy behind it, it will be sort of a flag.

301

00:46:24.390 --> 00:46:32.850

Anna Schauer: yeah I'm a bit skeptical about the parent stability supernova detections because stay on India for such a short amount of time.

302

00:46:33.450 --> 00:46:41.550

Abraham Loeb: Right, you need you need a transient this very rather than one snapshot you need multiple snapshots to see the time dependence, yes.

303

00:46:42.480 --> 00:46:42.990

Anna Schauer: yeah.

304

00:46:43.440 --> 00:46:57.840

josh: Have you muted, covering a very large fraction of the sky, which is never going to happen with aws tea or know anything else so that's the advantage of jeremy's you've got a you've got a trigger, then you put a big telescope on it.

305

00:46:59.370 --> 00:47:02.160

josh: So it's a very direct way to go about this.

306

00:47:04.830 --> 00:47:05.430

Anna Schauer: yeah.

307

00:47:08.910 --> 00:47:25.800

Anna Schauer: So what would be needed as pretty much the opposite of what we propose here, which is this telescope that just stuck look stationary in one direction to get as much light as long as a timeframe as possible and write with a pen stability supernova.

308

00:47:27.900 --> 00:47:34.890

Anna Schauer: Think I think it's yeah it's hard because they existed for a very short amount of time.

309

00:47:35.550 --> 00:47:38.550

Abraham Loeb: Times one plus Z right, so we gain a factor of 10.

310

00:47:39.270 --> 00:47:39.720

yeah.

311

00:47:41.370 --> 00:47:45.900

Abraham Loeb: You supernova can last for up to a year, and you know 10 years is a long time.

312

00:47:46.470 --> 00:47:47.640

Anna Schauer: huh yeah.

313

00:47:50.640 --> 00:47:55.290

Anna Schauer: 10 years make for models, we assume like a.

314

00:47:56.670 --> 00:47:59.010

Anna Schauer: stellar lifetime of a few hundred.

315

00:48:00.330 --> 00:48:08.610

Anna Schauer: A few million years so it's still a factor tentative five off and bandwidth yeah yeah.

316

00:48:08.640 --> 00:48:19.440

Abraham Loeb: Compared to the stars, but then it shines much more brightly so the quick and if you have a big enough field of view you should be able to pick those up, I mean it's an interesting question to check.

317

00:48:19.860 --> 00:48:22.890

Anna Schauer: yeah yeah for sure yeah yeah.

318

00:48:23.040 --> 00:48:26.100

Ana Bonaca: very, very messy I think there's like something intermediate like.

319

00:48:28.800 --> 00:48:33.960

Ana Bonaca: Say doable and we'll see if there is kind of a regional parameter space that can do that.

320

00:48:36.060 --> 00:48:45.870

Ana Bonaca: Okay, so to kind of bring it back made to the to the physical aspect of things Eric keep i've had a lot of questions that are just go ahead.

321

00:48:48.600 --> 00:48:56.250

Eric Keto: yeah I was wondering if you've looked at what the spectrum of the turbulence is with respect to the size scale of.

322

00:48:57.210 --> 00:49:07.470

Eric Keto: The stars clouds and form the stars or the mini halos and the background for the question is that say, for example in our galaxy.

323

00:49:08.280 --> 00:49:20.070

Eric Keto: The thermal energy generally isn't dominant in molecular clouds because once you've managed to cool the cloud down to below the energy density of the turbulence.

324

00:49:20.610 --> 00:49:28.530

Eric Keto: Then the turbulence really controls the fragmentation and so a few kilometers per second is kind of equivalent to a few thousand kelvin.

325

00:49:30.540 --> 00:49:43.920

Eric Keto: So what is, what does your simulation to say about that, with respect to the mini halos which you have in the simulation or the top three stars which you're kind of almost to that resolution.

326

00:49:46.140 --> 00:49:50.490

Anna Schauer: So you're saying if turbulence plays a role in the centers of the.

327

00:49:51.780 --> 00:49:52.860

Anna Schauer: After many healers.

328

00:49:54.120 --> 00:50:05.580

Eric Keto: Right, so there I know your colleagues and Heidelberg have some questions about whether turbulence can support a cloud against gravitational collapse its own but nonetheless the energy density.

329

00:50:06.420 --> 00:50:17.130

Eric Keto: Of the turbulence is generally higher than the thermal energy density, as long as it managed to cool it down to say 1000 Calvin or something like that.

330

00:50:19.140 --> 00:50:19.620

Anna Schauer: mm hmm.

331

00:50:24.060 --> 00:50:28.110

Anna Schauer: We have not checked in detail necklace.

332

00:50:29.220 --> 00:50:30.750

Anna Schauer: That type of energy.

333

00:50:32.790 --> 00:50:41.130

Anna Schauer: I can like report what I observe and my mini halos at centers and what I see there is that.

334

00:50:42.570 --> 00:50:56.520

Anna Schauer: Quite often, form a disc like structure it's not like a perfect disk but it's sometimes like looks like a fish or something like that that is rotating so at some point.

335

00:50:59.130 --> 00:51:09.870

Anna Schauer: Like i'm not dominated by the turbulence, but the central core as Monica semi stable slowly rotating high density structure.

336

00:51:11.100 --> 00:51:15.210

Eric Keto: To angular momentum is support everybody knows.

337

00:51:16.710 --> 00:51:29.760

Anna Schauer: Yes, like this in a structure has some angular momentum and this angular momentum of this in our structure is not correlated whatsoever with the angular momentum of the mini HALO scale.

338

00:51:32.100 --> 00:51:34.440

Anna Schauer: That is something my student checked.

339

00:51:35.970 --> 00:51:37.320

Eric Keto: Okay well that's producers.

340

00:51:42.150 --> 00:51:45.540

Ana Bonaca: As as they're getting close to the end of our.

341

00:51:46.770 --> 00:51:51.090

Ana Bonaca: or a lot of time slot you can go back and sort of.

342

00:51:52.290 --> 00:51:59.190

Ana Bonaca: look into the more computational aspects and ileana have another question the simulation.

343

00:51:59.910 --> 00:52:00.480

I do.

344

00:52:02.070 --> 00:52:10.320

Julian Munoz: yeah i'm very interesting the simulation so like i've read your paper and there was a paper by the lobbyists, but we also mentioned, and I think.

345

00:52:10.500 --> 00:52:11.580

Julian Munoz: was the first author.

346

00:52:11.790 --> 00:52:19.650

Julian Munoz: yeah and so both of your lemon voter feedbacks are much, much lower than the old results because of self shielding right.

347

00:52:20.400 --> 00:52:20.970

Anna Schauer: Yes.

348

00:52:21.030 --> 00:52:25.440

Anna Schauer: yeah but then there's 2001 2000 papers right.

349

00:52:25.590 --> 00:52:33.600

Julian Munoz: yeah but but, but there were sold seem to have a larger lemon verner FLEX but lower feedback overall like have you compare against them and see if there's any difference.

350

00:52:34.170 --> 00:52:42.240

Anna Schauer: we're working on that one thing that differ significantly, is that we choose a different HALO definition So while I take.

351

00:52:43.440 --> 00:52:51.810

Anna Schauer: In terms of code with like friends of friends HALO mass they take the empty handed and that's usually a little bit smaller.

352

00:52:53.640 --> 00:53:04.770

Anna Schauer: So, and then we have another major difference, but that's, so to say what's make the discrepancy even bigger is that I employ a merger tree.

353

00:53:05.940 --> 00:53:10.800

Anna Schauer: And I only covered my nose once once they start forming and they don't so therefore I think.

354

00:53:11.640 --> 00:53:27.930

Anna Schauer: Unfortunately, this would make our discrepancy even bigger so yeah but we're talking and we're trying to figure this out because I think we want to have a consistent picture, but my guess is, it would be largely due to the different definition of the hino masses.

355

00:53:28.860 --> 00:53:30.690

Julian Munoz: Right, so that that's very interesting, thank you.

356

00:53:32.820 --> 00:53:37.560

Ana Bonaca: Okay, and so so just to follow up on this a little bit.

357

00:53:38.730 --> 00:53:41.970

Ana Bonaca: seems like at least exploration of the different.

358

00:53:43.110 --> 00:53:54.720

Ana Bonaca: cosmological simulations let's agree on the on the kind of general picture, because they have a sort of they can be tied at the observer balls in the local universe.

359

00:53:55.080 --> 00:54:08.370

Ana Bonaca: And so I want to kind of close this may be forward looking question of what do you think it would take to run your simulations beyond redshift of 14 to two where hopefully we'll have a lot of circles.

360

00:54:09.900 --> 00:54:13.740

Ana Bonaca: With the upcoming gws the observations.

361

00:54:15.690 --> 00:54:33.750

Anna Schauer: I think one thing that would be important, would be to couple of primordial chemistry to population to chemistry so currently i'm not aware of any code that both feeds molecular hydrogen information to those H minus s purchase channels.

362

00:54:34.860 --> 00:54:36.690

Anna Schauer: And also treats Stan.

363

00:54:38.490 --> 00:54:41.820

Anna Schauer: metal enriched universe chemistry so.

364

00:54:43.410 --> 00:54:47.820

Anna Schauer: I think those are the computational steps that needs to be overcome, to do that.

365

00:54:48.420 --> 00:54:56.430

Ana Bonaca: Can you guess how illustration of some sort of hot how how challenging it is, is just like that the metrics are much wider or.

366

00:54:58.590 --> 00:54:59.580

Anna Schauer: You need to.

367

00:55:00.870 --> 00:55:07.200

Anna Schauer: trace different elements and you then need to switch from tracing.

368

00:55:08.340 --> 00:55:12.030

Anna Schauer: H minus, for example, to tracing carbon and your simulation.

369

00:55:14.160 --> 00:55:21.900

Anna Schauer: I don't think it's out of the question that this can be done, like, I think this this can follow fairly quickly okay.

370

00:55:22.110 --> 00:55:26.160

Ana Bonaca: And then the harbor advances, like the.

371

00:55:27.240 --> 00:55:31.470

Ana Bonaca: Does it help or like the gpu architectures or something.

372

00:55:32.580 --> 00:55:39.690

Ana Bonaca: With on the softer side with machine learning, do you think is there kind of some effective way, so that those two can be merger.

373

00:55:44.760 --> 00:55:45.750

Anna Schauer: So.

374

00:55:48.600 --> 00:56:09.180

Anna Schauer: i'm not sure if machine learning can can do much, maybe if it's studied a comparison between a simulation that doesn't include the promoter chemistry, then, with a simulation that does study to promote your chemistry and find some prescription.

375

00:56:10.350 --> 00:56:19.170

Anna Schauer: In the non primary a chemistry just add your simulation that it can then translate to a pseudo chemical network in the.

376

00:56:20.460 --> 00:56:26.580

Anna Schauer: pop to chemistry or metal enriched chemistry think that might work.

377

00:56:28.410 --> 00:56:28.680

yeah.

378

00:56:31.710 --> 00:56:33.540

Ana Bonaca: Thank you so much for this talk.

379

00:56:34.470 --> 00:56:35.970

Anna Schauer: And thank you so much for having me.

380

00:56:36.660 --> 00:56:52.620

Ana Bonaca: A pleasure, we had a very interesting ideas that kind of where came up or we're reinforced with this interaction so so Thank you everyone for joining and we'll see you next week again same time same place.

381

00:56:53.430 --> 00:56:54.210

Morgan Elowe MacLeod: Thank you.

382

00:56:54.690 --> 00:56:55.620

Anna Schauer: Thank you bye.