WEBVTT

1
00:00:02.010 --> 00:00:10.920
Morgan Elowe MacLeod: And that anytime basically if you have questions what you can do is send via the private chat to me Morgan.

2
00:00:12.120 --> 00:00:20.760
Morgan Elowe MacLeod: Just like a couple words on the topic of your question and that'll sort of slot you into the queue and then i'll call on you to ask your questions.

3
00:00:22.110 --> 00:00:42.600
Morgan Elowe MacLeod: So without further delay, let me introduce today's speaker park avila schools Navarro and Packwood did his PhD in Valencia after that was a postdoc in trista and then is now postdoc at the CCA in New York.

4
00:00:43.170 --> 00:00:45.180
Francisco Villaescusa-Navarro: And reason and princeton also.

5
00:00:46.080 --> 00:00:47.580
Morgan Elowe MacLeod: or sorry so.

6
00:00:48.000 --> 00:00:49.740
Francisco Villaescusa-Navarro: What you see on name bring stuff.

7
00:00:50.100 --> 00:00:52.620
Morgan Elowe MacLeod: Okay Okay, thank you, sorry about that.

8
00:00:54.030 --> 00:00:55.020
Morgan Elowe MacLeod: Somewhere down there.

9
00:00:57.120 --> 00:01:01.110
Morgan Elowe MacLeod: we're very grateful to have pocket today backers and expert and.

10
00:01:02.820 --> 00:01:10.830
Morgan Elowe MacLeod: sort of everything about the largest scale of the universe, I would say, and has been really doing a lot of work that I think like.

11
00:01:11.520 --> 00:01:25.290

Morgan Elowe MacLeod: brings together, making simulation models and and using them to kind of test like diagnostics that we might use in observation so i'm really excited to hear today.

12
00:01:28.260 --> 00:01:34.020
Morgan Elowe MacLeod: From that and talk about you know how do we get there, and how do we move forward, so thank you so much.

13
00:01:35.490 --> 00:01:39.210
Francisco Villaescusa-Navarro: Thank you, let me share my screen, I guess, you can see this.

14
00:01:39.360 --> 00:01:40.320
Morgan Elowe MacLeod: yeah that looks great.

15
00:01:41.610 --> 00:01:48.270
Francisco Villaescusa-Navarro: Alright, so, first of all, thank you very much, of course, for limitation is an honor for me for me to dock in front of you at least a weekly.

16
00:01:49.980 --> 00:02:01.140
Francisco Villaescusa-Navarro: want to talk about something I would have been doing, like a few couple of years and something I believe we are going to be working on for the next a maybe five years or so that these a.

17
00:02:02.550 --> 00:02:07.410
Francisco Villaescusa-Navarro: Like yeah the register the maximum information from from becoming a cosmological sorry.

18
00:02:09.180 --> 00:02:13.200
Francisco Villaescusa-Navarro: So let me start with the with the with the basically with a summary of the dog.

19
00:02:14.220 --> 00:02:30.450
Francisco Villaescusa-Navarro: So we as cosmology we carry out these cosmic observations and we basically try to extract information from this service so at the end of the day, what we are trying to do is to improve our understanding of the constituents and the laws governing our universe.

20
00:02:31.830 --> 00:02:42.750
Francisco Villaescusa-Navarro: So basically what I will be showing is that the typical tools that we use a tool is analysis to study information and probably not very optimal.

21
00:02:43.650 --> 00:02:52.050
Francisco Villaescusa-Navarro: So I will be making the comparison, I hope that this is, I don't want to bring this berry berry berry far it's just a comparison.

22
00:02:52.890 --> 00:02:57.060
Francisco Villaescusa-Navarro: Of is kind of similar to you know what a few centuries ago when we were looking at these head of lives.

23
00:02:57.780 --> 00:03:08.850
Francisco Villaescusa-Navarro: and basically a would pretty much missing, most of the information that he was that we were really just being able to read very, very, very small things and basically we're really missing, most of the metrics.

24
00:03:09.870 --> 00:03:21.390
Francisco Villaescusa-Navarro: That so at some point, there was a major breakthrough and we cover the rosetta stone, as you know, for that time is basically has the same message written in three different languages.

25
00:03:22.290 --> 00:03:28.260
Francisco Villaescusa-Navarro: And then, what really the key to basically allow us to basically integrate this head, or at least most of them.

26
00:03:30.330 --> 00:03:38.460
Francisco Villaescusa-Navarro: I will, I will, I will try to show you in this talk is that they, I believe that we as a Community, we can type movies, in the 21st century.

27
00:03:39.540 --> 00:03:51.000
Francisco Villaescusa-Navarro: and try to build this cosmological make a positive tone, but hopefully will allow us to basically read, most of the information, if not all that is written on this guy.

28
00:03:51.960 --> 00:04:06.480
Francisco Villaescusa-Navarro: And, at least when I see this is that these rosetta stone cosmic rosetta stone should should be a mixture of numerical simulations mo the state of the art hierarchical simulations combined with the deep learning techniques and.

29
00:04:07.830 --> 00:04:08.400
Francisco Villaescusa-Navarro: methods.

30

00:04:10.410 --> 00:04:19.290
Francisco Villaescusa-Navarro: So let me quickly so talk about the motivation, so we have this amazing mowed the lawn Dr moto moto sort of you know very well, this model was amazing.

31
00:04:20.160 --> 00:04:28.740
Francisco Villaescusa-Navarro: were able to explain very large variety of cosmological observation from the temperature on a shuttle between the CME to the distribution of galaxies.

32
00:04:29.790 --> 00:04:42.390
Francisco Villaescusa-Navarro: allergic to if you have a model that bores and the model seems to be working very well, then I think at the end of the day, the ultimate goal will be to constrain the value of the three parameters of the model as accurate as possible.

33
00:04:43.530 --> 00:04:46.710
Francisco Villaescusa-Navarro: And I see the ask you one of the ultimate goals and got molly.

34
00:04:48.300 --> 00:04:56.010
Francisco Villaescusa-Navarro: So he has to concentrate on something a little message with a smaller set of our orchestrator, for instance, the w w w with a small better.

35
00:04:57.270 --> 00:05:09.960
Francisco Villaescusa-Navarro: We want to know what is the sun, the absolute San Bernardino massey's maybe the hierarchy, would like to, of course, know what is the nature of that energy and these kind of things, so does that go and get the smallest error bar.

36
00:05:10.980 --> 00:05:11.910
Francisco Villaescusa-Navarro: On the value of the customer.

37
00:05:13.020 --> 00:05:13.410
Francisco Villaescusa-Navarro: As they go.

38
00:05:16.410 --> 00:05:26.370
Francisco Villaescusa-Navarro: So how do we do this in practice, so the way that we believe is that we carry on song a cosmological some patients in this talk, I think I will be focusing on focusing on galaxy sorry for this is completely general.

39
00:05:28.140 --> 00:05:34.410

Francisco Villaescusa-Navarro: And then, what I would say is that we right now we don't know how to work at the level of what we have cellulite this image itself.

40
00:05:35.760 --> 00:05:39.780
Francisco Villaescusa-Navarro: So what we do is to compress this image into a low dimensional.

41
00:05:41.400 --> 00:05:43.620
Francisco Villaescusa-Navarro: And the typical thing that we're using communities, of course, the power.

42
00:05:46.050 --> 00:05:51.450
Francisco Villaescusa-Navarro: And then from the theory side, what you do is you select like somebody figures Monica parameters this data.

43
00:05:52.500 --> 00:05:55.410
Francisco Villaescusa-Navarro: And then you make a prediction for how this quantity will look like.

44
00:05:56.850 --> 00:06:01.860
Francisco Villaescusa-Navarro: And of course you later, change your clinical practice and you try to match the two bars.

45
00:06:03.060 --> 00:06:04.020
Francisco Villaescusa-Navarro: Or the rest of the season.

46
00:06:05.610 --> 00:06:08.730
Francisco Villaescusa-Navarro: And this is the way that we've we've got more traditional.

47
00:06:10.890 --> 00:06:17.280
Francisco Villaescusa-Navarro: cuisine the bottom question here is what summary statistics shula us what am I said this is truly you know.

48
00:06:18.390 --> 00:06:20.910
Francisco Villaescusa-Navarro: compressed or the information from my feet.

49
00:06:22.140 --> 00:06:25.440
Francisco Villaescusa-Navarro: In order to get the smallest error on the cosmological parameters.

50

00:06:26.700 --> 00:06:34.590
Francisco Villaescusa-Navarro: or not, was what some statistics, allow us to basically don't lose any information from the fee to compress the information without losing anything.

51
00:06:37.860 --> 00:06:38.670
Francisco Villaescusa-Navarro: So these are pushing have.

52
00:06:39.960 --> 00:06:49.320
Francisco Villaescusa-Navarro: Some particular cases like, for instance, if you have a gaussian there's a TV, as you know very well the power spectrum can fully characterize this completely ascribed.

53
00:06:50.940 --> 00:07:02.520
Francisco Villaescusa-Navarro: If you want to start with cosmological parameters from these kind of feelings you compute the power spectrum and Jordan anything that you do, you will not constrained the values with a smaller Sir.

54
00:07:04.080 --> 00:07:12.360
Francisco Villaescusa-Navarro: I think the important question is, what about something like this right like galaxy surveys or in a completely other way, like what about generally known gaps fantastic.

55
00:07:14.250 --> 00:07:22.500
Francisco Villaescusa-Navarro: So these are question about the principle is word from within from the one of your mathematics will have been asking this question to mathematicians, the answer is that this is a mathematical.

56
00:07:24.120 --> 00:07:27.120
Francisco Villaescusa-Navarro: There is really no solution, but you can I guess the right.

57
00:07:29.550 --> 00:07:37.620
Francisco Villaescusa-Navarro: So this is the case, what I will say is that the way to to try to tackle this problem is to okay let's consider the power spectrum.

58
00:07:38.190 --> 00:07:50.220
Francisco Villaescusa-Navarro: let's see how we can position, the value of the parameters let's take a look at the spectrum spectrum the fantastic I mean goes be functional anything of you very much let's just take a look and let's see which one is the best.

59

00:07:53.490 --> 00:08:01.110
Francisco Villaescusa-Navarro: So how do we do this in practice, so there is a very well defined formulas for these so let's say that you have some statistics.

60
00:08:02.460 --> 00:08:06.150
Francisco Villaescusa-Navarro: Here, and considering the power spectrum Amigos be functional anything that you can imagine.

61
00:08:07.980 --> 00:08:09.870
Francisco Villaescusa-Navarro: question is given the statistics.

62
00:08:10.950 --> 00:08:13.680
Francisco Villaescusa-Navarro: How can I can constrain the value of the cosmological parameter.

63
00:08:15.360 --> 00:08:23.460
Francisco Villaescusa-Navarro: So for doing these you can construct this feature matrix that, basically, the only thing you need to compute these these everybody for your observer Paul would expect to the parameters.

64
00:08:24.870 --> 00:08:27.150
Francisco Villaescusa-Navarro: You compute your audience and then you went these metrics.

65
00:08:28.680 --> 00:08:36.360
Francisco Villaescusa-Navarro: And then there is this during the grammar upon that tell you that the variance of an optimal unbiased estimate will always be larger than this quantic.

66
00:08:38.130 --> 00:08:48.570
Francisco Villaescusa-Navarro: So basically this is pretty much all we have to We just need to compute this, and this will give us basically like a maximal information that they are not in my studies that will allow you to start.

67
00:08:50.430 --> 00:09:01.050
Francisco Villaescusa-Navarro: So doing this for any generally observable and doing this and in the northern and again it's not a trivial thing it's not, I would say trivial to compute these quantities and he's not really have to compute the glorious.

68
00:09:03.270 --> 00:09:08.310
Francisco Villaescusa-Navarro: So, in order to basically do this in our approach, what we have decided to Louisiana fooling Omega.

69
00:09:09.360 --> 00:09:18.960
Francisco Villaescusa-Navarro: and for this we have run this hotel simulation, so this is a set of more than 44,000 koulamallah simulations we have we sample.

70
00:09:20.490 --> 00:09:32.250
Francisco Villaescusa-Navarro: hyper playing compares by these parameters, with more than 7000 cosmology is, if you put all the simulation to whether you have trillions of particles, but I think the most important thing is that.

71
00:09:32.700 --> 00:09:40.830
Francisco Villaescusa-Navarro: single race, if we go with a volume that is larger than the volume of them kind of survival so interface of these these I think this version that.

72
00:09:42.840 --> 00:09:45.600
Francisco Villaescusa-Navarro: We can compute things like about as much with a better better precision.

73
00:09:47.460 --> 00:09:59.370
Francisco Villaescusa-Navarro: So we have billions of halos boys galaxies and all these kind of things and we spend a significant computational resources on these and everything is particularly if you want to use it, everything is.

74
00:10:00.990 --> 00:10:18.720
Francisco Villaescusa-Navarro: Let me just quickly like acknowledge the team, we all work very hard on these is very sort of people here is mostly people from three different areas, the bay area with Berkeley and Stanford princeton and New York, and then a lot of people from, as you can see, you will maybe find some.

75
00:10:19.860 --> 00:10:21.240
Francisco Villaescusa-Navarro: faces, that you will recognize.

76
00:10:22.260 --> 00:10:22.860
Francisco Villaescusa-Navarro: So.

77
00:10:24.030 --> 00:10:27.240
Francisco Villaescusa-Navarro: Basically, once you have these kind of things you're going to start asking like what.

78

00:10:28.560 --> 00:10:32.280
Francisco Villaescusa-Navarro: How I can understand the value of the parameters, with a given a statistics.

79
00:10:34.380 --> 00:10:42.720
Francisco Villaescusa-Navarro: So you can do this with a traditional powers right on this isn't that many people has done so, there is nothing so let's say that the country because the mother powers.

80
00:10:43.890 --> 00:10:48.840
Francisco Villaescusa-Navarro: And you go to something like a point three movies, what you obtain are these air right.

81
00:10:50.370 --> 00:10:50.970
Francisco Villaescusa-Navarro: ellipses.

82
00:10:53.220 --> 00:11:00.630
Francisco Villaescusa-Navarro: And the thing is that if you now go to your point five, or just like hierarchy basically this constraint doesn't really change.

83
00:11:02.040 --> 00:11:10.170
Francisco Villaescusa-Navarro: And these showed that basically information about spectrum Saturdays, at least on this scale your point five or six of these are skills, what I trust the simulations.

84
00:11:13.710 --> 00:11:21.960
Francisco Villaescusa-Navarro: So it seems that about speaking might not be maybe the best thing, so now, you know we started playing with this, and one of the most powerful things that we have found.

85
00:11:22.530 --> 00:11:26.580
Francisco Villaescusa-Navarro: Is the marbles peyton I know some of you guys that are also working on this.

86
00:11:27.570 --> 00:11:36.240
Francisco Villaescusa-Navarro: And the amount of hours between something medicine, when we compute a standard power spectrum we eat the same weight to every galaxy or two every particle in your simulation.

87
00:11:37.080 --> 00:11:44.400
Francisco Villaescusa-Navarro: And there is no reason why the movies and principal you can give a different a different weight to it for impact or different gods.

88
00:11:45.270 --> 00:12:00.300
Francisco Villaescusa-Navarro: So, in our case, what we did was to assign away to everybody, but basically we are waiting more on the densities if you're a galaxy and you live in avoid then we're gonna give you a higher weight, but if you are a galaxy and Julie Athena cluster, for instance.

89
00:12:02.250 --> 00:12:08.580
Francisco Villaescusa-Navarro: And just by doing this, you can repeat all this exercise, and the constraint do that in blue shown here, and you can see that the.

90
00:12:09.690 --> 00:12:16.530
Francisco Villaescusa-Navarro: Information content, by the way, what I mean by information content here is just constraint on the bottom of the bottom there on the parameters.

91
00:12:17.340 --> 00:12:25.260
Francisco Villaescusa-Navarro: that's what I mean by information condemn, you can see that you're doing much, much, much better, I mean particularly dangerous, the results are.

92
00:12:26.010 --> 00:12:36.300
Francisco Villaescusa-Navarro: ready specify a spectacular for our Boston office more last one, the capacity, you you, you can get a Phi Sigma constraints within all these forms right, this is at the level of the mountain field on these things.

93
00:12:37.560 --> 00:12:39.600
Francisco Villaescusa-Navarro: But he seems to be incredibly incredibly powerful.

94
00:12:42.150 --> 00:12:51.630
Francisco Villaescusa-Navarro: And we have not a bit this exercise in a very systematic way right for many different statistics we recently have the paper with adrienne again is another student at Berkeley.

95
00:12:52.380 --> 00:13:02.010
Francisco Villaescusa-Navarro: we'd have complete information content on the boys side function, combined with the HALO much passion and when you combine also with our spectrum concerns are also very good.

96
00:13:03.570 --> 00:13:05.880
Francisco Villaescusa-Navarro: Filipinos you're very, very tight constraints.

97
00:13:07.140 --> 00:13:16.260
Francisco Villaescusa-Navarro: Lena I forgot to say when I was also got a CCA a within this multiple speaker for a time, and I think, maybe this one of the most powerful things.

98
00:13:17.190 --> 00:13:28.230
Francisco Villaescusa-Navarro: chang's apostle got brimstone he has been leading this effort of computing information content on the full spectrum, I think the first time that this has been done into nonlinear scale using pretty much all the triangles.

99
00:13:29.280 --> 00:13:45.360
Francisco Villaescusa-Navarro: A we recently have a paper using the full let's say with galaxies and you can get even between a few times to five times, or even more information that the one that you get if you only use the power.

100
00:13:47.850 --> 00:13:52.890
Francisco Villaescusa-Navarro: cord, I was a postdoc at Cambridge and he has repeat exercise using the PDF that.

101
00:13:54.210 --> 00:13:58.620
Francisco Villaescusa-Navarro: The product is delusion fashion, but if you use these studies, a lot.

102
00:14:00.540 --> 00:14:15.510
Francisco Villaescusa-Navarro: And many people has on this, some people have looked at it, I speak my not even involved in all these things and try spectrum like three point function for velocities recently a game it nearest neighbors you know a lot of a lot of things.

103
00:14:18.150 --> 00:14:19.530
Francisco Villaescusa-Navarro: There is always a generic conclusion.

104
00:14:21.300 --> 00:14:26.940
Francisco Villaescusa-Navarro: And the United conclusion is that there is a lot of cosmological information, but this one is mosque.

105
00:14:28.230 --> 00:14:31.590
Francisco Villaescusa-Navarro: And this information cannot be reconstructed using the power.

106
00:14:34.380 --> 00:14:42.180

Francisco Villaescusa-Navarro: So this is basically my motivation to basically go to Morris case we're spending billions of dollars in UK.

107
00:14:44.190 --> 00:14:44.670
Francisco Villaescusa-Navarro: Moving.

108
00:14:46.140 --> 00:14:49.500
Francisco Villaescusa-Navarro: As gay or the service station and.

109
00:14:50.700 --> 00:14:52.890
Francisco Villaescusa-Navarro: If we're not really talking all this information.

110
00:14:54.030 --> 00:14:58.560
Francisco Villaescusa-Navarro: Then we are, we are maybe not doing our our best and.

111
00:15:00.510 --> 00:15:09.330
Francisco Villaescusa-Navarro: So we should go to this case like a small scale So what are the planning of this is the Bernie is that festival, they are gonna be nonlinear so you will need medical simulations in order to have your theory predictions.

112
00:15:10.110 --> 00:15:12.900
Francisco Villaescusa-Navarro: And the second thing is a business case I want to be affected by by the only difference.

113
00:15:14.010 --> 00:15:23.670
Francisco Villaescusa-Navarro: Here you know, let me be very ambitious, we are really talking about going to care of 100 I mean, why not let's go crazy if there is information that less is more for it, why not.

114
00:15:24.690 --> 00:15:31.440
Francisco Villaescusa-Navarro: So on these escapes about ending affects not only will change things they're not properties of gases, but will also, of course I modify.

115
00:15:33.150 --> 00:15:40.260
Francisco Villaescusa-Navarro: The solution of matter on galaxy but also probably this vision of galaxies the answer, so we need to take in these these these things in Hong Kong.

116
00:15:41.910 --> 00:15:46.560

Francisco Villaescusa-Navarro: And I would say the most conservative solution for this is to marginalize our efforts.

117
00:15:49.410 --> 00:16:04.920
Francisco Villaescusa-Navarro: So let me summarize this back so we make cosmological observations and we started information from this service, basically, in order to improve our knowledge about finance, not the constituents and the laws governing our.

118
00:16:06.960 --> 00:16:18.090
Francisco Villaescusa-Navarro: I have time to show you that using the standard tools that we use like the power spectrum we're really missing most of information and i'm delighted to have a dog, you will see that the disclaimer even gets much, much, much stronger.

119
00:16:19.560 --> 00:16:24.390
Francisco Villaescusa-Navarro: So, going back to these comparison, again I want to bring these very far.

120
00:16:24.990 --> 00:16:32.400
Francisco Villaescusa-Navarro: But I have the feeling that you know we're like a few centuries ago when we were looking at this paragraph, you know information what today is like with the service right it's not that the.

121
00:16:33.120 --> 00:16:45.420
Francisco Villaescusa-Navarro: data is really bad or something we can we were looking at this head of like they were amazing right, you can see everything they're all these details it's just that we were not able to stop all this information within brief have the tools or the dictionary.

122
00:16:49.470 --> 00:16:58.950
Francisco Villaescusa-Navarro: So now, I would like to change gears a little bit and as a question like maybe maybe the question and he's like.

123
00:17:00.240 --> 00:17:09.030
Francisco Villaescusa-Navarro: let's forget about the summary statistic right because I mean I don't mind principle, the could be an infinite number of these things will be incredibly boring go one by one, and you know I don't know.

124
00:17:11.130 --> 00:17:12.840
Francisco Villaescusa-Navarro: Can we start information from the fee.

125
00:17:14.010 --> 00:17:25.920

Francisco Villaescusa-Navarro: And can we drop all the information i'm putting here all with capital works is a very important thing is all information by this, so we can discuss this later, but this is the question is, all the homes or.

126
00:17:27.930 --> 00:17:30.390
Francisco Villaescusa-Navarro: And at the same time, can we marginalize we're running a fence.

127
00:17:32.940 --> 00:17:37.290
Francisco Villaescusa-Navarro: So yeah yeah will be something that you know if we'll have some universal on some simulation.

128
00:17:38.400 --> 00:17:40.590
Francisco Villaescusa-Navarro: There will be some corresponding value of the cosmos.

129
00:17:42.000 --> 00:17:46.770
Francisco Villaescusa-Navarro: And, in principle, the word is better than they should be some function lighting these parameters with your field.

130
00:17:49.020 --> 00:17:53.400
Francisco Villaescusa-Navarro: So, if that is this function, then we know that neural nets can approximate.

131
00:17:54.690 --> 00:18:02.820
Francisco Villaescusa-Navarro: That is this mathematical ferran that tell you that, on the very, very general conditions and you don't know can can always approximated by anything.

132
00:18:06.540 --> 00:18:14.160
Francisco Villaescusa-Navarro: So what i'm going to try to do now is to prove that the answer to this question is yes i'm gonna prove these for one particular case, for example.

133
00:18:15.330 --> 00:18:18.690
Francisco Villaescusa-Navarro: And I would like to clean up, I think, probably, the answer is yes in general.

134
00:18:20.760 --> 00:18:25.560
Francisco Villaescusa-Navarro: So hi and when I blew it, I want to use that example, something that is very simple, but they still I think is not trivial.

135

00:18:27.510 --> 00:18:29.790
Francisco Villaescusa-Navarro: So let's consider like to the gaussian distribution.

136
00:18:30.990 --> 00:18:33.450
Francisco Villaescusa-Navarro: and showing here like six examples of these.

137
00:18:34.800 --> 00:18:51.180
Francisco Villaescusa-Navarro: As you know, ago sensitivity can be fully characterized by the power spectrum, so they whether they can like create this a gaussian there's differences using these power strips you have some constant here, because it is a seat my safari parameter, and then you have some power.

138
00:18:52.260 --> 00:18:53.910
Francisco Villaescusa-Navarro: The results of the power law doesn't really matter.

139
00:18:56.640 --> 00:19:07.800
Francisco Villaescusa-Navarro: So what I want to do is to basically train the neural net to basically take the input, the map, just a month, without anything else i'm just going to basically provide the value of.

140
00:19:10.080 --> 00:19:19.200
Francisco Villaescusa-Navarro: Basically, to try to straddle the formation of these on the fee without me telling it what summary statistics should I use and see how would this isn't.

141
00:19:20.610 --> 00:19:26.910
Francisco Villaescusa-Navarro: So you know, this is a very simple simple wouldn't later talk about architecture that is really nothing here in particular.

142
00:19:28.650 --> 00:19:33.930
Francisco Villaescusa-Navarro: So you train the neural net you drink it with millions of map these maps are super easy to United so there's no problem.

143
00:19:35.940 --> 00:19:39.570
Francisco Villaescusa-Navarro: And then, once you have during your neural net you basically test how well is to.

144
00:19:41.250 --> 00:19:46.860

Francisco Villaescusa-Navarro: try not to test this what we do is the following we input to the neural net a 100,000 marks.

145
00:19:47.910 --> 00:19:49.860
Francisco Villaescusa-Navarro: What is the value of these parameters for.

146
00:19:51.600 --> 00:19:58.410
Francisco Villaescusa-Navarro: It must have the same value of a buddy's mom is different, but the cheetah more seats are different.

147
00:20:00.210 --> 00:20:15.270
Francisco Villaescusa-Navarro: And then you put them on the value of a job well done over the map, you will another value face another man who do get at the end of the day, 100,000 volume of American compute things like they mean and the standard deviation to view this video, what do we.

148
00:20:16.650 --> 00:20:21.240
Francisco Villaescusa-Navarro: do get that they mean by your face is this, and this is basically the standard deviation.

149
00:20:22.740 --> 00:20:34.290
Francisco Villaescusa-Navarro: So the first thing is that you can see that the neural net is behaving as an unbiased estimate, you can see, you can see the neural net here as an estimate right you input your field, and if give you one choice basically an estimate.

150
00:20:35.850 --> 00:20:39.000
Francisco Villaescusa-Navarro: So you'd be giving us an unbiased estimate, and this is there.

151
00:20:41.250 --> 00:20:44.070
Francisco Villaescusa-Navarro: but also because this model is so simple.

152
00:20:45.090 --> 00:20:58.170
Francisco Villaescusa-Navarro: And I know that these fields can be completely characterized by our spectrum, then I can do, efficient matters calculation on this, and this will give me the very best error bars that I can put on a when I use these maps.

153
00:21:00.030 --> 00:21:01.530
Francisco Villaescusa-Navarro: For the simple case I can lose.

154
00:21:02.610 --> 00:21:05.760

Francisco Villaescusa-Navarro: And you're not easy it's very simple basically solution is this.

155
00:21:06.870 --> 00:21:09.390
Francisco Villaescusa-Navarro: And this is their own sexuality so.

156
00:21:11.580 --> 00:21:25.800
Francisco Villaescusa-Navarro: Basically, this is a legitimate, so what you can see is that the error from the official marty's it's only like one or 2% better than the one from an event, and you know I can improve on them, you know, and I can train more I can put more data basically this number of the same.

157
00:21:27.240 --> 00:21:33.090
Francisco Villaescusa-Navarro: So the conclusion here is basically the neural net has fine is not behaving as the optimal unbiased estimate.

158
00:21:34.260 --> 00:21:41.790
Francisco Villaescusa-Navarro: So I think now we've got Francisco we're trying to prove that this really computing the bounce back, but it has to be windy maybe it's confusing the correlation function.

159
00:21:42.810 --> 00:21:47.220
Francisco Villaescusa-Navarro: But you know it's something that is from the machine learning point of view, is of course the abuse, but.

160
00:21:48.150 --> 00:21:57.570
Francisco Villaescusa-Navarro: But it still is fascinating to me this right, you only give data and he's one I basically learned to lose it took me years in the university right boo to learn to do all these things and.

161
00:21:58.620 --> 00:22:07.170
Francisco Villaescusa-Navarro: So basically implement something in two hours in the beauty, you know Saturday I was a little bit more DVDs so.

162
00:22:08.610 --> 00:22:12.420
Francisco Villaescusa-Navarro: The conclusion from this is that the neural net kind of scrap all the information from or.

163
00:22:13.470 --> 00:22:14.550
Francisco Villaescusa-Navarro: In this particular case.

164
00:22:16.170 --> 00:22:23.040

Francisco Villaescusa-Navarro: Let me show you about by the only difference i'm going to show you that, also known as can automatically learn to marginalize over these guys.

165
00:22:24.780 --> 00:22:28.890
Francisco Villaescusa-Navarro: So what we want to always so positive here three different gaussian these are still.

166
00:22:31.080 --> 00:22:36.690
Francisco Villaescusa-Navarro: The power spectrum of these fields are here in our spectrum as a function of K.

167
00:22:37.800 --> 00:22:42.330
Francisco Villaescusa-Navarro: You can see that these three fields have the same shape or larger scales.

168
00:22:43.830 --> 00:22:46.830
Francisco Villaescusa-Navarro: on a small scale, they maybe they have like different power.

169
00:22:47.880 --> 00:22:54.270
Francisco Villaescusa-Navarro: So these are ways to kind of mimic by the only Defense what we're assuming is upon larger scales your field will be.

170
00:22:56.130 --> 00:22:57.360
Francisco Villaescusa-Navarro: The last thing you have this field we.

171
00:22:58.410 --> 00:23:04.770
Francisco Villaescusa-Navarro: dominated by cosmology bothers Morris case below on escape, but you have to confess can really do anything.

172
00:23:06.090 --> 00:23:11.070
Francisco Villaescusa-Navarro: And this is a way to basically account for or or similar, but even if it's.

173
00:23:12.690 --> 00:23:20.850
Francisco Villaescusa-Navarro: So, will it be the exercise we input this maps into on your own IT and basically do a complete the values of the estimate.

174
00:23:22.230 --> 00:23:40.470
Francisco Villaescusa-Navarro: and basically what we found is that the audience of this is tomato is basically the same as the volume of if you

will compute the maps or the way down police escape basically if you come to the power of these maps down to this particular scale so basically ignoring all these case.

175
00:23:42.300 --> 00:23:42.780
Francisco Villaescusa-Navarro: So.

176
00:23:44.070 --> 00:23:44.910
Francisco Villaescusa-Navarro: In conclusion.

177
00:23:46.170 --> 00:23:56.070
Francisco Villaescusa-Navarro: Then you know net has basically learned that he has to ignore this escape like a small escapes, it has to ignore these and basically on a larger scale, it has to compute the hospital or the correlation function.

178
00:23:57.270 --> 00:23:59.100
Francisco Villaescusa-Navarro: and basically has to stop at this particular.

179
00:24:00.660 --> 00:24:09.960
Francisco Villaescusa-Navarro: So he has been able to extract all the information from the field and basically it's the very best the optimal way to.

180
00:24:12.300 --> 00:24:19.650
Francisco Villaescusa-Navarro: conclude this part and with this example, I have tried to prove that newness kind of stopped all the information all the information.

181
00:24:20.970 --> 00:24:24.150
Francisco Villaescusa-Navarro: And at the same time, they can also learn to marginalize or wondering offense.

182
00:24:25.800 --> 00:24:37.680
Francisco Villaescusa-Navarro: I think the important thing here is that I never say anything about the neural nets that these workouts and match the fields, the only thing that, then you know that you see in his values of over this theme different pictures, as all.

183
00:24:38.700 --> 00:24:39.120
Francisco Villaescusa-Navarro: The scene.

184
00:24:40.560 --> 00:24:46.320

Francisco Villaescusa-Navarro: I never done anything about the neural network these escape what what Erika fetzer has to learn this awesome article.

185
00:24:47.430 --> 00:25:00.810
Francisco Villaescusa-Navarro: So this is the reason why you know if I will just change my field to talk about this completely are getting longer and there's the field, I believe this will work, I cannot prove it, I don't know how to prove it, but I believe that this is the case.

186
00:25:03.600 --> 00:25:08.040
Francisco Villaescusa-Navarro: So the answer to this question seems to be this again, I have only proof for one very particular case.

187
00:25:09.060 --> 00:25:10.290
Francisco Villaescusa-Navarro: But I believe that is.

188
00:25:11.460 --> 00:25:12.210
Francisco Villaescusa-Navarro: Just in there.

189
00:25:13.980 --> 00:25:22.410
Francisco Villaescusa-Navarro: So this is the case, and we want to this what doing it, so what what will it will be simulation we have different cosmologists different astrophysicist and then we will need to train you on this.

190
00:25:23.370 --> 00:25:34.470
Francisco Villaescusa-Navarro: And then the idea would be to basically start information not only for our galaxy versus survey budget for next race from dsc from week lensing from one centimeter anything.

191
00:25:37.800 --> 00:25:42.870
Francisco Villaescusa-Navarro: And this brings me to the second treat of simulation that we are using not this problem, but these companies.

192
00:25:43.890 --> 00:25:57.180
Francisco Villaescusa-Navarro: So come on sister for cosmology and services with machine learning simulation, this is a suite of more than 4000 simulations half of them are embody nothing, in particular the other half are a state of the art magneto because.

193
00:25:59.160 --> 00:26:00.960
Francisco Villaescusa-Navarro: Half of this has been done using.

194

00:26:02.040 --> 00:26:12.000
Francisco Villaescusa-Navarro: The last three D amp D separate model and the other half harming has been brand using gizmo and this mm hmm so to a state of their calls and suddenly.

195
00:26:13.740 --> 00:26:24.510
Francisco Villaescusa-Navarro: We have six parameters that we brought in the simulation to fork of molly Omega matters, it might and for for us to have is to have control supernova feedback and to 4am.

196
00:26:25.860 --> 00:26:32.640
Francisco Villaescusa-Navarro: So, this one is not as much, these are only 25% boxes Medusa thousands of different cosmology some different services.

197
00:26:33.810 --> 00:26:51.330
Francisco Villaescusa-Navarro: So they have been really the time to to to to to bring neural nets and basically to the one on the machinery with machine So these are working in collaboration with many people I haven't say this, a new governor who's faculty at uconn Shannon.

198
00:26:52.350 --> 00:26:56.310
Francisco Villaescusa-Navarro: Who is accessing these at the title institute also many people.

199
00:26:57.630 --> 00:27:00.570
Francisco Villaescusa-Navarro: Lots of courses were involved body many.

200
00:27:02.910 --> 00:27:04.770
Francisco Villaescusa-Navarro: So let me show you here like one movie.

201
00:27:06.060 --> 00:27:18.510
Francisco Villaescusa-Navarro: So what you have seen this movie is that we run simulations the two simulation half the same initial conditions, the one on the left is wrong, we chose to stay in the young, one on the right is wrong with him.

202
00:27:19.950 --> 00:27:20.400
Francisco Villaescusa-Navarro: So.

203
00:27:21.960 --> 00:27:30.390
Francisco Villaescusa-Navarro: What you'll see here is from Sunday that matter of St things look very much the same in the two cases, if you look at the gas density, which will ensure here.

204
00:27:30.990 --> 00:27:43.080
Francisco Villaescusa-Navarro: There are some differences, but when you look at the vast temperature here, there are some striking differences, even though this simulation the free parameters of the model has been done to replace observation, not all, of course.

205
00:27:44.520 --> 00:27:45.180
Francisco Villaescusa-Navarro: A.

206
00:27:46.440 --> 00:27:53.790
Francisco Villaescusa-Navarro: When you play really compare then you'll see out there, I would say very, very different and that's exactly what we want in this.

207
00:27:56.520 --> 00:27:58.770
Francisco Villaescusa-Navarro: In these in these kind of programs.

208
00:28:00.480 --> 00:28:05.280
Francisco Villaescusa-Navarro: Okay, so let me go to the last part i'm running out of time, but he's probably the most interesting.

209
00:28:06.450 --> 00:28:15.210
Francisco Villaescusa-Navarro: So now let's let's go crazy right, I mean, why not Ellis Ellis try to local small very, very small so let's try to local small, medium K of 30.

210
00:28:16.590 --> 00:28:32.970
Francisco Villaescusa-Navarro: So what we have done is basically to construct, these are these are not even a freely fields, so we go to a simulation and we just take a slice of size 2525 by five so something negligible from the cosmological point of view, with a hat kind of hydrogen.

211
00:28:34.470 --> 00:28:37.140
Francisco Villaescusa-Navarro: depend on how you see these things 100 kilometers.

212
00:28:38.760 --> 00:28:51.930
Francisco Villaescusa-Navarro: And then you know we have like 1000 a simulation where we have different cosmology is the philosophies for each of them we create much of these things and basically we train on the roadmap to work from these maps to the value of the cosmological astrophysical.

213

00:28:53.130 --> 00:28:56.370
Francisco Villaescusa-Navarro: We saw Gaston bedrooms I don't know if I say something that.

214
00:28:57.600 --> 00:29:04.380
Francisco Villaescusa-Navarro: We haven't seen this is should be very affected by astrophysics I was expecting that there will be no information here.

215
00:29:06.360 --> 00:29:09.330
Francisco Villaescusa-Navarro: So one of the one of the string basically a contest.

216
00:29:10.740 --> 00:29:11.730
Francisco Villaescusa-Navarro: And these are the results.

217
00:29:14.250 --> 00:29:24.360
Francisco Villaescusa-Navarro: So let me, let me emphasize here is another posterior is basically distribution of the mean of the posterior over 3000 different maps that are in this.

218
00:29:25.230 --> 00:29:34.830
Francisco Villaescusa-Navarro: In some particular cases these really can be seen as the studio, but if you are near the areas where you are affected by priorities, but I mean for most of the cases I think it's safe to.

219
00:29:35.970 --> 00:29:37.770
Francisco Villaescusa-Navarro: succeed as a kind of that ourselves.

220
00:29:39.390 --> 00:29:45.960
Francisco Villaescusa-Navarro: So, if you look at, for instance, the constraint on Omega Martin has in mind, you can see that the social climate like an unbiased estimate.

221
00:29:46.560 --> 00:29:51.930
Francisco Villaescusa-Navarro: And the constraints are kind of amazing life for me, no matter where getting something like a 5%.

222
00:29:52.590 --> 00:30:07.650
Francisco Villaescusa-Navarro: and forcing myself like a 4% and this already includes the modernization or Veronica face of the level of the fee for something that they should be, I was expecting that to be very affected by the services so also anyone nothing this case he's really behaving as expected.

223
00:30:10.920 --> 00:30:15.150
Francisco Villaescusa-Navarro: And you know, this is not then have a story, and you can now lease for any field that you want.

224
00:30:16.230 --> 00:30:27.720
Francisco Villaescusa-Navarro: So we have a bit these for the gas density, who have repeated this, for that matter, density stellar mass Gospel or city that matter velocity.

225
00:30:28.440 --> 00:30:39.240
Francisco Villaescusa-Navarro: Motor hydrogen gas temperature, I think this is electron density gas mentally city, I think these guys pressure, these are magnetic fields.

226
00:30:39.720 --> 00:30:48.960
Francisco Villaescusa-Navarro: And this is something that channel told me to a certain biblical and I wouldn't have never do this, this is basically for the gas is the ratio between the mark nation on the hydro.

227
00:30:51.570 --> 00:30:54.870
Francisco Villaescusa-Navarro: Not maybe not very familiar with this thing, but you know I can just put this in 2011.

228
00:30:56.340 --> 00:31:08.130
Francisco Villaescusa-Navarro: So this is how things look like this is the error that you get on the parameters, so in this case, they are on is related basically the variance that you get from the mean of the posterior to the true value.

229
00:31:09.330 --> 00:31:15.450
Francisco Villaescusa-Navarro: So again, if you are near the edges and you are affected by priors these are lower and overestimate.

230
00:31:17.340 --> 00:31:21.420
Francisco Villaescusa-Navarro: In red is for Sigma and in blue for my grandmother so.

231
00:31:23.850 --> 00:31:34.050
Francisco Villaescusa-Navarro: The best feelings, for instance, this one, but these are that matter, this is from the full hybrids integration, I think this is affected because this film is less affected by astrophysics.

232

00:31:34.980 --> 00:31:39.870
Francisco Villaescusa-Navarro: This is a total madness defeat, something that we can spot with witnessing still constraints are very good.

233
00:31:40.380 --> 00:31:46.800
Francisco Villaescusa-Navarro: And as you move in this direction things get worse, but it's different on things like each one I think will be very happy with this.

234
00:31:47.340 --> 00:32:03.240
Francisco Villaescusa-Navarro: A it's doing incredibly well and even you know this kind of super we are feels like a machination over the hydrogen is not doing very well for my mother about this, the force it might were getting like a 7%, which is, I mean, I still, I would like to understand how this event.

235
00:32:06.450 --> 00:32:16.440
Francisco Villaescusa-Navarro: And the very last thing I want to say is that impossible, you can even combine all these finished with there is no reason why you need to consider one by one component all these fields together.

236
00:32:17.490 --> 00:32:22.500
Francisco Villaescusa-Navarro: And this is what basically I have realized that I have to throw away my intuition, because he's completely worthless.

237
00:32:23.220 --> 00:32:31.140
Francisco Villaescusa-Navarro: So I was expecting I was not expecting that the constraint will be so using these fields, while I was expecting that when I will put all this together.

238
00:32:31.620 --> 00:32:36.720
Francisco Villaescusa-Navarro: I will get like you know amazing or saying something like will be here completely manageable.

239
00:32:37.620 --> 00:32:49.950
Francisco Villaescusa-Navarro: And this under under us and what we're finding is not is that the constraints of this is the very best have you been using all the fields together but it's not really helping you much more than already having these kind of fish.

240
00:32:51.090 --> 00:32:52.680
Francisco Villaescusa-Navarro: And I think this is very interesting.

241

00:32:54.090 --> 00:32:54.870
Francisco Villaescusa-Navarro: So let me go look.

242
00:32:56.250 --> 00:32:56.820
Francisco Villaescusa-Navarro: So.

243
00:32:58.980 --> 00:33:02.700
Francisco Villaescusa-Navarro: So when spending billions of dollars in this course Monica service.

244
00:33:03.870 --> 00:33:14.340
Francisco Villaescusa-Navarro: We would like to really start all the information from these from these who really understand improve our understanding and the fundamental laws and fundamental constituents of our units.

245
00:33:15.570 --> 00:33:22.350
Francisco Villaescusa-Navarro: Using the typical tools that we use in cosmology I think we are really missing, most of the information at least, if you look at the results that we get from these maps.

246
00:33:23.400 --> 00:33:30.960
Francisco Villaescusa-Navarro: So I comparison is that the you know we are a few centuries ago where we were looking at these headlines and we will basically missing most of their message.

247
00:33:33.030 --> 00:33:38.550
Francisco Villaescusa-Navarro: Someone will discover that are set in stone, and then you know, for the first time, we were able to pay.

248
00:33:39.450 --> 00:33:46.530
Francisco Villaescusa-Navarro: 3000 years of history of these amazing civilization right that is still we are amazed by this.

249
00:33:47.460 --> 00:33:54.690
Francisco Villaescusa-Navarro: So I believe that the Community the stage we can be this a cosmological stone and the way that I see this is will be a combination of.

250
00:33:55.080 --> 00:34:02.370
Francisco Villaescusa-Navarro: embellishing rationalizing something about push, of course, we play a leading role on this and also have to be combined with the state of the.

251

00:34:02.760 --> 00:34:07.860
Francisco Villaescusa-Navarro: harmonica simulation procedure stingy and, of course, the things that the group of losses is doing there.

252
00:34:08.850 --> 00:34:17.520
Francisco Villaescusa-Navarro: But maybe also in combination with things like comments and then I believe that if we blow all these things together, using machine learning state of the art deep learning techniques.

253
00:34:18.210 --> 00:34:31.170
Francisco Villaescusa-Navarro: Hopefully, hopefully, we may be able to basically create all or most of the information that is written on the sky and improve our knowledge, so thank you very much thank you, I wish to.

254
00:34:33.510 --> 00:34:36.570
Morgan Elowe MacLeod: Thank you, the applause isn't as good as enjoy life.

255
00:34:39.030 --> 00:34:49.920
Morgan Elowe MacLeod: we're really grateful for such an interesting talk, so let me remind everyone who's coming in, if you have questions send me a private message I will call on you to speak up and.

256
00:34:51.060 --> 00:34:56.640
Morgan Elowe MacLeod: let's let's let's have a great conversation and again you don't have to send me your whole question just order to.

257
00:34:57.720 --> 00:34:59.520
Morgan Elowe MacLeod: But as we.

258
00:35:01.590 --> 00:35:13.530
Morgan Elowe MacLeod: dig into it and I don't think there's a full answer to this question, but it strikes me that as we marginalize over things that we are uncertain of.

259
00:35:14.760 --> 00:35:36.390
Morgan Elowe MacLeod: It it seems that we can perform that exercise if we know what knobs we're uncertain about are we in our training data if we know our uncertainty so maybe as I, as we go to other people's questions if you could talk a little bit about like, how do we include.

260
00:35:37.830 --> 00:35:48.210

Morgan Elowe MacLeod: How do we include sort of either sort of unconstrained physics or new physics, or what about things that are training data doesn't necessarily encapsulate.

261
00:35:50.010 --> 00:35:51.090
Morgan Elowe MacLeod: strategize that.

262
00:35:51.420 --> 00:36:00.300
Francisco Villaescusa-Navarro: that's a super good question, so let me, let me go back here, so I think that i'd like to maybe answer for these The first one is that they.

263
00:36:00.900 --> 00:36:12.030
Francisco Villaescusa-Navarro: What they've been showing so far is for the last exchange and I believe that this will not work if you turn on your end and you test notice end this will always work because you can just learn.

264
00:36:12.060 --> 00:36:13.950
Francisco Villaescusa-Navarro: Basically, read the features of the US to see.

265
00:36:15.420 --> 00:36:27.630
Francisco Villaescusa-Navarro: So this is actually the reason why, for this commerce we don't have only like they lose this energy, we also have the same gitmo and simple, these are completely different simulation so somewhere along right now.

266
00:36:29.280 --> 00:36:30.570
Francisco Villaescusa-Navarro: We still don't have any workshops.

267
00:36:31.770 --> 00:36:44.700
Francisco Villaescusa-Navarro: Is that something much more let's say robots or, at least until I would maybe trash more will be less strain on the loose change, and you know net to predict cosmology from the last exchange.

268
00:36:46.020 --> 00:36:49.740
Francisco Villaescusa-Navarro: One this is stain on elitist end less tears the some simple.

269
00:36:50.910 --> 00:36:55.830
Francisco Villaescusa-Navarro: When you don't have never seen him my understanding of symbiosis that is a completely different way.

270
00:36:56.880 --> 00:37:06.000
Francisco Villaescusa-Navarro: of solving the hypothetical equation that even completely way of this athlete modern so if we are able to recover the correct cosmology from symbol or.

271
00:37:06.690 --> 00:37:17.850
Francisco Villaescusa-Navarro: anything, then I think they will be reliable, robust, so we are working on these This may be the first answer the second thing is that they, but what about things that does not include a light use this in your symbol, a.

272
00:37:19.800 --> 00:37:21.810
Francisco Villaescusa-Navarro: cosmic rays, maybe or these kind of things.

273
00:37:23.160 --> 00:37:35.220
Francisco Villaescusa-Navarro: So I think, in this case, and what you would like to do is that, then the horror of here would be to create deposit boxes, with the you know the software basically having the resolution of.

274
00:37:36.750 --> 00:37:39.120
Francisco Villaescusa-Navarro: A lot of time to work on creating all these different things.

275
00:37:39.720 --> 00:37:42.120
Francisco Villaescusa-Navarro: So basically you can't really compare this with real data.

276
00:37:43.350 --> 00:37:57.480
Francisco Villaescusa-Navarro: I think, in this case once you have these mock data looks at the simplicity of the very best that you can achieve you can try to compute something like there was this time distance with respect to the real the real observations basically another was tried to find anomalies.

277
00:37:58.500 --> 00:38:11.370
Francisco Villaescusa-Navarro: So we will find anomalies and it will be anomalies at the level of the fields, so you know it might not only be like especially distribution of galaxies is wrong, but you know, maybe they got properties of galaxies are wrong already have a cdn who knows.

278
00:38:12.930 --> 00:38:21.090

Francisco Villaescusa-Navarro: If we find this kind of anomalies, then I think we need to go back to the simulations and try to improve on this on this species that should be missing and.

279
00:38:22.170 --> 00:38:27.300
Francisco Villaescusa-Navarro: or otherwise, try to marginalize over these things, maybe in the observation don't consider these particular things.

280
00:38:28.320 --> 00:38:28.920
interesting.

281
00:38:30.090 --> 00:38:35.640
Morgan Elowe MacLeod: Julian I think is is thinking along these lines, but a step further, do you want to go ahead and.

282
00:38:35.820 --> 00:38:37.890
Julian Munoz: Because yeah obviously great tobacco.

283
00:38:39.000 --> 00:38:47.460
Julian Munoz: So in distance like rosetta stone like what I would like to do with our set of stone is understand texts that i've never seen before right like.

284
00:38:48.060 --> 00:38:57.360
Julian Munoz: And, and what i'm thinking like in this line says, how can we use this to learn say about dark matter very small skills like things that the simulations maybe haven't seen, but things are.

285
00:38:58.320 --> 00:39:03.570
Julian Munoz: Equal learn, it could figure it out, can we, is there a way to look for exotic physic like you know back matter stuff like that.

286
00:39:04.440 --> 00:39:06.720
Francisco Villaescusa-Navarro: yeah that's a very good question and.

287
00:39:07.890 --> 00:39:17.400
Francisco Villaescusa-Navarro: I think is maybe kind of similar to before right, I mean, I think we will, in this case, we will need to find look for anomalies, something that the simulation by themselves cannot really explain.

288
00:39:18.780 --> 00:39:31.830

Francisco Villaescusa-Navarro: I think, right now, as things are use a this we're not really privy to any extra parameter or something like that, so this will not work, so I think the way to to do these will be to find this anomaly, so I believe.

289
00:39:33.060 --> 00:39:40.710
Francisco Villaescusa-Navarro: And it's also not Caribbean how to find this at the level of the field and reading the breath Why exactly when but then jump.

290
00:39:41.790 --> 00:39:45.180
Francisco Villaescusa-Navarro: Otherwise, young I not sure how how the least.

291
00:39:50.370 --> 00:39:50.550
Francisco Villaescusa-Navarro: I.

292
00:39:52.110 --> 00:39:52.980
Morgan Elowe MacLeod: Had a couple.

293
00:39:53.070 --> 00:39:57.900
Morgan Elowe MacLeod: of questions and, if you want to go ahead and ask either one or several that'd be great.

294
00:39:58.620 --> 00:39:59.070
yeah.

295
00:40:00.090 --> 00:40:06.390
Mila Chadayammuri: Your work is really excellent, and I have a lot of questions and maybe I should just leave with you separately to ask some more.

296
00:40:06.900 --> 00:40:19.920
Mila Chadayammuri: Questions um yeah so first of all it's impressive just how many simulations you've run and i'm curious about what your technique was for for sampling the perimeter space.

297
00:40:22.050 --> 00:40:24.870
Mila Chadayammuri: yeah I guess my first most basic.

298
00:40:25.800 --> 00:40:28.050
Morgan Elowe MacLeod: yeah nobody into said that you know.

299

00:40:29.280 --> 00:40:41.640
Morgan Elowe MacLeod: This is the ITC talk so we're as close to like fellow computer nerds that has, as it gets so like you know I like died of being overwhelmed when I ran a.

300
00:40:42.180 --> 00:40:51.030
Morgan Elowe MacLeod: 20 models and I had to like keep changing them when I entered things wrong in the parameter health, so you know how do we scale up these kinds of experiments.

301
00:40:52.530 --> 00:40:56.700
Francisco Villaescusa-Navarro: yeah so I mean it is a very good question, of course, a festival him.

302
00:40:58.980 --> 00:41:13.470
Francisco Villaescusa-Navarro: I think i've been super lucky that's basically, I think you know i've been I was in CCA before now i'm in princeton I have very good competition other sources and the has not always been my case you know I did my PhD in his pain and I remember that day, I have my laptop.

303
00:41:14.850 --> 00:41:26.640
Francisco Villaescusa-Navarro: And that's it, you know I understood, I really wanted to reservation, but I never basically was able to because I have my gap right, so I couldn't do much so that's why you know I know I always for these and I always pushing.

304
00:41:30.540 --> 00:41:34.710
Francisco Villaescusa-Navarro: Everything should we should we made polycom right like, and you know.

305
00:41:35.790 --> 00:41:44.460
Francisco Villaescusa-Navarro: At least 444 we release everything basically from the first week that we didn't even yeah so so basically that they need for this is a very simple, this is just a lot in hyper.

306
00:41:45.090 --> 00:41:55.680
Francisco Villaescusa-Navarro: So we have some of these with right, we have a uniform volume, for instance, for this commerce a this Latin hyperloop it's like very, very broad for Omega matter we take something like 1.5.

307
00:41:56.430 --> 00:42:04.950
Francisco Villaescusa-Navarro: forces, maybe something like from point 621 point zero something really crazy, and these are some physical parameters what they told me is that.

308
00:42:06.180 --> 00:42:16.200
Francisco Villaescusa-Navarro: it's nothing contained situation that i'm not even feasible you either you completely destroyed your galaxy or basically there is not enough feedback to produce something realistic.

309
00:42:16.860 --> 00:42:23.490
Francisco Villaescusa-Navarro: So you have these gigantic volume and basically you just blow this with a lightning happened I don't know if you know what that I think hyper to peace.

310
00:42:26.100 --> 00:42:30.630
Francisco Villaescusa-Navarro: But it's basically a way to sample the parameter space what you want, basically repeat.

311
00:42:30.720 --> 00:42:32.070
Francisco Villaescusa-Navarro: The value of any parameters.

312
00:42:33.090 --> 00:42:35.790
Francisco Villaescusa-Navarro: In every simulation last must be the sampling methods.

313
00:42:37.470 --> 00:42:37.920
Mila Chadayammuri: Ah.

314
00:42:39.030 --> 00:42:41.790
Mila Chadayammuri: Okay, I think it's still a different question.

315
00:42:43.590 --> 00:42:52.140
Mila Chadayammuri: Well, no, no, if you're starting to get there right, but I think as Morgan was mentioning yeah like you know if I run 100 i'm back.

316
00:42:54.150 --> 00:42:54.690
Mila Chadayammuri: And i'm.

317
00:42:55.830 --> 00:42:59.880
Mila Chadayammuri: Running run thousands, if not hundreds of thousands of simulations.

318
00:43:00.870 --> 00:43:01.380
Francisco Villaescusa-Navarro: Are you.

319
00:43:01.440 --> 00:43:04.830
Mila Chadayammuri: auto generate the initial conditions are you, you know.

320
00:43:05.940 --> 00:43:06.180
Mila Chadayammuri: yeah.

321
00:43:06.240 --> 00:43:07.200
Mila Chadayammuri: This movie 2d.

322
00:43:08.340 --> 00:43:09.090
Francisco Villaescusa-Navarro: Or do you mean.

323
00:43:09.450 --> 00:43:12.900
Francisco Villaescusa-Navarro: How to run 1000 simulations without going one by one.

324
00:43:16.230 --> 00:43:22.410
Mila Chadayammuri: you're using you know supercomputers I get that we caught on laptops they just mean.

325
00:43:22.680 --> 00:43:33.150
Mila Chadayammuri: How do you tell a supercomputer here's the six dimensional parameters space sample it like this, and then generate a simulation for each of them without manually having to say, and in this simulation we use this.

326
00:43:33.390 --> 00:43:38.610
Mila Chadayammuri: parameter set in this simulation to use this I mean you're not doing that 44,000 times right.

327
00:43:39.330 --> 00:43:40.980
Francisco Villaescusa-Navarro: i'm very patient, thank you, thank you, you know.

328
00:43:42.870 --> 00:43:47.880
Francisco Villaescusa-Navarro: we're not doing this is very simple, I mean you just you just write that script you know physically present.

329
00:43:49.050 --> 00:43:53.940
Francisco Villaescusa-Navarro: In most of the cases, the only thing that changes is the initial condition on the value of the cosmological parameters.

330
00:43:54.510 --> 00:43:59.670
Francisco Villaescusa-Navarro: So you need to sleep basically what you change the value of the ownership and then you need another script where.

331
00:44:00.420 --> 00:44:10.680
Francisco Villaescusa-Navarro: Basically, you change the value of the cosmological parameters and then you tend to like you, you look very careful to is a script but that's easy it's not going anywhere, but if you know.

332
00:44:12.450 --> 00:44:14.490
Mila Chadayammuri: that's very inspiring to know, thank you.

333
00:44:15.930 --> 00:44:16.770
Francisco Villaescusa-Navarro: compute that I think.

334
00:44:18.240 --> 00:44:33.240
Mila Chadayammuri: Okay, my last question for now is you know you were you were seeing how much information you could extract from all of these maps right and you were measured, you were using things like temperature medalists D and.

335
00:44:34.980 --> 00:44:42.960
Mila Chadayammuri: You know the goal, presumably is to figure out how much information, we can extract from observations right but.

336
00:44:45.150 --> 00:44:46.710
Mila Chadayammuri: map they're.

337
00:44:47.910 --> 00:44:52.020
Mila Chadayammuri: going to be very sparse they're going to have large error bars.

338
00:44:52.590 --> 00:45:02.820
Mila Chadayammuri: Right so and so they're going to be course they're going to be sparse and they're going to have large error bars so um How does that affect the quality of your parameters.

339
00:45:03.480 --> 00:45:10.530
Mila Chadayammuri: Like if you only know your temperatures to plus minus 50% or metal cities, plus minus 50% and you don't have a map.

340

00:45:10.860 --> 00:45:21.960
Mila Chadayammuri: Over a continuous or large region and even within what regions, you have it is course it's lower resolution because each of those things affect the quality of your parameter estimation.

341
00:45:23.070 --> 00:45:30.570
Francisco Villaescusa-Navarro: yeah that's a good question so if anything we haven't gone that far to try to maybe try to really do this with a real observations.

342
00:45:31.020 --> 00:45:37.470
Francisco Villaescusa-Navarro: But definitely I mean these maps is a song song kind of idealistic right, I mean we're not we don't have noise right so.

343
00:45:37.800 --> 00:45:45.720
Francisco Villaescusa-Navarro: The same principle, the very best that you can do and I with real data, of course, you will not be able to, for instance sample the boys are separate us as we are doing here.

344
00:45:47.820 --> 00:45:54.330
Francisco Villaescusa-Navarro: In terms of of having the data like you say, like a split in different parties, if I understood correctly.

345
00:45:55.410 --> 00:46:08.820
Francisco Villaescusa-Navarro: yeah maybe not so much concerned about this because, in principle, you know you can even just take this a small batches and just you know, maybe you start information from these are smart part this is more parts disorders most part, and then you can try to combine these things.

346
00:46:10.740 --> 00:46:24.690
Francisco Villaescusa-Navarro: I don't know if you can assume that this thing will be independent, but you know if maybe we are very far away, maybe you can do it and, basically, you can reduce your during this way, but they do we honestly we haven't really explored this possibility in detail so yeah.

347
00:46:28.020 --> 00:46:31.110
Morgan Elowe MacLeod: let's keep thanking me let's keep talking noise.

348
00:46:32.340 --> 00:46:34.560
Morgan Elowe MacLeod: indra has a question along.

349
00:46:34.590 --> 00:46:42.900

Andrew Saydjari: I think my question was very similar to the last one about how adding noise modifies things but maybe I can adjust the question a bit, since you answered that one and.

350
00:46:43.530 --> 00:46:49.590
Andrew Saydjari: I mean, do you understand what your filters and these neural networks are actually learning, have you visualize feature maps because.

351
00:46:49.890 --> 00:46:58.620
Andrew Saydjari: You might be really worried that you're susceptible to gaussian noise or adversarial nice attacks and you'll do very poorly unreal data so, can you give us an idea what the filters are lending.

352
00:46:59.370 --> 00:47:05.040
Francisco Villaescusa-Navarro: yeah so we haven't looked at the filter of the CNN in this particular case, I think i'm training juicing.

353
00:47:06.120 --> 00:47:13.470
Francisco Villaescusa-Navarro: girls have three by three or five by five so sometimes you know when you look at this, I think you really don't don't cannot really look at anything.

354
00:47:14.040 --> 00:47:24.270
Francisco Villaescusa-Navarro: There is a parcel at princeton seminary for Asia who is basically looking at this fallacy maps or these kind of techniques to see exactly where the information is coming from so.

355
00:47:25.500 --> 00:47:34.800
Francisco Villaescusa-Navarro: I think the preliminary sauce is that a lot of information is actually coming from boats and is similar to the previous question boys will be sure been affected by noise so.

356
00:47:35.400 --> 00:47:42.300
Francisco Villaescusa-Navarro: You know these might change dramatically if we start adding noise, but the yeah I mean he's looking at all these different.

357
00:47:42.930 --> 00:47:50.940
Francisco Villaescusa-Navarro: methods to try to understand and quantify economies is really looking at the high temperature regions or the law at the metro regions.

358
00:47:51.570 --> 00:47:55.380

Francisco Villaescusa-Navarro: And the conclusion is that this is is taking information from everyone.

359
00:47:56.220 --> 00:48:13.530
Francisco Villaescusa-Navarro: But somehow, it seems that there is a kind of the peak of information is in regions where the actual is not very high, but also not very long, so I think this might respond to something like they feel admins have a cdn and yeah but then it's also clear why Why is doing this.

360
00:48:15.360 --> 00:48:20.070
Andrew Saydjari: So Bobby said what's your filter size was how deep and wider these neural networks could use.

361
00:48:20.250 --> 00:48:23.940
Francisco Villaescusa-Navarro: yeah so yeah so for this, I spent a lot of time, you know this Christmas.

362
00:48:24.390 --> 00:48:30.420
Francisco Villaescusa-Navarro: So I was using basically it's an architectural I was using for the option maps, it was getting very borders house and then.

363
00:48:31.140 --> 00:48:44.100
Francisco Villaescusa-Navarro: I started playing with architecture, I guess, as you as you as you might know this is super boring doing this right now, what I have is basically a CPA convolution neural net mature activation and I have a team of these.

364
00:48:45.300 --> 00:48:48.060
Francisco Villaescusa-Navarro: And then I have, I think, like two or three fully connected layers.

365
00:48:49.110 --> 00:48:57.450
Francisco Villaescusa-Navarro: The first one has like at least 1000 euros or something like that so it's I think pretty deep, but in terms of parameters is not that matches.

366
00:48:59.400 --> 00:49:07.740
Francisco Villaescusa-Navarro: With also here like Beijing hyper parameter optimization and I think we have between five and 15 million kilometers there's nothing crazy on.

367
00:49:09.240 --> 00:49:11.310
Francisco Villaescusa-Navarro: My video is basically a team CNN.

368
00:49:17.550 --> 00:49:19.140
Morgan Elowe MacLeod: Charlotte would you like to go ahead.

369
00:49:22.380 --> 00:49:29.010
Charlotte Mason: hi Well, my question was very similar to me this so I can adapt to a bit, but if there's someone else who has a different question.

370
00:49:29.820 --> 00:49:31.380
Morgan Elowe MacLeod: So I think it's.

371
00:49:31.380 --> 00:49:33.060
Morgan Elowe MacLeod: still go ahead.

372
00:49:33.420 --> 00:49:42.150
Charlotte Mason: Okay alright so um yeah this is really beautiful and I think I think I was thinking along the same lines is Mina I think particularly thinking about.

373
00:49:43.530 --> 00:49:54.420
Charlotte Mason: I guess the sparseness that you that we really measured with galaxy survey so obviously what you show, I think, is great for intensity mapping, but most of the.

374
00:49:55.470 --> 00:50:02.550
Charlotte Mason: A lot of cosmos was ever a moment at galaxy survey so you're just looking kind of this very sparsely sampled field.

375
00:50:03.660 --> 00:50:07.350
Charlotte Mason: And so yeah I was just wondering if if that's something that.

376
00:50:08.070 --> 00:50:08.970
Francisco Villaescusa-Navarro: yeah is it is available.

377
00:50:09.150 --> 00:50:09.960
Charlotte Mason: to explore.

378
00:50:10.020 --> 00:50:18.210
Francisco Villaescusa-Navarro: yeah so the closest thing that we have here to kind of through galaxy services is this field, but these these telomeres and I think this is.

379
00:50:20.340 --> 00:50:22.260
Francisco Villaescusa-Navarro: Maybe perishing to what you're really upset.

380
00:50:24.870 --> 00:50:28.260
Francisco Villaescusa-Navarro: In this case, this is actually the field that is when worse so.

381
00:50:29.820 --> 00:50:37.740
Francisco Villaescusa-Navarro: But it's also true that this field is also very sparse so my model to drain the sentence might not be the most the best one here.

382
00:50:38.220 --> 00:50:52.680
Francisco Villaescusa-Navarro: we're not going to use these graph neural nets what you will not have this point anymore, you can use the burning of the CNS that you need to find a great and, if you agree, these verifying it will not fit in the memory of GPA, but if you use Good afternoon, so you don't have these anymore.

383
00:50:54.420 --> 00:51:14.790
Francisco Villaescusa-Navarro: So yeah you're completely right and yeah we'll have to to go from these kind of St like two examples to more real data and see how things look like and it's just like a fresh inspiration of in principle of things at least have a question.

384
00:51:15.840 --> 00:51:41.010
Morgan Elowe MacLeod: We can ask just a clarification question so when you say sparse it sparse in terms of your different realizations of the stellar mass or like sparse on the sky, in terms of like coverage like I see only one galaxy at a very nonlinear point of the cosmological intensity.

385
00:51:41.220 --> 00:51:45.240
Francisco Villaescusa-Navarro: it's actually he is like most of the big cells in this image.

386
00:51:46.290 --> 00:51:48.240
Francisco Villaescusa-Navarro: are basically are basically pseudo.

387
00:51:49.380 --> 00:51:56.880
Francisco Villaescusa-Navarro: Right and then for some cases this is actually a problem for for Ireland to to live with the dispatch that.

388
00:51:58.620 --> 00:52:01.380
Morgan Elowe MacLeod: So, can you talk a little bit more about you were talking about the.

389
00:52:02.760 --> 00:52:11.520
Morgan Elowe MacLeod: It were you saying my graph neural network, can you tell someone who doesn't know about the works, a little bit more about that.

390
00:52:11.700 --> 00:52:26.340
Francisco Villaescusa-Navarro: So, so this graph here let's see so it's a completely different and architecture, so in that case, what you what you do is that, then you can start like a graph so let's say that you have a set of points, so you can, in principle, you know join the points to whether or.

391
00:52:27.210 --> 00:52:27.780
Morgan Elowe MacLeod: Whatever theme.

392
00:52:28.200 --> 00:52:29.040
Francisco Villaescusa-Navarro: And you make a graph.

393
00:52:30.390 --> 00:52:40.620
Francisco Villaescusa-Navarro: And then the idea is that, from the graph you directly, try to go to the body of the cosmological product or a service called parameters, and this is actually our friends and people working on in.

394
00:52:43.500 --> 00:52:50.220
Francisco Villaescusa-Navarro: Chemistry I don't know if you want to quantum chemistry enemy is a V4 chemistry well, you have this molecule so these proteins.

395
00:52:50.730 --> 00:52:58.800
Francisco Villaescusa-Navarro: Basically, these pretty much like a graph right, you have a graph and then basically given the structure of this protein or this molecule you try to breathe life.

396
00:52:59.670 --> 00:53:09.450
Francisco Villaescusa-Navarro: chemical properties of these so you know, there is a lot of people working on this, and these are burning that is perfect for this good after that, because you're you're you're you're really working on the level of the graph.

397

00:53:10.230 --> 00:53:17.280
Francisco Villaescusa-Navarro: And by the, by the way our graph is something is a generalization actually have this units within us, you have to have agreed.

398
00:53:17.730 --> 00:53:33.570
Francisco Villaescusa-Navarro: Our graph is really to work at the level of on a structure late, you can have as many neighbors have you on the graph can be something super we are is really this will work on this, so there will be to basically put all these galaxies.

399
00:53:34.650 --> 00:53:46.530
Francisco Villaescusa-Navarro: Basically, you can maybe join them and make a graph and then even this graph because the graph already contain like you know the clustering properties in principle, you can put all the galaxy properties that you upset in and not.

400
00:53:47.340 --> 00:53:59.790
Francisco Villaescusa-Navarro: Then, given this graph basically try to predict the value of the cost of medical practice and yeah we're we're working on these, and I think, in principle, she will she will do much better than when these kind of architecture.

401
00:54:00.660 --> 00:54:10.080
Morgan Elowe MacLeod: that's really interesting, and I mean something that's at least to me really compelling about this sort of approach is is that.

402
00:54:12.000 --> 00:54:29.790
Morgan Elowe MacLeod: You know, in a sense, we get to try, all of these different methods and and and essentially have a benchmark on their robustness against themselves, or at least their self consistency, if not their robustness against the real universe, which is slightly less determined.

403
00:54:31.290 --> 00:54:31.650
Morgan Elowe MacLeod: So.

404
00:54:33.270 --> 00:54:43.590
Morgan Elowe MacLeod: yeah so as part of that story, do you think it's really critical that we are simulating all the way up to the quantity that we're observing like in a sense, like if we're.

405
00:54:44.400 --> 00:54:56.460

Morgan Elowe MacLeod: Observing as traveler was saying, like galaxy counts do like versus a dark matter density that correlates but isn't exactly the same thing.

406
00:54:57.750 --> 00:55:08.520
Francisco Villaescusa-Navarro: yeah exactly I think this is actually what what we should really try to work at the level of the field, but you know when when they do the same in detail, it gets very kind of messy so.

407
00:55:09.360 --> 00:55:18.780
Francisco Villaescusa-Navarro: I mean surely Horn myself with a group in euclid for for machine learning a better version we're basically we're trying to do this for one model right.

408
00:55:20.100 --> 00:55:24.870
Francisco Villaescusa-Navarro: And the other day, we have a very interesting discussion is like, but I mean what level do we stop right because.

409
00:55:26.640 --> 00:55:36.870
Francisco Villaescusa-Navarro: What you really have said is you know you have your you know your comment or your your detector or whatever, and you upset like photons coming all you need to take into account.

410
00:55:36.930 --> 00:55:45.030
Francisco Villaescusa-Navarro: yeah you know even the maybe the quantum fluctuation or hopefully not but then, but this is, you know it's really so.

411
00:55:46.290 --> 00:55:52.680
Morgan Elowe MacLeod: Right like what part is part of the simulation pipeline and what part is part of the data and instrument pipeline.

412
00:55:52.980 --> 00:56:07.410
Francisco Villaescusa-Navarro: is very important that you also take into account all these things in the systematics not only simulate the field of yourself on this team, but also see semantics that you really are effective, otherwise I think you are going to get a gigantic bias so.

413
00:56:07.800 --> 00:56:12.540
Morgan Elowe MacLeod: Right right there your statistical sort of summary doesn't represent.

414
00:56:13.200 --> 00:56:19.920

Morgan Elowe MacLeod: yeah that's really interesting well with that sort of note towards the future, do you have any sort of closing thoughts about.

415
00:56:20.250 --> 00:56:33.570
Morgan Elowe MacLeod: You know what are the next steps, what are we, where do we go from here, and I think you've presented a really compelling argument for know how much there is to learn and how much information content, there is in the information we're starting to collect.

416
00:56:34.260 --> 00:56:39.150
Francisco Villaescusa-Navarro: yeah so let me, let me, maybe quickly mentioned this thing I mean this is a, as I said before, our.

417
00:56:41.280 --> 00:56:42.720
Francisco Villaescusa-Navarro: Our goal right now is.

418
00:56:42.750 --> 00:56:45.990
Francisco Villaescusa-Navarro: To create deposit boxes.

419
00:56:48.000 --> 00:56:57.240
Francisco Villaescusa-Navarro: Where we are going to have a source, a lot of tend to anime and then these the opposite boxes, we want to be like full hydrodynamic like if you do this.

420
00:56:57.870 --> 00:57:08.040
Francisco Villaescusa-Navarro: Like brute force, this probably computationally unfeasible so not only we want to at least for one simulation, but we want to release for basically millions of simulations right so.

421
00:57:09.030 --> 00:57:18.660
Francisco Villaescusa-Navarro: it's one of your major challenge so yeah will you very simple is that with this condition Roger we have our coach, what are we have like thousands of different cause marketing.

422
00:57:20.340 --> 00:57:26.520
Francisco Villaescusa-Navarro: And then, what we can do this immersion doesn't have like hires, but what we can do is to use the super resolution techniques.

423
00:57:27.000 --> 00:57:40.710
Francisco Villaescusa-Navarro: I was one of the outdoors of what we show, for the first time that you can train you on so basically increase the

resolution of your simulation so we can take this key code assimilation, increase the resolution going all the way to tend to a nice solid message.

424
00:57:42.030 --> 00:57:56.970
Francisco Villaescusa-Navarro: And then, now we have thousands of different cosmologist with the opposite boxes are solving 1020 now we can go with comments, what we have the empathy and the full five, and then we can use on your net to basically learn the mapping we don't embody to full credit.

425
00:57:58.260 --> 00:58:07.110
Francisco Villaescusa-Navarro: And this will be the way to basically having millions of the deposit boxes to solving a lot of them to interact with full hydro.

426
00:58:07.650 --> 00:58:24.750
Francisco Villaescusa-Navarro: Well, you will have also thousand of different astrophysical models and once you have all these things and we'll see who is able to install these things, then you put everything in your in your likelihood of influence or just simulation base influence and you go to a parameters and.

427
00:58:26.520 --> 00:58:26.940
Francisco Villaescusa-Navarro: i'm not sure.

428
00:58:28.230 --> 00:58:28.620
Francisco Villaescusa-Navarro: If.

429
00:58:30.240 --> 00:58:41.220
Francisco Villaescusa-Navarro: That will be room for improvement, if someone is able to be right, because this, I think this will really contain all the information I think it's again it's a very big word but.

430
00:58:42.300 --> 00:58:42.780
Francisco Villaescusa-Navarro: I believe.

431
00:58:44.100 --> 00:58:44.610
Francisco Villaescusa-Navarro: This will be.

432
00:58:47.130 --> 00:58:56.700
Morgan Elowe MacLeod: A beautiful Jason and and also, and that will give us all plenty to work on coming years, because as astrophysicist, we need to keep ourselves busy.

433
00:58:58.470 --> 00:59:06.720
Morgan Elowe MacLeod: This is really wonderful, thank you for a beautiful talk I learned a tremendous amount Thank you to everyone here, thank you for your great questions and conversation.

434
00:59:08.310 --> 00:59:12.390
Morgan Elowe MacLeod: really grateful and we'll look forward to convening again next week.

435
00:59:13.560 --> 00:59:16.410
Morgan Elowe MacLeod: let's thank our speaker, one more time as best as we can.

436
00:59:20.340 --> 00:59:20.940
Francisco Villaescusa-Navarro: Thank you guys.

437
00:59:21.930 --> 00:59:22.560
Thank you.