

WEBVTT

1

00:00:08.069 --> 00:00:08.370

Morgan Macleod: I'm

2

00:00:10.769 --> 00:00:13.349

Morgan Macleod: Gonna let me introduce our first speaker.

3

00:00:14.190 --> 00:00:15.330

Morgan Macleod: Or have been Aruba

4

00:00:15.509 --> 00:00:20.730

Morgan Macleod: Rubio, who is a member of the faculty at the University of Edinburgh.

5

00:00:21.750 --> 00:00:37.380

Morgan Macleod: Before that he did his PhD in Heidelberg, and held positions at the Max Planck Institute at the University of Victoria and at the University of the original Cambridge and

6

00:00:39.660 --> 00:00:45.870

Morgan Macleod: And why I was so consumed with my joke that I lost track of what I was

7

00:00:48.330 --> 00:01:05.280

Morgan Macleod: In any case, her as an expert in it. I guess we'll find out if this is a fair characterization, but like using stars as tracers of the underlying sort of dark matter dynamics that that our galaxy and others.

8

00:01:06.450 --> 00:01:10.320

Morgan Macleod: Enclose. So without further ado, we're very happy to have you here.

9

00:01:11.280 --> 00:01:12.630

Jorge Penarrubia: Thank you, Maria. Thank you very much.

10

00:01:13.140 --> 00:01:16.680

Jorge Penarrubia: Okay, so let me try to share my screen.

11

00:01:24.360 --> 00:01:24.660

Here.

12

00:01:25.740 --> 00:01:26.940
Right and

13

00:01:30.390 --> 00:01:37.860
Morgan Macleod: Also, not to say that when when when there's five minutes to go on that has a bell sound that sharp

14

00:01:38.790 --> 00:01:41.490
Jorge Penarrubia: Oh, right. So can you see my screen.

15

00:01:41.550 --> 00:01:41.940
Morgan Macleod: Yeah, and

16

00:01:42.270 --> 00:01:42.990
Jorge Penarrubia: And the cursor.

17

00:01:43.110 --> 00:01:46.140
Jorge Penarrubia: Yep, perfect. Alright. So let me start in

18

00:01:46.440 --> 00:01:56.820
Jorge Penarrubia: So today's talk. Thank you very much for the invitation. I should say so and so. So today's talk is going to be about tomatoes have a structure and whether or not

19

00:01:57.630 --> 00:02:09.540
Jorge Penarrubia: We can use it to put constraints on call them other particles with a very massive above you get it from votes. So we're going to go look at the very fine detail.

20

00:02:10.050 --> 00:02:23.040
Jorge Penarrubia: Of our galactic and I'm at the halo and. Okay, so I've seen you, everyone has seen this picture so many times. I'm not going to explain what this in here. But what I would like to draw your attention is to the fact

21

00:02:23.670 --> 00:02:36.240
Jorge Penarrubia: That the lander CPM model is a classical mold in the sense that it uses classical physics, there is no sort of physics. There is no new physics in these in our paradigm that mother behaves us are perfect fluid.

22

00:02:36.960 --> 00:02:43.770

Jorge Penarrubia: We don't interact through gravity. So, and we really see no deviation from these classical

23

00:02:44.250 --> 00:03:02.100

Jorge Penarrubia: Picture and all the way down to very high a moment here you can see the cosmic microwave background. So, in principle, and with the data at hand, we have no evidence that the matter is a particle and in principle, as you can see behind us through it.

24

00:03:03.300 --> 00:03:04.170

Jorge Penarrubia: All right, so

25

00:03:05.250 --> 00:03:09.120

Jorge Penarrubia: And the question now is, where he said it doesn't matter is metal

26

00:03:09.660 --> 00:03:18.930

Jorge Penarrubia: Particles, where are we going to see deviations from the target fluid and and basically all the matter political candidates and predict some dumping of his kids.

27

00:03:19.410 --> 00:03:29.280

Jorge Penarrubia: And view to quantum effects and those quantum effects can vary depending on the model, but these truncation is predicted by all political models.

28

00:03:30.000 --> 00:03:45.270

Jorge Penarrubia: And the scale or the energy where these truncation arises and mainly depends on the data particle mass and they think you can see here the bottom is that for colder matter with particles with masses of the order of culture on board.

29

00:03:45.780 --> 00:03:51.840

Jorge Penarrubia: And we expect the truncation to happen on a scale of parsecs which are very small and astronomical terms.

30

00:03:52.350 --> 00:03:58.290

Jorge Penarrubia: So people go back to receive 60, for example, the coupling time and then the calculate what is

31

00:03:59.010 --> 00:04:04.530

Jorge Penarrubia: The mother, the mother mass and close within this volume within the scale on would define a stat.

32

00:04:05.130 --> 00:04:14.220

Jorge Penarrubia: That masses of theater of tend to minus six solar masses which is of the order of the planet like the planet Earth. So these massive scale is where you would expect.

33

00:04:15.000 --> 00:04:25.560

Jorge Penarrubia: Very strong suppression of structures in the universe. Right below 10 to six minor and then one minus 600 muscles, we should not expect any a pillow.

34

00:04:26.310 --> 00:04:38.490

Jorge Penarrubia: In these models. And so when people adopt the power spectrum we saw before, and seeing the power spectrum assumed our mother behaves as a perfect fluid and then current simulations.

35

00:04:38.880 --> 00:04:48.000

Jorge Penarrubia: Like here. This one is Aquarius is one of the best simulations of the diameter halo of the Milky Way with 510 to nine particles were defined

36

00:04:48.570 --> 00:04:55.140

Jorge Penarrubia: Already a few years ago we were talking before about getting old. So this simulation. It's already 12 years old.

37

00:04:55.920 --> 00:05:04.140

Jorge Penarrubia: And what they found polka and colleagues and his colleagues words and a lot of substructure. A lot of structuring our Halo.

38

00:05:04.830 --> 00:05:19.470

Jorge Penarrubia: And more interestingly, when people when they assume in substructure with the phone is SAP halos contain themselves SAP haters. So this is what we call the sub sub Halo hierarchy. And if you, you could do the same thing can zoom

39

00:05:20.550 --> 00:05:33.510

Jorge Penarrubia: In one of these affiliate Sup sup heroes and then you will find sub sub sub pages and this hierarchy intense and repeats itself very much like a fractal all the way down to the free streaming of the article.

40

00:05:34.530 --> 00:05:45.690

Jorge Penarrubia: Okay, so another interesting result from the Aquarius collaboration was this is the massive spectrum of those subpoenas I showed you before, it seems to

41

00:05:46.350 --> 00:05:54.960

Jorge Penarrubia: Who are very, very tight our law, the end he goes like em to manage to and if you see here, we acquire you simulate

42

00:05:55.680 --> 00:06:06.630

Jorge Penarrubia: Resolution. So this is the poorest versus a five this best resolution, a one, what happens is that a far, I've only results of healers, all the way to tend to

43

00:06:07.350 --> 00:06:23.550

Jorge Penarrubia: Do a solar masses investment solution to to find more structure which goes all the way to the five solar masses, but something that to bear in mind is that this is a still make any orders of magnitude low

44

00:06:34.350 --> 00:06:42.780

Jorge Penarrubia: Structures in the simulations and so well. You can see here the number if you extrapolate the Aquarius. Oh, sorry.

45

00:06:44.100 --> 00:06:53.370

Jorge Penarrubia: So if you extrapolate the Aquarius and mass function and to the estimated length, mass, then you find you the simulation would predict, of the order of 10 to 15

46

00:06:54.210 --> 00:07:01.080

Jorge Penarrubia: And some structures in the Milky Way Halo milky way here. So these 10 10,000 times more than stops.

47

00:07:01.560 --> 00:07:11.670

Jorge Penarrubia: Visible some structures and what we call satellites and occupy on the halos with above tend to be a sort of masses. So the area within this curve is really time

48

00:07:12.210 --> 00:07:22.560

Jorge Penarrubia: And the rest dark and on interact through gravity so 10 to 15 sup heroes is really an upper sorry. Is it really a lot lower limit because

49

00:07:22.890 --> 00:07:33.240

Jorge Penarrubia: If you consider particle masters about TV and people nowadays. Consider even TV. Then you these these truncation moves to the left.

50

00:07:33.780 --> 00:07:46.470

Jorge Penarrubia: And to even tend to minus 12 Solomon says the masters of asteroids and these number becomes very close to our album. So this is the production from CDN, really, is that, you know, at some point.

51

00:07:47.700 --> 00:07:56.700

Jorge Penarrubia: We have to think of the Dharma. The Halo like almost like a people think about the molecules in gaps. Right. So, so this is a big challenge.

52

00:07:57.210 --> 00:08:00.630

Jorge Penarrubia: To to our theoretical understanding of the of the matter here.

53

00:08:01.200 --> 00:08:13.380

Jorge Penarrubia: Alright, so, so this talk, I will try to answer very briefly, these three questions. So first question is do micro halos these 10 to the minus x six and Solomon says a lot either dynamics or physical systems.

54

00:08:13.800 --> 00:08:22.440

Jorge Penarrubia: This is an important question because if the answer is yes, we might hope to put constraints on the dark matter particle energy mats.

55

00:08:23.040 --> 00:08:31.680

Jorge Penarrubia: And and the question would be, like, very much like in particle physics. How sensitive are we to what energy range. Can we actually test it perfectly mobile

56

00:08:32.310 --> 00:08:40.080

Jorge Penarrubia: You know, and that's not clear. And finally, what are the best observational systems to put constraints on the on the truncation of them aspect.

57

00:08:41.100 --> 00:08:52.620

Jorge Penarrubia: Some aspect. So what I'm going to show today is actually very old work that I read to a couple of years ago. And this goes back to attend the seminar, he published three papers in 41

58

00:08:53.130 --> 00:09:01.680

Jorge Penarrubia: What he did was very interesting. And I have to say. And so what he did was to, first of all, write it down. The question of motion of a

59

00:09:02.070 --> 00:09:11.130

Jorge Penarrubia: Particle so much less particle moving in a clumpy potential. And so the first thing he did was to divide the potential into a smooth.

60

00:09:11.700 --> 00:09:24.180

Jorge Penarrubia: Mean feel component last and this little forces in the US by all these individual superstructures okay so and in these models is very large, much larger than one

61

00:09:25.020 --> 00:09:30.060

Jorge Penarrubia: Then he defined these combined for us, which is there some of the new evil forces of this have healers.

62

00:09:30.570 --> 00:09:38.430

Jorge Penarrubia: And if he's work. You can see this point masses. But what they did in 2018 was to extend, extend the ticket theory to extended optics.

63

00:09:39.000 --> 00:09:47.400

Jorge Penarrubia: And are very convenient. The object is a hank with his fears, because the modification of appointment is quite true. We are the only thing you do is to add

64

00:09:47.760 --> 00:09:56.850

Jorge Penarrubia: This size, which I'm going to the note with see this work. So point masters. Terrific. Our work is recovered when you said C C equals zero.

65

00:09:58.740 --> 00:10:08.130

Jorge Penarrubia: Okay, once we wrote down this. And the first question is, and that's Undertaker answer was, what is the spectrum of force fluctuations, right, because

66

00:10:08.580 --> 00:10:26.130

Jorge Penarrubia: Each individual force depends on the relative location of the particles. These particles move. So the relative location changes with time and that causes fluctuations in capital F. So, you can calculate the spectrum of for fluctuations. This is based on the work that holds marketing.

67

00:10:27.810 --> 00:10:34.620

Jorge Penarrubia: Date. So this paper is really beautiful. He was investigating the motion of charged particles in a plasma.

68

00:10:35.130 --> 00:10:51.810

Jorge Penarrubia: So what the tender second did was to basically change the electromagnetic forces by gravitational forces and everything can be used again. So I did the same thing, but instead of using a show of deriving this equation for you, which I don't have time for doing that is very elegant

69

00:10:52.950 --> 00:11:02.490

Jorge Penarrubia: And but I don't have time. So I'm going to show you an experiment that shows how how this spectrum arises. So in this experiment, you're going to see a tracer particle and a circular orbit.

70

00:11:03.270 --> 00:11:10.320

Jorge Penarrubia: You're going to see how they combined for fluctuates here with time. And here I'm going to calculate a histogram of forces.

71

00:11:10.770 --> 00:11:19.470

Jorge Penarrubia: So this is what's going on. So very quickly, those departure from sequel or Orbitz you perturbations of these little dots which are our structures.

72

00:11:20.130 --> 00:11:31.020

Jorge Penarrubia: As expected, the combined for slack to AIDS and randomly around some mean but what you see here is that the spectrum and forth fluctuations. This is static.

73

00:11:31.560 --> 00:11:44.070

Jorge Penarrubia: So, and this is a what we call the whole smart distribution. Right. So this distribution is static, because these objects dots and and mechanically real. So this is what we call the whole smart distribution fee of it.

74

00:11:45.420 --> 00:11:55.380

Jorge Penarrubia: Okay, and something interesting to see is that actually you see the maximum forces experiencing by attrition particles keeps rising. Right. So this is an important observations will come back to these

75

00:11:56.640 --> 00:12:03.150

Jorge Penarrubia: Alright. So as I said, what I did was to repeat the whole smart innovation. This time for Hank with his fears.

76

00:12:03.870 --> 00:12:14.940

Jorge Penarrubia: Is interesting because you get done analytical audience here is just a second moment of this division which is proportional to the mass of the substructure says queer times the number of density divided by size.

77

00:12:15.630 --> 00:12:30.990

Jorge Penarrubia: So you see that immediately that tend to think I had a problem because for him, he was using point masses so libertarians four point masters diverges. But for extended objects. There is no issue the theories that contain any any divergence

78

00:12:32.250 --> 00:12:41.400

Jorge Penarrubia: Alright, so this is for forces. Now we know the spectrum of sap halos. And we know the how the size of the masters are related in in a call the other

79

00:12:41.820 --> 00:12:51.930

Jorge Penarrubia: So we can model that as a simple power law here. And because it is a linear theory, we, we just need to operate in the variance. Right. So when you average the variance

80

00:12:52.590 --> 00:13:06.780

Jorge Penarrubia: With these math functions and size functions, but you guys I know the power law with an index three plus or minus meter. So if you substitute alpha here minus two and beat up plus your point five. What you find is that three plus or minus, which is your boy.

81

00:13:08.100 --> 00:13:18.660

Jorge Penarrubia: This is a positive number, which means that, you know, here the violence is dominated by this term, the maximum papilloma so the fluctuations are dominated by massive subpoenas

82

00:13:19.110 --> 00:13:30.930

Jorge Penarrubia: And this was very bad news at the time when I got this result after so much work because basically was telling me that the truncation is impossible. We have no access to em one if we use forces.

83

00:13:32.010 --> 00:13:39.690

Jorge Penarrubia: But what I did was basically not give up so easily. And then I look at the title forces which are the derivative of the forces.

84

00:13:40.320 --> 00:13:48.150

Jorge Penarrubia: So in this case we are not interested in single Trisha particles we are dealing now with several gravity. The North Texas. For example, a binary star.

85

00:13:48.660 --> 00:13:54.360

Jorge Penarrubia: Now what we're interested in the equation of motion is that relative separation between the binary particles.

86

00:13:55.080 --> 00:14:09.990

Jorge Penarrubia: Then you have the self gravity of the bear. You have a smooth style tensor from the external potential. And then you have another moister fluctuating target answer and the flexibility tensor SSH directly for the combined forces. I was showing you before.

87

00:14:11.100 --> 00:14:24.000

Jorge Penarrubia: Now there is a problem here before I could use hold smart aviation and I had to isotope is this forces, right, because you know holds America method is very arrogant but the only works if the forces are random. The

88

00:14:24.630 --> 00:14:39.990

Jorge Penarrubia: Point in a random directions. So what they did was to die on Allah is basically the individual talent answers. And then I saw two is the forces. So I define this combined our vector which points in random directions, but it contains the magnitude of the Tyler forces.

89

00:14:41.280 --> 00:14:45.000

Jorge Penarrubia: Alright, that works very well. We take and he said very good approximation.

90

00:14:46.170 --> 00:14:55.710

Jorge Penarrubia: Alright, so again we can do the same thing as before. Now you have a binary particle subject to a random forces from these little dots in dynamic equilibrium

91

00:14:56.040 --> 00:15:04.140

Jorge Penarrubia: So they combine our answer. Sorry combined title force fluctuates, but you see again that something the whole smart distribution arises pretty quick.

92

00:15:05.430 --> 00:15:16.740

Jorge Penarrubia: Something interesting here is that the binary tends to gain energy. Right. So you see that the binary particles are getting less and less bound with them and eventually now.

93

00:15:17.190 --> 00:15:31.470

Jorge Penarrubia: They just become disrupted. So this is an interesting, interesting observation, because it means that you know binary stars and subject to entitled for fluctuations. We can be disruptive us. It was very well.

94

00:15:33.240 --> 00:15:37.200

Jorge Penarrubia: Alright, so we calculate now they're part of the task forces and now

95

00:15:38.610 --> 00:15:47.670

Jorge Penarrubia: An analytical and equation. Now, it's very similar to the force variants, but you might notice here that instead of one divided by s²

96

00:15:48.090 --> 00:15:54.930

Jorge Penarrubia: What we have is one way by sides to the third power. And this is very interesting. When I got this result because it's really showing you

97

00:15:55.410 --> 00:16:00.810

Jorge Penarrubia: The task forces are much more sensitive to a small objects as I give at a fixed mass

98

00:16:01.230 --> 00:16:07.620

Jorge Penarrubia: So this is a very promising when I when I saw this and, indeed, when you combine the Manson. This is functions.

99

00:16:08.010 --> 00:16:14.280

Jorge Penarrubia: But you get this and our power law by now the exponent is the index is three plus alpha minus three beta, which is negative.

100

00:16:14.730 --> 00:16:26.880

Jorge Penarrubia: Which means that these variances now dominated by the smallest, smallest Peters, the truncation of the spectrum. So this was really great news. Right. This was it made my day at the time.

101

00:16:27.840 --> 00:16:37.680

Jorge Penarrubia: Okay. The final bit. This is the most difficult part now is to understand how to use those for fluctuations to basically described the motion of Trisha particles.

102

00:16:38.400 --> 00:16:43.380

Jorge Penarrubia: Or self correction in particles. So this was the first step to get the spectrum of force fluctuations.

103

00:16:43.830 --> 00:16:54.330

Jorge Penarrubia: Now, the problem here is that if you could, you have to know that when the effect of the of this enforces you need two times, right, you need to Tea quality one

104

00:16:54.660 --> 00:17:00.780

Jorge Penarrubia: And Tea quality to. And the problem is that at a later time. The location of these objects. It's not random.

105

00:17:01.680 --> 00:17:14.430

Jorge Penarrubia: Because they disappeared. Follow trajectory. So it means that instead of multiplication here. Well, you have a compilation of this spectrum this mathematically as some of the show is quite

106

00:17:14.670 --> 00:17:21.090

Jorge Penarrubia: Difficult, I wouldn't recommend anyone to try this approach, it was a mathematically is is quite a nightmare.

107

00:17:21.840 --> 00:17:28.860

Jorge Penarrubia: So thankfully, in terms of cigar and also in 1941 and propose a third method, which is the one I'm going to use

108

00:17:29.760 --> 00:17:37.380

Jorge Penarrubia: When he said you know trace a particular subject to force fluctuations are going to undergo a random walk in Gotham City space.

109

00:17:37.710 --> 00:17:48.660

Jorge Penarrubia: And that's a huge simplification is a beautiful idea because basically what happens now is that the probability to experience a velocity is just a calcium. So it goes and probably the function

110

00:17:49.050 --> 00:17:54.420

Jorge Penarrubia: And the only thing we need to do is to compute to coefficients. The truth coefficient and the diffusion coefficient

111

00:17:55.800 --> 00:18:03.900

Jorge Penarrubia: So the drift coefficient is zero by symmetry. If you are dealing with a nicer tropic distribution of separate structures that so that's easy.

112

00:18:04.230 --> 00:18:15.930

Jorge Penarrubia: The sink on coefficient that efficient coefficient is the one that is difficult to calculate. So this bracket denote average over the key of F and the probability of experiencing.

113

00:18:16.500 --> 00:18:26.100

Jorge Penarrubia: And London sorry pure fun. Alright, so here you see it's a complicated question. Yes, sir. I'm going to Russia will be so so you can solve these in

114

00:18:26.640 --> 00:18:33.390

Jorge Penarrubia: This equation analytically under certain cases. So first of all, you have here the fluctuation mean life.

115

00:18:33.900 --> 00:18:41.760

Jorge Penarrubia: So I cannot explain how how this is calculated it goes back to an idea from smoking in 1916. It's a very elegant one

116

00:18:42.300 --> 00:18:57.000

Jorge Penarrubia: And but basically for this month's operations is telling you that the fluctuation mean, life is just the time that are given a payload takes to close this radius. And so he said so divided by the diversity of the mean those gifts. I feel so it is simple.

117

00:18:58.050 --> 00:19:02.700

Jorge Penarrubia: The second component was derived by Feinberg in 94 is

118

00:19:04.530 --> 00:19:10.110

Jorge Penarrubia: This a correction is an automatic correction to the energy absorbed by binary star, for example.

119

00:19:10.680 --> 00:19:19.320

Jorge Penarrubia: And so binaries with very high or written frequencies or less energy from the fluctuating title field and these coefficient takes that into account.

120

00:19:19.830 --> 00:19:32.760

Jorge Penarrubia: Some way forward, what we find it. You have to solve this integral, which you can do in these two limits when either for binaries with very or lower frequencies or combine it with a story with very high frequencies.

121

00:19:33.150 --> 00:19:43.530

Jorge Penarrubia: These are tightly bound binaries or loosely bound binaries with very low return frequency. So we are interested in this one impulsively team. These are low loosely bound by owners.

122

00:19:44.100 --> 00:19:52.830

Jorge Penarrubia: And again, something familiar faces again GM is square races in the equation. And now we have a size square in the denominator. So

123

00:19:53.520 --> 00:20:03.810

Jorge Penarrubia: Indeed, is going to be in between what I showed you before, when you integrate mean velocity kicks and that the tracer binary start going to kick again.

124

00:20:04.380 --> 00:20:12.960

Jorge Penarrubia: It's another power law with an index three plus or minus two beta, which in this case is very close to zero. So zero means algorithmic divergence

125

00:20:13.980 --> 00:20:26.820

Jorge Penarrubia: Where the violence of the velocity impulses gross library of one divided by the truncation of the spectrum, but you might see here you are very, very close to either diverting or converting

126

00:20:27.750 --> 00:20:38.790

Jorge Penarrubia: Our functions here. So let's take one step back and see how we really allow to extrapolate this mass this size function in particular.

127

00:20:39.300 --> 00:20:48.000

Jorge Penarrubia: To masters of 10 to 16 right so this is what we are doing really well. Assuming that is a power all the way down with this exponent.

128

00:20:48.540 --> 00:20:55.080

Jorge Penarrubia: But we are neglecting scattered and I think this this this is very much UNKNOWN I'm not very confident

129

00:20:55.800 --> 00:21:05.520

Jorge Penarrubia: On this Appalachian sweetie. So I would say that CDN cannot make very strong predictions unless we find out what are the masses and the sizes.

130

00:21:06.030 --> 00:21:11.220

Jorge Penarrubia: Of SAP halos with planet size planet is kind of mass killed

131

00:21:12.210 --> 00:21:21.180

Jorge Penarrubia: All right, but still we can use these beautiful theoretical sorry statistical theory to construct a Monte Carlo simulations, where we are going to

132

00:21:21.600 --> 00:21:27.150

Jorge Penarrubia: Some publicity kicks from a Gaussian and he really doesn't get more much more simple than that in statistics.

133

00:21:27.570 --> 00:21:39.150

Jorge Penarrubia: So this is a super, super efficient way of mimicking the effect of separate structures and I've tested that I can show you the results of test against direct force calculations, if you want.

134

00:21:39.840 --> 00:21:51.660

Jorge Penarrubia: But for now, this is my last slide or penultimate slide there just to show you this experiment is our planetary disk composed of tracer particles on sequel or Orbitz moving in a plane.

135

00:21:52.320 --> 00:21:59.130

Jorge Penarrubia: Run into t equals zero, you're going to see here the set component of the momentum and the energy of these particles.

136

00:21:59.580 --> 00:22:05.370

Jorge Penarrubia: And this is what happens when you, when when you introduce this velocity fluctuations, the velocity kicks.

137

00:22:05.970 --> 00:22:11.910

Jorge Penarrubia: So what happens to this planetary this case study hits hits up in the radio direction and in the vertical direction.

138

00:22:12.420 --> 00:22:19.020

Jorge Penarrubia: Very quickly, you see these red dots which are particles say it could be comments on retrograde or it

139

00:22:19.770 --> 00:22:28.350

Jorge Penarrubia: And you see also that the something like an order cloud starts to arise as well. These are particles moving on basically so trippy Corbett.

140

00:22:28.800 --> 00:22:35.730

Jorge Penarrubia: Which are almost like a cocoon around and forming a cuckoo around the central potential

141

00:22:36.450 --> 00:22:45.000

Jorge Penarrubia: But these are the clouds, if I may call it like that then vanishes with time, just because there is an operation going on all the time. So there are particles crossing

142

00:22:45.330 --> 00:22:54.210

Jorge Penarrubia: To positive energies. So I mean, my, my, like this result because it's showing that basically something like the solar system. This process must be going on.

143

00:22:54.630 --> 00:23:03.630

Jorge Penarrubia: We must be sharing some comments of the Oort cloud to the interstellar medium and vice versa. We might be, you know, getting some comments.

144

00:23:04.050 --> 00:23:14.760

Jorge Penarrubia: From other star systems on to our system. So okay, so this is enough. And so this is a with the theory, you can compute escape rate and

145

00:23:15.150 --> 00:23:24.690

Jorge Penarrubia: Basically will show us something you can connect. Now this keep rate of the of the comments to the mass and the sizes of the servers, which is very nice as well.

146

00:23:25.170 --> 00:23:32.970

Jorge Penarrubia: And of course this is at predicting that some stars will be naked, they will devoid of commentary clouds. If they are embedded in Colombia media.

147

00:23:34.350 --> 00:23:45.330

Jorge Penarrubia: All right, and that's the structure of course when it has evaporation. So we might hope to use a commentary clouds around planetary systems to put constraints on tax structure as well in the future.

148

00:23:46.050 --> 00:23:56.490

Jorge Penarrubia: Alright, so this is my summary. Sorry if I went a limited time. So hopefully you like this and these statistical theory, which is based on some soccer.

149

00:23:56.970 --> 00:24:08.340

Jorge Penarrubia: And working 9041 and thanks to this theory. Now we have a Monte Carlo method to samples that he kicks, which can be implemented in the body of hydro simulations.

150

00:24:08.700 --> 00:24:13.770

Jorge Penarrubia: And basically no cost because we are drawing from a Gaussian Lhasa think is from a Gaussian

151

00:24:14.400 --> 00:24:20.820

Jorge Penarrubia: It's also a linear theory. So you can very easily combine the effect of all the performers like start Monica clouds matches.

152

00:24:21.510 --> 00:24:28.320

Jorge Penarrubia: And you can apply this to the best systems to apply these methods, it will be too loosely bound objects like

153

00:24:28.920 --> 00:24:45.240

Jorge Penarrubia: Or cloud, but also white binaries movie stars, said our class, they're serving God guys course. I think this will be very interesting to see whether these these fluctuations can remove many of the infringement of cluster populations. And thank you very much for your attention.

154

00:24:53.190 --> 00:24:57.870

Ana Bonaca: And if we are to judge by the number of questions your thoughts.

155

00:24:59.160 --> 00:25:05.430

Ana Bonaca: Inspired on our Slack channel. I think he had just definitely shows that you're still being creative and therefore young has

156

00:25:07.110 --> 00:25:08.160

Ana Bonaca: Hit the beginning

157

00:25:08.970 --> 00:25:11.880

Jorge Penarrubia: What do one papers right so 1942 and

158

00:25:13.140 --> 00:25:33.360

Ana Bonaca: I'm so keep kind of a theme going other a couple of questions, dealing with the distribution of sub structures and I'll start on the kind of small scales as harsh will come to our asks, How difficult would say interpolations be for and not as a tropic distribution of sub structures.

159

00:25:33.900 --> 00:25:46.740

Jorge Penarrubia: And much more difficult I think unfortunately to derive the the power spectrum. Sorry. The P affair for P have landed a spectrum of force fluctuations and so you do that basically inferior space and

160

00:25:47.310 --> 00:25:55.080

Jorge Penarrubia: So if you drop the assumption of so typically distributed objects, then it becomes much harder.

161

00:25:55.770 --> 00:26:03.570

Jorge Penarrubia: And so that's why it's in the cigar use completely different technique to derive dynamic of friction. Although the ideas for some very similar and you

162

00:26:04.080 --> 00:26:14.550

Jorge Penarrubia: You find many common ingredients. But then he had to drop this approach, the approach that we're showing you today, it's not it's not very good for us to pick up chicks.

163

00:26:15.810 --> 00:26:26.880

Ana Bonaca: Okay, so that's kind of what happens on a small scale and an RV then had a sort of like an independent question, but it might be related to a more global distribution of of sub halos and

164

00:26:28.110 --> 00:26:37.050

Ana Bonaca: So he brought to our attention, of course, that the sub halos are being disrupted in the inner parts of the galaxy preferentially and so

165

00:26:37.050 --> 00:26:37.500

Jorge Penarrubia: I

166

00:26:37.530 --> 00:26:38.490

Was wondering

167

00:26:39.660 --> 00:26:54.600

Ana Bonaca: That that might happen before they they managed to disrupt applied binary. So the question really is about the the timing, which of course first kind of disruption of solar binaries artist title disruption of of sub halos in the inner parts of the

168

00:26:54.930 --> 00:27:09.720

Jorge Penarrubia: Yeah, I will show you, if I may, a flash every one. The slide from my students who show and refine that Ronnie. You might know him who showed that basically that if you are dealing with casspi doesn't matter. He knows is impossible to disrupt him by tides.

169

00:27:10.260 --> 00:27:20.850

Jorge Penarrubia: So these are these are simulations that follow the evolution of us are paid or, you know, for for several years and you see here revolution of the mass and close within the our max. So this is

170

00:27:21.900 --> 00:27:35.160

Jorge Penarrubia: So this is quite severe mass loss. You see you in the simulations. Basically what we found is that the mass evolution of payloads on a fixed salary is basically exponential. It never goes to zero.

171

00:27:35.910 --> 00:27:45.090

Jorge Penarrubia: And this is yes because the inner, inner regions of our cast be Halo reactor automatically to extend out of the title of fields that was the reason

172

00:27:48.900 --> 00:27:54.420

Jorge Penarrubia: So even though so close to be around solar system. If they are cast be okay.

173

00:27:56.430 --> 00:28:00.210

Ana Bonaca: Then there is some word questions about down

174

00:28:01.680 --> 00:28:16.320

Ana Bonaca: The sort of free screaming scale off for each document or mass. So, who then when he was asked what is some sermons go into determining the free streaming scale out for each dark matter mass. We have to assume some thermal history in the early universe.

175

00:28:16.680 --> 00:28:27.300

Jorge Penarrubia: Yes, I think that's what I mean I'm not really an expert. I just briefly look at those papers, but that's exactly what they're doing. It basically calculate what is the distance travel with again.

176

00:28:27.780 --> 00:28:42.240

Jorge Penarrubia: For a given velocity and velocity comes from the thermal distribution of tomato particles and then you know that gives you a scale that so that basically was in those equations, roughly. I'm sure it's much more more more complicated than that. But

177

00:28:43.290 --> 00:28:43.980

Jorge Penarrubia: That's the idea.

178

00:28:46.230 --> 00:28:58.440

Ana Bonaca: So we're kind of wrapping up the the Q AMP. A. I wanted to ask a couple of questions that are kind of what applying this further on. And first, this from Morgan, the cloud, who has

179

00:29:00.120 --> 00:29:06.840

Ana Bonaca: If you could talk about how we might apply to steer to disrupt the six of binary black hole orbits and then stellar systems.

180

00:29:08.040 --> 00:29:14.250

Ana Bonaca: They be affected by similar distributions of kicks based on the masses and healthy velocities of their servers.

181

00:29:15.030 --> 00:29:24.360

Jorge Penarrubia: And yeah, absolutely. I mean, this and this. So here I'm assuming that so for the forces, I'm assuming, Teresa particles. So in principle.

182

00:29:24.840 --> 00:29:35.490

Jorge Penarrubia: Any particle will be subject to the same distribution of velocity kicks in. The thing is that some for some very hot systems. Those velocity kicks are completely inconsequential.

183

00:29:36.030 --> 00:29:47.100

Jorge Penarrubia: Whereas for very cold objects. Those are the loosely bound once then those will have statistics do matter. So that's why we should go for the for the loosely bound for objects.

184

00:29:48.630 --> 00:29:59.670

Ana Bonaca: And and as a final question very much out there. So you're and it touches upon the Oort Cloud and you showed the effect of those fluctuations on

185

00:30:01.380 --> 00:30:12.240

Ana Bonaca: The objects formed in the galaxy. And now we we have sent one of our spacecrafts into debt sort of territory. So I was wondering, like, what your character.

186

00:30:13.530 --> 00:30:14.010

Ana Bonaca: Is like

187

00:30:14.250 --> 00:30:16.110

Ana Bonaca: In a future missions like

188

00:30:16.140 --> 00:30:18.630

Ana Bonaca: Is there like some instrument that would be helpful.

189

00:30:19.290 --> 00:30:32.130

Jorge Penarrubia: I really, really wanted to put a student, because it would be such a beautiful prayer. And actually, I will not send 1111

mission but to you and I will look i'd love to send to in different directions.

190

00:30:32.880 --> 00:30:43.350

Jorge Penarrubia: Because as we saw the derivative of the forces is what contains information on a small scale. So I think sending to be much more clever, but I have to work on the idea

191

00:30:46.650 --> 00:30:48.540

Jorge Penarrubia: It will be a really, really fun project.

192

00:30:49.050 --> 00:30:53.430

Jorge Penarrubia: I think i think is going to be really interesting to see what happens to those products.

193

00:30:55.500 --> 00:31:01.140

Ana Bonaca: iPhone awesome this is. Yeah. I think this is this so great that you managed to connect that the tech sector with

194

00:31:01.200 --> 00:31:01.680

Jorge Penarrubia: My mother.

195

00:31:02.370 --> 00:31:04.950

Ana Bonaca: Yeah what through our lives that excellent

196

00:31:05.970 --> 00:31:10.500

Ana Bonaca: Thank you so much. Her head there a few more questions on Slack, so please stick around and yeah

197

00:31:12.810 --> 00:31:14.130

Ana Bonaca: Again, thank you.

198

00:31:17.430 --> 00:31:19.140

Morgan Macleod: Well, thank you again so much and

199

00:31:20.220 --> 00:31:32.370

Morgan Macleod: Let me transition us to our second talk. Our second speaker is cash holiday and who is a graduate student at Caltech and we can see your screen. That's great.

200

00:31:33.450 --> 00:31:34.230

Morgan Macleod: And

201

00:31:35.580 --> 00:31:54.090

Morgan Macleod: He's advisor by Manti constantly wall and he's over the past years really become one of the leaders of the field of following up and discovering optical and infrared transients and then in particular is focusing on sort of the

202

00:31:56.400 --> 00:32:07.980

Morgan Macleod: Growing abundance. I guess I would say of transients that we're realizing can come from accreting compact objects in binary systems. And so today, we're going to hear about

203

00:32:09.450 --> 00:32:16.620

Morgan Macleod: Sort of peculiar thermonuclear supernovae, and welcome, and we're really grateful for having you here. Thanks.

204

00:32:17.520 --> 00:32:23.760

Kishalay De: Thank you for the game introductions. Yes, I'm starting my fifth year as a grad student at Caltech and I wanted to talk

205

00:32:24.150 --> 00:32:34.170

Kishalay De: A bit about some, some of my recent work in finding and catalyzing very large samples of nearby supernovae. And what that is telling us about the fates of helium repeating my boss.

206

00:32:34.590 --> 00:32:40.860

Kishalay De: So I'll start off with this plot, which I imagine many of you have seen before, which is the space of optical transients

207

00:32:41.220 --> 00:32:51.630

Kishalay De: On the y axis is the peak luminosity have the chance of the transients in absolute magnitude on the x axis is the characteristic timescale. So back in 2005 there were essentially just three classes next

208

00:32:52.020 --> 00:32:58.260

Ana Bonaca: Can just like interrupt. I see like on the direct side of your screen that build order window.

209

00:32:58.830 --> 00:32:59.130

Oh,

210

00:33:00.690 --> 00:33:02.550

Ana Bonaca: Sure. Like if others see that to

211

00:33:06.600 --> 00:33:07.500

Kishalay De: See if this

212

00:33:11.430 --> 00:33:13.500

Kishalay De: Is that you still see that

213

00:33:14.430 --> 00:33:16.020

Ana Bonaca: Morgan days. Do you see that

214

00:33:18.390 --> 00:33:20.700

Morgan Macleod: I do. There's, there's a gray window.

215

00:33:20.730 --> 00:33:21.690

With, like the

216

00:33:22.770 --> 00:33:23.130

Morgan Macleod: I don't know.

217

00:33:25.020 --> 00:33:25.200

Kishalay De: Oh,

218

00:33:26.100 --> 00:33:27.600

Ana Bonaca: Yeah. Yes. Oh.

219

00:33:30.720 --> 00:33:31.050

Kishalay De: Yes.

220

00:33:31.800 --> 00:33:32.700

Morgan Macleod: Oh, no problem.

221

00:33:35.520 --> 00:33:44.640

Kishalay De: Right. So like I was saying. So back in 2005 there were essentially the street classes of transients the classical Novae the core collapse supernovae, and the community supernovae which live over here.

222

00:33:45.030 --> 00:33:51.060

Kishalay De: But as Whitefield surveys came online with a variety of cadences we soon realized that this was definitely not the entire story.

223

00:33:51.390 --> 00:33:57.690

Kishalay De: And for the purposes of this talk, the face face that I'm most excited about are things that live over here, which are fast and fast transients

224

00:33:58.110 --> 00:34:09.030

Kishalay De: And in 2011 it was you know well understood that this space, space is not empty, for sure. And, but the number of objects in this space, space really small. At the time, so that there are a lot of questions about where these might be coming from

225

00:34:09.660 --> 00:34:15.300

Kishalay De: But today we live in an era where Whitefield service can not only show that the space, space is not empty, but

226

00:34:15.780 --> 00:34:21.960

Kishalay De: Routinely find them at a rate that allows you to do. Demographics of these transients and relate them to other types of objects.

227

00:34:22.320 --> 00:34:29.280

Kishalay De: And the one thing that is perhaps very interesting is that these things live very close to the faintest thermonuclear supernovae that we know of.

228

00:34:29.550 --> 00:34:37.260

Kishalay De: So earlier right from early on. It was suspected that these might be extremes of how many supernovae. They were not recognized in previous service.

229

00:34:38.070 --> 00:34:44.490

Kishalay De: So I wanted to give another introduction to what the canonical picture for Terminator supernovae has been

230

00:34:44.880 --> 00:34:53.340

Kishalay De: The canonical picture is that you have a hot white dwarf. That's a greeting material from non degenerate companion could be a main sequence star or the giant and at some point.

231

00:34:53.970 --> 00:34:58.050

Kishalay De: The wider features on the shaker mass, it explodes and produces a supernova.

232

00:34:58.560 --> 00:35:04.710

Kishalay De: But I think it's safe to say now that we, it's not very obvious that this is not the correct picture there are definitely

233

00:35:05.160 --> 00:35:11.010

Kishalay De: Most type on a supernova do not appear to be coming from this scenario, both from very early time and late time observations.

234

00:35:11.460 --> 00:35:21.990

Kishalay De: And that naturally leads to the question of what are called produces this technically supernovae are these even coming from single digit system. So do you have to white dwarfs that are merging into each other and producing these objects.

235

00:35:22.380 --> 00:35:30.240

Kishalay De: Whether the explosion happens at the undertaker mass or substandard chicken mass and especially if it's a sandwich sandwich chicken mass. What is the trigger for the exclusion.

236

00:35:30.780 --> 00:35:41.100

Kishalay De: So because Tom the shaker mass exposure stonework, I wanted to talk about Sutton, the shaker mass explosions, which is really what's picking up in the last few years. And one of the really common.

237

00:35:41.610 --> 00:35:49.230

Kishalay De: Pathways and stellar evolution to get us up to and the schematics blueprints is one that it was too low mass mean sequence does. So you start with to

238

00:35:49.500 --> 00:35:57.090

Kishalay De: Know mass me sequence stars you undergo some common and with of evolution that produces a data binary with the white dwarf and the main sequence data and and it and then

239

00:35:57.480 --> 00:36:02.640

Kishalay De: Undergoing. Another common another revolution, you can end up with cry to have that either orbiting

240

00:36:03.510 --> 00:36:07.530

Kishalay De: Helium burning star or a car ride off into another helium. Why do I found it.

241

00:36:08.160 --> 00:36:16.770

Kishalay De: And, you know, this is a very well known sequence in evolution because you know there's so much of rich physics in a phenomenon phenomenon. This you know right from

242

00:36:17.100 --> 00:36:24.150

Kishalay De: The common envelope phase, which you don't understand very well to accretion and outflows and so on. And what happens from the Iran is really a

243

00:36:24.750 --> 00:36:30.420

Kishalay De: Sort of a competition between a gravitational waves trying to pull the system in together and eventually the

244

00:36:30.930 --> 00:36:42.360

Kishalay De: White dwarfs the two objects come into contact and from here on. It really is a battle between gravitational waves trying to pull nothing together and stellar physics that trying to pull it up and throw it out so

245

00:36:43.140 --> 00:36:51.870

Kishalay De: You know, the point that I wanted to drive home is that the reason the scenario is really popular is because there are many avenues to explosions in this scenario. So here I'm showing a

246

00:36:52.740 --> 00:36:57.960

Kishalay De: Popular lot of the mass loss rate as a function of the orbital period for as the system, it was

247

00:36:58.260 --> 00:37:05.130

Kishalay De: So if you have to lie to us the system comes in comes in because of graduation with radiation and as soon as it goes into contact the attrition rate jumps up

248

00:37:05.460 --> 00:37:12.600

Kishalay De: The first avenue to explosion is right over here. If you have unstable mass transfer, then the system can merge and possibly produce an exotic explosion.

249

00:37:13.230 --> 00:37:16.980

Kishalay De: Even if not as the system starts separating out because of mass loss.

250

00:37:17.490 --> 00:37:25.800

Kishalay De: Below about 10 to the minus six solar masses per year. You don't get stable helium burning and HERE. SO WHAT YOU'RE GETTING HERE IS A cry door that's slowly building up

251

00:37:26.340 --> 00:37:36.690

Kishalay De: Helium shell around it. So the other really common scenario, you can get an explosion from is that at some point the pressure at the base of the shell is going to be high enough that you know you can get an explosion.

252

00:37:36.960 --> 00:37:40.200

Kishalay De: It could be a helium know God, perhaps even something what exactly

253

00:37:40.830 --> 00:37:51.450

Kishalay De: How many supernova, and that you know this understanding this face face of explosions is a is perhaps the only probe of our understanding of what really happens to these old low mass does

254

00:37:51.870 --> 00:38:00.810

Kishalay De: In which we see in our own galaxy know even from the point of view of understanding the occasion physics, the gravitational waves sources which these will be once Lisa dance online. And of course,

255

00:38:01.170 --> 00:38:06.930

Kishalay De: Some of these peculiar chemical synthesis signatures that we see in some of these objects so

256

00:38:08.130 --> 00:38:14.520

Kishalay De: The this exactly this helium shall excluded scenario is the reason why these have been long proposed back from the thesis.

257

00:38:15.030 --> 00:38:18.810

Kishalay De: The projectors of Taekwondo supernovae from the so called double detonation mechanism.

258

00:38:19.080 --> 00:38:29.550

Kishalay De: The idea is that you have a co write off with the helium shell around it. And if you can designate a shell detonate an explosion in the shin, you can drive an explosion in the underlying core that can produce a supernova.

259

00:38:30.240 --> 00:38:38.730

Kishalay De: Now this picture works. It's really elegant in terms of the Stellar Evolution aspect of it. But in terms of observations. This has had long problems. And the problem is

260

00:38:39.360 --> 00:38:45.720

Kishalay De: As you can see here what you get in this cartoon is that you have a supernova. That's essentially a bond. Carbon core of a white dwarf.

261

00:38:46.050 --> 00:38:56.040

Kishalay De: With a lot of Ireland group material around it that comes from the burning of the helium shell. So that's essentially the ashes of the helium shell that are left over on top of the wind off and those can

262

00:38:56.490 --> 00:39:03.240

Kishalay De: Produce what I call us you know quite distinctive footprints of the shell that nation which we want to look for and understand if these are consistent

263

00:39:03.720 --> 00:39:10.050

Kishalay De: So one of the things that comes from having so much of a bond material is that you have a lot of shallow radioactive material in the

264

00:39:10.410 --> 00:39:16.140

Kishalay De: Otter injector and that produces what are the so called early access is in the light goes. So here I'm showing some of

265

00:39:16.620 --> 00:39:22.020

Kishalay De: model that we use in my recent paper that was created by a big component at Berkeley. At the time when I'm showing

266

00:39:22.530 --> 00:39:26.850

Kishalay De: An explosion of a point eight solar mass white dog with about 2.08 so learn my shell around it.

267

00:39:27.240 --> 00:39:36.720

Kishalay De: And what you see here is that there's this early time access that's coming from the radioactive decay in the material in the out outskirts of the Jetta followed by some, something that looks like a normal type on a supernova.

268

00:39:37.230 --> 00:39:47.940

Kishalay De: And if you increase the mass of the shell. You get a brighter for speak because there's more rejected material. And in some sense, the first week traces the mass of the shell and the second picture is the total mass of the system.

269

00:39:48.450 --> 00:39:54.120

Kishalay De: But what is really remarkable in terms of in terms of the observational signatures, is that when you have

270

00:39:54.810 --> 00:40:03.900

Kishalay De: So much of iron grip material in the otter injector. The actually remarkably remarkably affect the specter of the object. And here I'm showing another model from again where

271

00:40:04.500 --> 00:40:12.060

Kishalay De: What I'm showing here is a spectrum of one of these explosions, but what you see is that on the blue and the red side of the spectrum, you see.

272

00:40:12.390 --> 00:40:16.050

Kishalay De: Typically, like on a supernova features. These are silicon two lines calcium lines.

273

00:40:16.350 --> 00:40:23.820

Kishalay De: But as soon as you go to short wavelengths and all of the iron grip material kicks in desirable materials have, you know, tons of transitions at blue wavelengths

274

00:40:24.150 --> 00:40:31.410

Kishalay De: And the enhancement of that Iran raw material really affects the spectrum in that you get strong Lang Lang getting signatures all of the blue flux is absorbed.

275

00:40:32.250 --> 00:40:40.440

Kishalay De: And this is remarkably different from what we've seen Normal Type one in supernovae. So I normally like when so when we are really homogeneous at peak and they really don't show the signatures at all.

276

00:40:40.890 --> 00:40:45.060

Kishalay De: Including the first peek here as well as the the lines and getting signatures.

277

00:40:45.570 --> 00:40:53.550

Kishalay De: So naturally, the questions have been maybe you can make this work. If you make the shell really tense, so that the the ashes are not as prominent in the observations.

278

00:40:54.000 --> 00:41:03.180

Kishalay De: And, you know, completely independently. These could be other types of thermonuclear transients that we don't know for, you know, I've been reno off but haven't realized it yet. So, you know, this

279

00:41:03.870 --> 00:41:11.220

Kishalay De: This could actually just be read in the universe. But, you know, the question that I wanted to answer is, Do this show that nations exist in nature, especially if they're rare objects.

280

00:41:11.940 --> 00:41:17.220

Kishalay De: So that leads me to my work, which is using this wiki chance and facility which is Whitefield time domain.

281

00:41:17.730 --> 00:41:23.340

Kishalay De: Survey at Palomar Observatory. So the start of the show is the 700 million pixel camera that lives over here.

282

00:41:24.000 --> 00:41:34.230

Kishalay De: It's a pretty small 1.2 meter telescope with this 47th grade in the field of view and with the public to decade and survey of the entire northern sky. We get about 10,000 supernovae per year.

283

00:41:34.650 --> 00:41:41.370

Kishalay De: And that's a really large number two, I need to digest. But we've tried to down. Select the samples to do to do science with it.

284

00:41:41.940 --> 00:41:48.390

Kishalay De: So my work has been in leading the largest volume limited supernova experiment and we're done with with this wiki changin facility.

285

00:41:48.810 --> 00:41:57.150

Kishalay De: And the idea is pretty simple, because this is a wide field service. What we do is that we take a catalog of nearby galaxies. This is just a known nearby galaxy from a CSS.

286

00:41:57.420 --> 00:42:06.510

Kishalay De: And we just asked the question, is this transients within 100 second radius of a galaxy that enough. And if it is, I will just go and take a spectrum of it and classify it and they do it for every single supernova.

287

00:42:07.380 --> 00:42:14.490

Kishalay De: That that is found in CTF so essentially what that does is it builds up volume limited sample of supernovae within the local universe.

288

00:42:15.390 --> 00:42:26.430

Kishalay De: And in terms of follow up our main machine for for bright transients things that are better than 19 magnitude has been the SCD machine spectrograph which is on the 16 inch telescope at Palomar and

289

00:42:26.880 --> 00:42:35.160

Kishalay De: fainter things we have to use the historic 200 instead of scope at Palomar and most of our follow up comes from the get go to school. So it's going to go really faint when the supernova gets

290

00:42:35.640 --> 00:42:46.620

Kishalay De: Especially at least times. So just to give you a sense for the numbers in the first 16 months we had 750 supernovae that record spectroscopic Lee classified in in the first 16 months and

291

00:42:47.160 --> 00:42:52.500

Kishalay De: As of last month we had about double that number 1500 supernovae. And this just goes to show you that you know this.

292

00:42:52.800 --> 00:43:05.670

Kishalay De: This you can actually build a very, very large samples of complete samples of nearby supernovae to start looking for their events and start relating them to the other populations of supernovae that we generally find in the universe. So

293

00:43:06.960 --> 00:43:17.040

Kishalay De: The first surprise came with this spectacular object called a sentiment eating big which is we found in one of our samples. So this is a supernova that was found in the outskirts of this elliptical galaxy over here.

294

00:43:17.460 --> 00:43:26.790

Kishalay De: And it was found relatively early on because ETFs observing the field every single night so that we have a very nice or daytime nighttime. You see this pasteurized and it peaks and then it fades away.

295

00:43:27.780 --> 00:43:33.120

Kishalay De: But you know it doesn't look very spectacular from the light curve, but the spectra is really what seems to be

296

00:43:34.200 --> 00:43:41.490

Kishalay De: So when we took a look at the spectrum. This is what it looks like. So on in black. Here I have actual data observed for this supernova.

297

00:43:41.970 --> 00:43:47.580

Kishalay De: This is about 10 days before peak. This is about at peak and the red and green actual models that were created by

298

00:43:48.330 --> 00:43:54.810

Kishalay De: People in for this particular scenario. And what you see here is these classic signatures that I was mentioning before,

299

00:43:55.170 --> 00:44:02.580

Kishalay De: Which is strong lines and getting signatures in the blue part of the spectrum, which I think before this. There are absolutely no other supernovae that showed the signatures.

300

00:44:02.820 --> 00:44:10.050

Kishalay De: And that really comes close to show you the power of big samples and finding rare objects and telling you how this how the universe works and

301

00:44:10.710 --> 00:44:13.020

Kishalay De: So we were able to show that this, this, this, this.

302

00:44:13.920 --> 00:44:21.930

Kishalay De: Signature that you see here is the evidence of the shell that nation. And that actually holds together pretty well, even when you compare the light curve because when what we

303

00:44:22.410 --> 00:44:32.460

Kishalay De: What I showed was that this early fast rise is exactly what you'd expect to see from the shelter pitches. Now you from the radioactive material. The king in the otter injector. And then you can explain the rest of the lighter with a

304

00:44:33.180 --> 00:44:40.620

Kishalay De: With a relatively massive WHY DOOR. So in this particular case we showed that this was a shell that nation that involved a point one five solar mass shell.

305

00:44:40.860 --> 00:44:48.690

Kishalay De: On a point seven five solar mass white dwarf. And in my mind. I think this is the first one, the where we have the smoking gun signature of this shell definition.

306

00:44:49.110 --> 00:44:55.290

Kishalay De: And since then there's been a couple more objects which are which are appear to be somewhat of cousins of these objects, although the, I don't think they show

307

00:44:55.590 --> 00:45:03.300

Kishalay De: As striking signatures as this one, but I think this, this, this, this really opens up a completely new thing to show that these shell that nations for sure exist in nature.

308

00:45:04.860 --> 00:45:11.130

Kishalay De: So one of the questions that you might ask immediately is you know that I was wondering about is this object was relatively bright at peak. So, it

309

00:45:11.460 --> 00:45:16.650

Kishalay De: Suggests that it's a relatively massive wide off because that's what controls the total nickel lan in the explosion.

310

00:45:17.100 --> 00:45:25.110

Kishalay De: And what we're able to show now is that these exclusions exist for sure, but these are relatively read about 1% of the time 20 supernovae that we find in the universe.

311

00:45:25.560 --> 00:45:35.460

Kishalay De: And the natural question that I need you to that you lead to is you know whether these lower mass why doors with helium shows also explored all do they explode as other types of champions that we haven't figured out yet.

312

00:45:36.150 --> 00:45:50.190

Kishalay De: So this leads me to a class of transients that has been known for, I think, 10 years now. But I think the origins have been quite mysterious. So these are the so called class of calcium rich transients they were first found in the likability supernova such where

313

00:45:51.540 --> 00:46:03.720

Kishalay De: I think they really remarkable part of all these objects, was that these turned out to be these type one BC supernovae in the outskirts of early type galaxies. And if you think of Tae Kwon bc supernovae, the canonical picture has been that these are these

314

00:46:04.830 --> 00:46:10.830

Kishalay De: Explosions show helium lines and then helium silicon lines and the canonical picture is that these come from exploring mass instance because

315

00:46:11.250 --> 00:46:13.650

Kishalay De: That's where we find them in mostly instead forming galaxies.

316

00:46:13.980 --> 00:46:20.670

Kishalay De: But this appear to be a completely different population of events that look like Daikon VC supernovae except there are systematically appearing in the outskirts of

317

00:46:20.940 --> 00:46:26.520

Kishalay De: Only type galaxies. And that I think is really the most remarkable part showing that this is a separate class of explosions.

318

00:46:27.210 --> 00:46:33.810

Kishalay De: And since then, PDF went on and found a few more objects are. This is a paper from a paper that I wrote compiling the PDF sample.

319

00:46:34.140 --> 00:46:38.190

Kishalay De: And essentially, these have relatively homogeneous light curves. The rise in about 1015 days.

320

00:46:38.430 --> 00:46:48.780

Kishalay De: And they fade away relatively quickly that allows us to estimate that about, you know, half a solar mass of ejector in these explosions and the numbers are really, really small, at least as of 2018 there were 10 non events.

321

00:46:49.680 --> 00:46:54.690

Kishalay De: And that really precluded as a systematic analysis of what the demographics were telling us

322

00:46:55.320 --> 00:47:00.390

Kishalay De: The reason they get their name is calcium niche events is because if you look at them in the nebula face when the

323

00:47:00.690 --> 00:47:08.040

Kishalay De: Supernova ejector become optically 10 and you can see right into the core of the explosion. They show these remarkably strong calcium ninth. We don't seen other types of supernovae.

324

00:47:08.430 --> 00:47:21.840

Kishalay De: And the consensus, at least early on was that maybe they might be pressing a lot of calcium and the ejector, which is interesting from the chemical synthesis point of view, but I think nowadays. There's a, there's, it's unclear whether that's really the case or if it's just

325

00:47:22.680 --> 00:47:24.960

Kishalay De: This the calcium being easily excited

326

00:47:26.070 --> 00:47:33.990

Kishalay De: So the reason why the entire calcium picture is interesting, from the point of view of someone that you can mass explosions and just give a broad

327

00:47:34.440 --> 00:47:41.460

Kishalay De: cartoon here is that when you go to smaller white dwarf masters in such Undertaker mass explosions. You get Lord central densities and that leads to

328

00:47:42.540 --> 00:47:49.470

Kishalay De: More Incomplete burning. To intermediate mass elements as compared to island with elements that you see in type on a supernova. And this was suggested

329

00:47:49.830 --> 00:47:59.280

Kishalay De: Right, early on from the when the first objects of this class were found. So I'm just to demonstrate this. I'm showing some recent models from again from Abby when she showed that

330

00:47:59.760 --> 00:48:04.500

Kishalay De: You know when you go from relatively massive why doors to relative enormous why dogs, you get a transition going from

331

00:48:05.220 --> 00:48:19.050

Kishalay De: ejecta cooling primarily via I didn't lines to reject cocooning primarily where calcium lines and that just gives you a hint that that is helium shell that nation scenario might actually be a natural pathway in stellar evolution to explain these calcium rich transients

332

00:48:20.130 --> 00:48:23.340

Kishalay De: So we do. We are. We wanted to, you know, really.

333

00:48:23.940 --> 00:48:30.060

Kishalay De: Completely change this filter by systematically looking for these events and in one year in the first year octa we found eight new events.

334

00:48:30.330 --> 00:48:37.500

Kishalay De: Just to compare you know there were 10 events known in the 10 years prior to CTF and in the first year we found a new events. So that really doubles the sample of events that

335

00:48:38.040 --> 00:48:40.620

Kishalay De: That we can get from a systematic lot samples like this.

336

00:48:40.950 --> 00:48:53.460

Kishalay De: The one thing that I like to point out is that these all appear in the very far outskirts of only time galaxies, which I think is really fascinating and really drives home the point that these must be coming from really old populations, regardless of how you find them and

337

00:48:54.930 --> 00:49:09.750

Kishalay De: With this bigger sample because ZTE is now giving us a light curves and you can get rapid follow up this I'm showing here some high cadence like us, that we got from CTF and follow up here in our in red points are the Arbonne light comes from CTF overloaded with some

338

00:49:10.830 --> 00:49:20.880

Kishalay De: Older objects from PDF. These are engraved. And what I think is really tantalizing signature from all of these lights Rails is that in in a substantial fraction of these we see these early time

339

00:49:21.180 --> 00:49:28.740

Kishalay De: bumps in the light of which is exactly the signature that I was mentioning that might indicate that there is reactive material in the otter injector and

340

00:49:29.100 --> 00:49:38.070

Kishalay De: Unfortunately, we do not have exquisite data does only time see it because, you know, now we're just trying to figure realize this, but hopefully at some point in the future, we get

341

00:49:39.000 --> 00:49:46.020

Kishalay De: Really good data set that has an inspector and then really be able to see whether the signatures are consistent with the Sherlock nation scenario.

342

00:49:46.680 --> 00:49:56.580

Kishalay De: But regardless, because we have a much larger sample. Now what I was able to show is that there is really a continuum of objects going from the from faint Terminator supernovae to this class of

343

00:49:56.850 --> 00:50:07.770

Kishalay De: Helium rich transients that look calcium rich in the late time Specter. So the, the spectral features that I'm talking about the helium lines in the in the spectrum, as well as the silicon nine CPC and type on a supernovae.

344

00:50:08.130 --> 00:50:13.320

Kishalay De: And essentially the continuum is that you go from events that look like, dive on a supernova that has strong silicon lines.

345

00:50:13.560 --> 00:50:24.450

Kishalay De: Two things that look like take one see supernovae that a week silicon lines and we kill him lines to events that have weeks like alliance and really strong helium lines and there's a continuum of objects in between these two and

346

00:50:24.930 --> 00:50:32.430

Kishalay De: In the same sequence, we see a continuum of property is going from in the lightbulbs as well that iconic supernovae are relatively slow and luminous

347

00:50:33.120 --> 00:50:40.860

Kishalay De: Is to go to further up this change, you get like those that are slow faint and read and as you go up the sequence, you get fast, fast and faint like girls.

348

00:50:41.160 --> 00:50:48.090

Kishalay De: And together, I think the the spectroscopic and automatic continuum is really telling us that there is a single family of exclusions. That explains this and

349

00:50:48.660 --> 00:50:57.900

Kishalay De: Because we have a really control volume limited sample, we can get quite tight estimates on the volume integrates we find about 15% of the one edit.

350

00:50:58.440 --> 00:51:04.740

Kishalay De: And if you compare it to the rates of for telephony supernovae in early time galaxies. They're really common in all environments is about

351

00:51:05.010 --> 00:51:17.010

Kishalay De: One calcium whichever for every three types. One is in only type galaxies. So this in my mind really loose out a lot of the exotic channels that have been proposed, you know, things like white dwarf neutron star mergers and why do have CDs because the rates are way too high.

352

00:51:18.060 --> 00:51:21.390

Kishalay De: And I think I'm with you know some empirical

353

00:51:22.950 --> 00:51:33.390

Kishalay De: modeling of the of the properties of the explosion. I was able to show that this is consistent with a picture where you have all of these explosions coming from helium shells on no mass white dwarfs, so

354

00:51:34.320 --> 00:51:40.260

Kishalay De: The picture that I have that I that is that this is something that we have already demonstrated that you have a

355

00:51:40.560 --> 00:51:46.530

Kishalay De: Relatively low mass, a point eight solar mass white dwarf with a thin helium shell around it, you actually get these calcium is transients that

356

00:51:47.280 --> 00:51:54.630

Kishalay De: That are consistent with the observations that we see. But, you know, the empirical continue in my mind. So that's that.

357

00:51:55.440 --> 00:52:03.180

Kishalay De: As you go to lower and lower mass y dos you get fainter explosions that can that can that progressively get more and more helium rich and this is again something that

358

00:52:03.570 --> 00:52:16.290

Kishalay De: Needs to be confronted with modeling, you're trying to do that right now. But I think the empirical evidence does point to this sequence. And as you get to the lowest mass white gloves, you get very incomplete helium burning. That looks that produces spectra that look helium rich

359

00:52:18.270 --> 00:52:25.680

Kishalay De: Right, so I think it just to summarize in terms of directions and the way ahead. I think there's a lot of work to be done into to understand what kind of

360

00:52:26.160 --> 00:52:33.000

Kishalay De: Shell detonations and very old populations can produce this is that a problem in the rates. I think the rates are a bit high for a lot of different scenarios.

361

00:52:33.630 --> 00:52:41.910

Kishalay De: We are working with you know I be Bolin is now working on trying to detonate this Lomas white dots to see whether we can reproduce the helium and the calcium signatures that we see.

362

00:52:42.300 --> 00:52:50.880

Kishalay De: In terms of observations. I think in terms of volume limiter samples desi will be great in terms of spectrum of millions of galaxies that will allow volume complete searches and

363

00:52:51.390 --> 00:52:56.460

Kishalay De: You know, going ahead with the CTF to now coming up with a two decade and survey of the sky analysis see on the horizon.

364

00:52:56.760 --> 00:53:03.030

Kishalay De: Will get exclusive early time night girls for nearby supernovae, as well as the lake time like which was constraints radioactive isotopes.

365

00:53:03.360 --> 00:53:12.150

Kishalay De: And finally, the polarization is something which is which you're trying to do right now because these helium shall deafness and so intrinsically symmetric and we're hoping to get a political spectrum soon.

366

00:53:13.050 --> 00:53:19.530

Kishalay De: So I will quickly mentioned something that I got interested in because these are extremely fast evolving core collapse supernovae seem to be a common

367

00:53:20.040 --> 00:53:29.370

Kishalay De: False positive in the search process. And here, and I'm happy to talk about this and this, these explosions, tell us a lot about how massive stars evolving close by entities. So with that,

368

00:53:29.730 --> 00:53:43.560

Kishalay De: I will end here. And I just wanted to drive home the fact that I think the long sword detonation double differences for type on a supernovae actually hiding in a in a population of transients that were not noticed before but there as common as that I wanted to personally thank you

369

00:53:51.120 --> 00:53:55.080

Ana Bonaca: Yeah, the numbers in Toronto, very fascinating and

370

00:53:57.750 --> 00:53:59.250
Ana Bonaca: Okay, maybe we can start with

371
00:54:00.660 --> 00:54:02.550
Ana Bonaca: Maybe a technical question of

372
00:54:04.620 --> 00:54:21.630
Ana Bonaca: Assembling all of the resources to to to make all of this possible. And how have you been coordinating with other users of the facilities, especially for the follow up where I assume that the timing of when you get the factories importance again can just tell us a little bit about that.

373
00:54:22.830 --> 00:54:24.120
Kishalay De: Yeah, yeah. So, um,

374
00:54:25.230 --> 00:54:32.910
Kishalay De: So, so like I said to be in terms of resources at Palomar there is a 16 inch telescope which allows us to get robotic spectroscopy for the brightest transients

375
00:54:33.840 --> 00:54:43.920
Kishalay De: Be so, so I think that the nominal sequences that we try to get spectrum of sources as close to Pete light as possible. So we will try to schedule a spectroscopic observation very close to peak.

376
00:54:44.550 --> 00:54:50.910
Kishalay De: For the bright transients for fainter things we have to rely on classical observing means that I have to stay awake all night and try to get a spectrum of the source.

377
00:54:51.510 --> 00:54:57.570
Kishalay De: Which which is also, you know, we have a classical reschedule nice maybe every couple of weeks that allows us to, you know, keep the sample very complete

378
00:54:57.840 --> 00:55:05.670
Kishalay De: We have been very fortunate to get a lot of help from the community as well because we really we announced all of our transients publicly to to the online service, which means that

379
00:55:05.880 --> 00:55:12.570
Kishalay De: Anyone if if there's a chance that we think is a supernova. It's already immediately announced to the community and we are able to get you

380

00:55:13.110 --> 00:55:24.300

Kishalay De: Also get a lot of specter from the community who use it topically so that's good. I think together that that has worked out really well in terms of getting followed for the sources. That's great. Yeah, I know, like those

381

00:55:24.810 --> 00:55:27.210

Ana Bonaca: Was like hundred thousand 10,000 Sabrina.

382

00:55:27.270 --> 00:55:28.080

That's, yeah.

383

00:55:30.210 --> 00:55:42.990

Ana Bonaca: So we have a question. Maybe that naturally follows from Boston bombers and saying, asking of how often do these transients turn out to be associated with a background source instead of the targeted galaxy.

384

00:55:44.130 --> 00:55:52.080

Kishalay De: Yes, that that's a good question. Right. So, so if you remember. So I mentioned that that we target.

385

00:55:52.920 --> 00:56:00.360

Kishalay De: All transients within hundred seconds of known galaxies and that that hundred our second number has really been an experimental trade off between try to get rid of.

386

00:56:00.750 --> 00:56:06.780

Kishalay De: Type one is going off in the background and eg and going off in the background and things that are close to the galaxy.

387

00:56:07.200 --> 00:56:12.270

Kishalay De: That are actually associated with the galaxy. And I think it. I think the the occurrence of

388

00:56:12.990 --> 00:56:20.850

Kishalay De: Background sources is really is a function of the radial distance from the galaxy. The farther you go with your background source, but let's see, I think.

389

00:56:21.480 --> 00:56:27.900

Kishalay De: I think beyond about 58 seconds from the galaxy, you're probably sitting, more than half of the things that you're seeing are probably background.

390

00:56:28.260 --> 00:56:37.290

Kishalay De: Type on a supernova. But again, because we have night customs ETF, it's all, it's sometimes it's obvious just just looking at the light of that is the type on a supernova. But, you know, we try to get a spectrum anyway.

391

00:56:39.240 --> 00:56:42.630

Ana Bonaca: Yeah, yeah, yeah. You need to get it spread

392

00:56:43.650 --> 00:56:47.280

Ana Bonaca: You know for sure. Um so monument past

393

00:56:48.540 --> 00:57:03.480

Ana Bonaca: Can you talk about the Galactic distribution of calcium rich transients in this model where Lomas for wide forest provide the time delay does the Galactic distribution match the underlying distribution of these white wars are these objects preferentially kicked

394

00:57:04.920 --> 00:57:12.630

Kishalay De: Yeah, that's a great question. So yeah, so that leads me to the, the, the system rate problem because like I said, the

395

00:57:13.140 --> 00:57:17.460

Kishalay De: The rates that we find for these objects are about 15% of the time on it and

396

00:57:18.180 --> 00:57:29.910

Kishalay De: If you and because these are systematically founding the healers of galaxies that is a bit problematic from what we currently know about the extremely enormous white dwarfs. So this is, you know, obviously work done by Ron Brown X CFA where they showed that

397

00:57:30.480 --> 00:57:42.960

Kishalay De: The rating the halos is about 10% of the data in the Milky Way, which is which is, yeah, that's about 1% of the time on it in the in the halos of galaxies. So that's a factor of 10 off over there, which is my concern in terms of the

398

00:57:43.920 --> 00:57:50.730

Kishalay De: The, the distribution. So there are way too many of these happening in the outskirts. But again, I think the thing that I've been wondering is that

399

00:57:51.180 --> 00:57:55.950

Kishalay De: You know the extremely low. My sisters might not necessarily be the only progenitors for these things in the sense that

400

00:57:56.700 --> 00:58:01.920

Kishalay De: Those systems have really low mass why dogs like point to point at solar mass why doors which are likely to evolve into stable.

401

00:58:02.220 --> 00:58:07.920

Kishalay De: Creating systems that will undergo maybe may undergo helium show definitions, but I think even a possible

402

00:58:08.190 --> 00:58:16.740

Kishalay De: New channel, which I think is not known so far observation and very rarely is these, you know, the more massive helium. I don't say point 3.4 so that is why does that have

403

00:58:17.250 --> 00:58:27.030

Kishalay De: Co white glove companions there you can there's mass transfer to be unstable that contact, but you could designate an explosion right at the time of contact and those. I don't think we have a very good sense of

404

00:58:27.480 --> 00:58:34.470

Kishalay De: What the rates for those things on because there's, it's hard to find. So so the so that's one aspect of it, which I think that

405

00:58:35.070 --> 00:58:42.030

Kishalay De: That is possibly a population of things in our own galaxy that we, that could be progenitors that we don't know very well, and the other things that have been

406

00:58:42.540 --> 00:58:49.140

Kishalay De: Have been selected for a long time I these globular cluster populations, whether this could be kicked out of nearby globular clusters and

407

00:58:49.710 --> 00:58:55.590

Kishalay De: So we don't really see globular clusters at the positions of these transients but some recent work from can Chen is now.

408

00:58:55.980 --> 00:59:00.750

Kishalay De: It's showing that you may not find something exactly at the position of the chance in but you could have

409

00:59:00.990 --> 00:59:11.310

Kishalay De: You know, something that's slightly kicked out of the globular cluster keeps circling around the Galactic potential for a few billion years, and then you find it exploding. A few, you know, few years later. So those I think

410

00:59:11.640 --> 00:59:16.860

Kishalay De: The globular cluster population, I think, is another attractive aspect of extending the roster distribution for these things.

411

00:59:21.690 --> 00:59:24.450

Ana Bonaca: To just close it off and really zoom in and

412

00:59:25.860 --> 00:59:38.550

Ana Bonaca: Then detonation mechanism. So, Evan bar asks about the lowest mess calcium rich explosions. Do you think that that nation transitions into the carbon oxygen core, or is it just a large helium shell.

413

00:59:39.840 --> 00:59:46.200

Kishalay De: Yeah, that's, that's the question I did not. I will, you know, to be honest, I do not have a concrete answer so that

414

00:59:46.620 --> 00:59:56.400

Kishalay De: It does appear that the faintest calcium less transients we find also have a lot of unburned helium and that we see very strong helium nights in the spectra that empirically suggests that these

415

00:59:56.880 --> 01:00:01.560

Kishalay De: Do not do not completely been the helium show and that just suggest that

416

01:00:02.070 --> 01:00:10.080

Kishalay De: The helium burning in the shell itself might be incomplete. So in that sense I there is an expectation that the faintest objects at least might just be undergoing

417

01:00:10.440 --> 01:00:14.940

Kishalay De: Your shell detonations for the shell either doesn't burn completely or you know undergoes maybe something

418

01:00:15.390 --> 01:00:23.100

Kishalay De: More interesting like a decoration, where the bonding is very incomplete. So that's something that I'm hoping will come out of the modeling. I'm hoping this big sample of events really

419

01:00:23.310 --> 01:00:32.580

Kishalay De: Gets in the model as excited about this population because I think that with this big population. We are really starting to see some of the trends which are telling us a lot about where these might be coming from

420

01:00:33.360 --> 01:00:40.380

Ana Bonaca: Yeah, it's it's really great to see how it's not like all the separate different things, but a continuum and

421

01:00:40.710 --> 01:00:53.190

Ana Bonaca: I had to abbreviate. Some of the questions. So, so, like, they all continued on and suddenly various definitely room for collaboration. So please, thank you so much for saying that us and yeah please stay engaged.

422

01:00:54.480 --> 01:00:59.220

Ana Bonaca: For the CFA people. Thank you for coming. And I'll see you next week, same time, same place.

423

01:00:59.340 --> 01:01:02.220

Morgan Macleod: Thank you to both of our speakers again. Thanks.