WEBVTT

1
00:00:09.599 --> 00:00:10.200
Sownak Bose: Can you see this

2
00:00:10.590 --> 00:00:10.920
Yep.

3
00:00:11.940 --> 00:00:17.640
Sownak Bose: Okay, great. So I'll just spend a couple of minutes. Tell me about a paper that

4
00:00:18.660 --> 00:00:27.930
Sownak Bose: I worked on with AFI that was submitted pretty recently and what it's to do with is looking at the velocity dispersion profiles of

5
00:00:28.680 --> 00:00:38.070
Sownak Bose: Dark matter and stars as measured in hydrogen chemical simulations, specifically the illustrious T AMP G simulation and I was interested to see

6
00:00:38.640 --> 00:00:48.930
Sownak Bose: What aspects of the host doc master Halo, one can actually learn from looking at the motions of these styles, at least in the context of these a numerical simulations.

7
00:00:50.130 --> 00:00:57.510
Sownak Bose: So in particular, we were interested in measuring these velocity dispersion profiles and each of these panels that kind of showing

8
00:00:57.870 --> 00:01:10.770
Sownak Bose: The three dimensional velocity dispersion of the dark matter and black and the stars in red as a function of radius. And each of these panels corresponds to a halo for different mass range.

9
00:01:11.490 --> 00:01:22.560
Sownak Bose: And what you notice is that this is pretty sort of generic ish shape where profile sort of increases as a functional radius, which is a maximum and then falls back down.

10
00:01:23.100 --> 00:01:33.930

Sownak Bose: And in particular, the sort of exterior parts of this profile is punctuated by a kink in the velocity dispersion, which typically occurs at somewhere around

11
00:01:34.530 --> 00:01:52.830
Sownak Bose: Our 200 mean, which is the radius that encloses a mean density that is 200 times the background density of the Universe and this radius this kink shape is often sometimes called the splashback radius of the halo, which essentially kind of the markets where the

12
00:01:54.330 --> 00:02:03.480
Sownak Bose: Master content of the stellar content of the halo actually is and separate objects that belongs to the halo from the sort of overall Cosmic Background

13
00:02:04.140 --> 00:02:13.140
Sownak Bose: And so it's typically shown in the guise of the density profile of the dark matter. But it's interesting to see that even in terms of the velocity dispersion. So you can actually see these features.

14
00:02:13.590 --> 00:02:24.600
Sownak Bose: Both in the dark matter and in the stars and these thin red curves actually show the diversity of profiles that you see around the stock profile, the mean profiles are shown in solid lines.

15
00:02:25.350 --> 00:02:33.150
Sownak Bose: And you see that there's quite a lot of diversity and a lot of it is actually down to the differences in the assembly history of the halo that fixed mass

16
00:02:34.230 --> 00:02:40.500
Sownak Bose: So one way to see this is by just taking objects of a certain mastering. This is low mass groups.

17
00:02:41.490 --> 00:02:48.300
Sownak Bose: And here, and I'm showing the line of sight philosophy dispersion as function of the projected distance from the halo

18
00:02:49.260 --> 00:03:05.220
Sownak Bose: And in this particular mass range, you can split objects that are the most different based on the late time formation history which is shown in the bottom row and the most different halos at fixed mass based on the early formation. History

19
00:03:06.540 --> 00:03:13.440

Sownak Bose: And you see that the corresponding scatter and the velocity dispersion actually picks out to different radial regimes in the velocity dispersion

20
00:03:14.040 --> 00:03:20.910
Sownak Bose: Where objects that are most different based on the early formation history show a larger scatter in the inner portion of their profile.

21
00:03:21.720 --> 00:03:32.820
Sownak Bose: Typically within about 10% of the radius, whereas objects that different most in terms of the late time history, but at the same final day mass show more differences in the exterior part of the profile.

22
00:03:33.600 --> 00:03:47.190
Sownak Bose: And this is probably not unexpected because you would think that, for example, if the lifetime assembly history is determined by late time mergers is for mostly add material and bring things out of dynamical equilibrium on the exterior part of the profile.

23
00:03:48.510 --> 00:03:56.700
Sownak Bose: So this basically suggested that you might actually be able to learn something to do with the assembly history of the halo by measuring these velocity dispersion profiles.

24
00:03:57.300 --> 00:04:03.930
Sownak Bose: And in particular for a dogmatic Halo a parameter that is often used to quantify the assembly history is something called the halo concentration

25
00:04:04.950 --> 00:04:15.180
Sownak Bose: Which for dark matter profiles that are defined by the so called and FW profile is just a measure of how centrally dense, the core of the dark matter Halo is

26
00:04:15.900 --> 00:04:24.480
Sownak Bose: And the larger the concentration. The earlier the halo forms, because it's a reflection of the typical epoch, when the south matter halos actually collapse.

27
00:04:25.710 --> 00:04:27.690
Sownak Bose: And so, to cut a long story short,

28
00:04:28.830 --> 00:04:32.730

Sownak Bose: We do a variety of experiments and we find that in fact you can express

29
00:04:33.540 --> 00:04:41.010
Sownak Bose: The philosophy dispersion profile of the stellar content and the stars with this equation here this is equation three.

30
00:04:41.460 --> 00:04:57.390
Sownak Bose: And the way we actually get to this equation is discussed in the preceding sections. And what's interesting to note is that the only free parameters in this equation turn out to be the halo concentration which is this see 200 value and the mass of the halo itself.

31
00:04:58.620 --> 00:05:06.480
Sownak Bose: And so what that means is that if you had a data set where you've measured the line of sight philosophies versions and you sort of normalize it by this

32
00:05:07.500 --> 00:05:21.090
Sownak Bose: The maximum value is we've written it here, you can actually try and fit for these two parameters and infer something about the mass of the halo and the concentration or not words the assembly history of the halo parameters in a very simple way.

33
00:05:22.230 --> 00:05:29.220
Sownak Bose: And you can see, well, we know what the mass and concentration relationship is for the hot halos and a cold or hot cosmology.

34
00:05:29.760 --> 00:05:37.110
Sownak Bose: And you can basically analytically predict what this profile should look like and see how well that actually fits the T AMP T data.

35
00:05:37.650 --> 00:05:46.650
Sownak Bose: And that's sort of shown in this figure here where I show the velocity dispersion profiles across a range of Halo masters in the different colors.

36
00:05:47.190 --> 00:05:55.080
Sownak Bose: And the stellar philosophy aspersions are shown with the stars and the sort of solid lines for the corresponding color.

37
00:05:55.740 --> 00:06:05.520

Sownak Bose: The predictions of this particular model shown, which was described in equation three. And you can see, to a very good to know if it's very good, but to some extent.

38
00:06:06.060 --> 00:06:15.390
Sownak Bose: You find that there's a pretty good level of agreement between the measurements from the simulations themselves and the prediction that comes out from

39
00:06:16.020 --> 00:06:27.180
Sownak Bose: This mass and concentration based and description of the line of sight loss discussions and you can actually then used to use those profiles to kind of estimate where the boundary of a halo is

40
00:06:27.990 --> 00:06:36.810
Sownak Bose: Simply by just extrapolating this profile and there's a particular criteria, you can use to determine where the boundary is and compare that with the true results.

41
00:06:37.860 --> 00:06:41.100
Sownak Bose: As and in, in general, we find that you

42
00:06:43.050 --> 00:06:43.890
Ana Bonaca: Supposed

43
00:06:43.920 --> 00:06:46.410
Ana Bonaca: To fight another whole meal. Sorry.

44
00:06:46.800 --> 00:06:47.370
Sownak Bose: No, sorry, this

45
00:06:48.030 --> 00:06:48.480
Ana Bonaca: Is again.

46
00:06:48.570 --> 00:06:49.410
Sownak Bose: That's the end. So

47
00:06:50.310 --> 00:06:56.310
Ana Bonaca: Yeah, we do. Sorry, we need to move on. But this is like super exciting. And yeah, for I think

48
00:06:57.540 --> 00:07:07.170

Ana Bonaca: For the discussion we can have with within the CFA in terms of a tracer so today we need to move on to our guest speakers so

49
00:07:07.680 --> 00:07:08.670
Morgan Elowe MacLeod: Thank you. So neck.

50
00:07:10.890 --> 00:07:14.370
Morgan Elowe MacLeod: So I wanted to start by thanking both of our speakers.

51
00:07:14.370 --> 00:07:17.250
Morgan Elowe MacLeod: For being here and and all everyone who's

52
00:07:17.250 --> 00:07:24.690
Morgan Elowe MacLeod: here listening for being here admits the sort of layered stresses of this moment.

53
00:07:26.220 --> 00:07:34.890
Morgan Elowe MacLeod: And we're really grateful for your commitment and we're grateful for your ability to sort of step above them and be here. So,

54
00:07:37.800 --> 00:07:56.610
Morgan Elowe MacLeod: Our first speaker today is Daniela bordellos goofy and she is a callback Cal accomplish research fellow at the American Museum of Natural History Before that she did her PhD in San Diego and her undergrad degree at MIT.

55
00:07:58.290 --> 00:08:03.600
Morgan Elowe MacLeod: And Daniela is an expert on all things tiny stars.

56
00:08:04.950 --> 00:08:09.870
Morgan Elowe MacLeod: And so we're going to hear today about brown dwarfs and

57
00:08:11.850 --> 00:08:13.980
Morgan Elowe MacLeod: I know that you take it away. Thank you.

58
00:08:15.090 --> 00:08:22.170
Daniella Bardalez Gagliuffi: Thank you so much for that. Really nice introduction. Let's see if I can do this correctly.

59
00:08:24.660 --> 00:08:26.130

Daniella Bardalez Gagliuffi: All right. Can you see my screen.

60
00:08:29.310 --> 00:08:45.030
Daniella Bardalez Gagliuffi: Cool. All right. Again, thank you so much for for inviting me and thank you everybody for coming today we're going to talk about stars and planets and I hold me talking for quite some interest in destruction from the dumpster fire that is this planet, right.

61
00:08:46.260 --> 00:08:57.600
Daniella Bardalez Gagliuffi: So again, I work at the Museum of Natural History, I, I can go see dinosaurs on the first floor. I'm not there right now, unfortunately, and so I thought this would be a nice introduction.

62
00:08:58.740 --> 00:09:09.990
Daniella Bardalez Gagliuffi: Because what I want to talk about is how the system architectures of brown dwarf and giant brown dwarf systems star systems and giant planets in obviously systems.

63
00:09:10.500 --> 00:09:21.570
Daniella Bardalez Gagliuffi: All of those are essentially fossils like snapshots or past that we don't really have access to. But we see what products are the birds. So I'm in the same way I think.

64
00:09:22.560 --> 00:09:29.040
Daniella Bardalez Gagliuffi: The same way that was the birds today and we know that there were dinosaurs and we have fun dinosaur fossils. I think that

65
00:09:30.180 --> 00:09:35.760
Daniella Bardalez Gagliuffi: The, the processes that led to the formation of stars and planets that we see today.

66
00:09:37.260 --> 00:09:52.590
Daniella Bardalez Gagliuffi: are reflected in the configuration of the systems. So brother formation is very likely an extension of star formation, whereas planet formation is fundamentally different, even though

67
00:09:54.120 --> 00:10:00.870
Daniella Bardalez Gagliuffi: Even though we're under some time planets there atmospheres and positively and interiors are governed by the same kind of physics.

68

00:10:01.620 --> 00:10:10.140
Daniella Bardalez Gagliuffi: In practice we actually use brown dwarfs as analog so giant planet is to compare their atmospheres and their physical properties because render of data so much nicer so much

69
00:10:10.590 --> 00:10:18.690
Daniella Bardalez Gagliuffi: Much better signal to notice them planet data from girls are usually found in isolation, therefore don't have a very bright star nearby to

70
00:10:19.950 --> 00:10:28.440
Daniella Bardalez Gagliuffi: To, you know, to the Ludo the all the data you can get from a blended and in a way, a brown horse art. We call it

71
00:10:28.920 --> 00:10:47.130
Daniella Bardalez Gagliuffi: So yes, within the store for similar way. And these two guys share parameters space in terms of effective temperature love G. Sorry. Surface gravity and there are fears. So in many ways from doors are true hybrids of stars and giant planets.

72
00:10:48.750 --> 00:10:55.500
Daniella Bardalez Gagliuffi: And the biggest differences or or other to characterize the subjects, a little more stars are

73
00:10:56.100 --> 00:11:13.620
Daniella Bardalez Gagliuffi: held together by thermal pressure and the comforter arts, the gravity that tries to collapse them in words and this thermal pressure is product of the fact that stars can fuse hydrogen, but it's obviously the more the key element to their

74
00:11:14.940 --> 00:11:22.530
Daniella Bardalez Gagliuffi: To how they work. And since they release protons through this fusion, they can reach out to assuaging equilibrium

75
00:11:24.720 --> 00:11:37.440
Daniella Bardalez Gagliuffi: And if we, there is a minimum us at a Jupiter masses down to which you don't have the conditions in your core anymore in order to sustain hydrogen fusion.

76
00:11:37.950 --> 00:11:53.220
Daniella Bardalez Gagliuffi: So that's where we find brown doors and brown doors are massive enough to fuse deuterium, but not hydrogen and deuterium is not that common. There's about 10 to the minus five. The abundance of the terms about 10 to

77

00:11:54.210 --> 00:12:04.890
Daniella Bardalez Gagliuffi: 10 to the minus five times the abundance of hydrogen. So brown dwarfs the more massive ones actually fewster deteriorate pretty quickly. And instead, since they run out of

78
00:12:05.430 --> 00:12:10.470
Daniella Bardalez Gagliuffi: An internal energy generated mechanism. There's a border by election degeneracy pressure

79
00:12:10.890 --> 00:12:20.130
Daniella Bardalez Gagliuffi: And they made like the light and the heat that they meet or or just left over from their initial collapse during the formation. So they cool down over time. And this is key.

80
00:12:20.760 --> 00:12:25.050
Daniella Bardalez Gagliuffi: This is what makes them so hard to characterize become a brown dwarf.

81
00:12:25.620 --> 00:12:36.720
Daniella Bardalez Gagliuffi: Planets, then the nominal distinction is that 13 Jupiter bosses, which is the memory mass and which you can no longer burn deuterium, but they're not the different actually.

82
00:12:37.650 --> 00:12:48.720
Daniella Bardalez Gagliuffi: I want to throw also held together by electronic dance fresher and the muscle muscle javelins um so it seems like a better way to classify these objects would be by formation.

83
00:12:49.890 --> 00:12:54.690
Daniella Bardalez Gagliuffi: The classical picture of formation is that stars.

84
00:12:55.860 --> 00:13:10.440
Daniella Bardalez Gagliuffi: And brown doors form from the gravitational collapse of a molecular cloud brands need a little help with local turbulence, because that leads to high density sooner to reach low critical masses to fragment as a low mass object.

85
00:13:12.120 --> 00:13:25.350
Daniella Bardalez Gagliuffi: But they are supposed to be an extension of the same process and the minimum mass for this process would be defined way to pass it to limit that as the smallest mass, where a column is opaque to with some radiation and therefore becomes a column.

86
00:13:26.760 --> 00:13:37.830

Daniella Bardalez Gagliuffi: And simulations places limited around one to five Jupiter muscles so very low, which also means that this heart cut at 13 Jupiter muscles is not physically motivated

87
00:13:38.910 --> 00:13:49.020
Daniella Bardalez Gagliuffi: I'm Jan and blend. It's on the other hand, our thoughts from my core accretion in a disk necessarily in a bottom up. Sorry that came to us in a bottom up.

88
00:13:50.850 --> 00:13:52.290
Daniella Bardalez Gagliuffi: In a bottom up process.

89
00:13:53.970 --> 00:14:08.460
Daniella Bardalez Gagliuffi: And cognition happens by the coagulation of solids and proto plant artists and until we were just muscle tendon earth mesas, at which point it has no gravity to go around the desk and collect gas in her to have an atmosphere.

90
00:14:10.110 --> 00:14:29.850
Daniella Bardalez Gagliuffi: And there are some studies that suggest that possibly corporation can make planets as massive as five Jupiter muscles. And then there's this middle, middle no man's land process of disk fragmentation that can make both in principle brown doors and and planets.

91
00:14:31.500 --> 00:14:42.900
Daniella Bardalez Gagliuffi: You need to start with a very massive disk. And because it's so massive and it's rotating it becomes unstable and the unstable fragments kind of become self gravitated

92
00:14:42.900 --> 00:14:52.950
Daniella Bardalez Gagliuffi: Objects disk mass scales with a host Smith's so more massive stars will host more massive discs that can produce more most of objects in that

93
00:14:53.250 --> 00:15:01.920
Daniella Bardalez Gagliuffi: In that order. And so these mechanisms lead to different objects that have different internal and trapeze at the beginning. Different term heats and different compositions

94
00:15:02.520 --> 00:15:13.260
Daniella Bardalez Gagliuffi: Because it follows from here that true planets that have formed in a disc my career creation to have a higher middle is City Thunder, thunder host star.

95

00:15:13.620 --> 00:15:19.170
Daniella Bardalez Gagliuffi: Right, because in those cases what we're seeing is an object that was formed from pre process material.

96
00:15:20.010 --> 00:15:31.950
Daniella Bardalez Gagliuffi: At a time later than when the star was formed, where the volatiles of that this have left because this needs needs to cool down in order to create these small particles.

97
00:15:32.370 --> 00:15:41.130
Daniella Bardalez Gagliuffi: So, in principle, the core accretion process should should yield planets companions, whatever you want to call them.

98
00:15:41.940 --> 00:15:55.050
Daniella Bardalez Gagliuffi: Time it probably but are more metal rich down their stars. And then in the converse case binary systems should have that are formed at the same time from St. Cloud.

99
00:15:55.740 --> 00:16:12.090
Daniella Bardalez Gagliuffi: They should have the exact same composition and there are some studies that right now are starting to test these this hypotheses. I'm for some lingo cell is now a 51 portfolio, but she was a grad student in our group would be the NYC.

100
00:16:13.560 --> 00:16:26.520
Daniella Bardalez Gagliuffi: She's studied retrieval. She did atmospheric retrieval speaking to two components of a white binary system of brand wars and they both have consistency to our ratios indicating co evil formation.

101
00:16:27.210 --> 00:16:41.730
Daniella Bardalez Gagliuffi: And also killin welcome from UCSB she just published a really interesting paper where they managed to measure the CTO ratio of a sub stellar companion cap on Terminal B which is

102
00:16:43.110 --> 00:16:59.220
Daniella Bardalez Gagliuffi: 1213 Jupiter mass object to a massive star. We don't have, they don't have the middle of the of the star yet, but the solar slightly sub solar middle of the city of the companion indicates a rapid process, possibly, if this fragmentation.

103
00:17:01.080 --> 00:17:08.130
Daniella Bardalez Gagliuffi: For brown dwarfs, in principle, we can also connect their population properties, and in particular diviner friction to a given information mechanism.

104
00:17:08.610 --> 00:17:22.170
Daniella Bardalez Gagliuffi: So here are some predictions from different different information scenarios if we jacked up reseller quarter was being formed. Don't give it enough time to let it form, then

105
00:17:23.250 --> 00:17:36.360
Daniella Bardalez Gagliuffi: Then we can end up with a brown dwarf. And that's predicted to be about an 8% final reflection from this fragmentation. We predicted what 16% from core fragmentation as a secondary fragmentation.

106
00:17:37.950 --> 00:17:48.900
Daniella Bardalez Gagliuffi: It just is that it's low and finally from photo photo arbitration reseller course they don't. There's not really a number given but also we don't expect we don't find brown dwarfs always around

107
00:17:49.200 --> 00:17:59.700
Daniella Bardalez Gagliuffi: massive stars such that the winds from the most of stars like push all the material out and leave a naked core the star essentially like a pro. To start living became a brown dwarf.

108
00:18:00.390 --> 00:18:11.640
Daniella Bardalez Gagliuffi: We don't see that happen all the time. So we don't think that this is a the most likely or sorry, the most prominent way in which we can form brand wars.

109
00:18:12.600 --> 00:18:19.980
Daniella Bardalez Gagliuffi: But this is a nice idea right we measure them multiplicative friction and they would can connect back to a formation mechanism and

110
00:18:20.550 --> 00:18:39.000
Daniella Bardalez Gagliuffi: This is what the theory predicts also brown doors, the binary fraction of brown doors polos very nicely from that have more massive stars. This is another reason why we think that brown dwarf formation is low mass is the lowest version of the star formation process.

111
00:18:40.140 --> 00:18:44.670
Daniella Bardalez Gagliuffi: But really it is much more complicated mushroom binary fractions is very difficult.

112
00:18:45.930 --> 00:18:51.840

Daniella Bardalez Gagliuffi: Because it depends on the technique that you're using in order to identify your binary system.

113
00:18:52.470 --> 00:19:05.880
Daniella Bardalez Gagliuffi: And it depends. Because each technique is going to be sensitive to different ranges and binary separation and the mass ratio and it depends also on the volume that you're on the completeness of your volume and how you chose your sample.

114
00:19:07.410 --> 00:19:20.070
Daniella Bardalez Gagliuffi: Each formation mechanism leaves distinct imprints on the distributions of orbital parameters in binary systems. So this is why using a specific technique is also important.

115
00:19:21.180 --> 00:19:33.450
Daniella Bardalez Gagliuffi: But this also means that the population trends can be inferred from system architectures and. And here are a few examples of extreme systems that are

116
00:19:34.500 --> 00:19:40.020
Daniella Bardalez Gagliuffi: Sort of in the middle of some formation mechanisms or will there extreme for their own right. This is

117
00:19:40.500 --> 00:19:56.580
Daniella Bardalez Gagliuffi: Too much 1119 it's a binary system equal most objects. Both of them are for Jupiter masses each one of them and they're very closest separated. This is a, this is very consistent with something like core fragmentation actually and

118
00:19:57.840 --> 00:20:03.270
Daniella Bardalez Gagliuffi: And competitive accretion leads to a mass ratio close to one.

119
00:20:04.500 --> 00:20:15.900
Daniella Bardalez Gagliuffi: It does. It is interesting, though, that both masters are so low that they may be very close and minimum as for opacity fragmentation Java seven is my favorite systems.

120
00:20:16.890 --> 00:20:32.400
Daniella Bardalez Gagliuffi: It's a five Jupiter must companion to a 33 Jupiter must around board and the mass ratio is very low is very unusual for Bronco refineries to be this low and it's fairly wide to think of this as a

121
00:20:32.940 --> 00:20:44.460

Daniella Bardalez Gagliuffi: As a planet formation are going to some because of this because I mentioned the more most of the starter. Most of the disc. This is a very low mass star brown dwarf and

122
00:20:44.880 --> 00:20:53.430
Daniella Bardalez Gagliuffi: Is this should also be very much. So this is also a bit unclear how it formed happened. Remember, be that I mentioned earlier, has a very low mass ratio.

123
00:20:53.730 --> 00:21:02.400
Daniella Bardalez Gagliuffi: This looks a lot more like a planet based on the loan must ratio, but it's a high muscle object as well. So he received possibly an evidence of

124
00:21:02.820 --> 00:21:20.580
Daniella Bardalez Gagliuffi: Disk fragmentation producing objects as big as massive as 12 Jupiter monsters HR at seven and nine is a system of four planets, possibly, and they are co planner, which definitely very strongly suggests that they were all formed in a disk.

125
00:21:22.680 --> 00:21:35.400
Daniella Bardalez Gagliuffi: And finally, oh 806 which is unknown and locked in the broader community. This is a white dwarf is one of the coldest types of brown dwarfs and its associated with a white dwarf.

126
00:21:36.870 --> 00:21:53.340
Daniella Bardalez Gagliuffi: But, which is interesting because the white dwarf in a past life wasn't a star. And that means that the mass ratio on this farm must have been point oh four, which is unheard of for proper binary system this month. This is probably a planet, but we call it a white

127
00:21:54.780 --> 00:21:55.560
Daniella Bardalez Gagliuffi: A whiteboard.

128
00:21:57.150 --> 00:22:05.160
Daniella Bardalez Gagliuffi: And another thing that's interesting about all the systems is that all of them except for the for the white dwarf system. They're all young

129
00:22:05.760 --> 00:22:18.570
Daniella Bardalez Gagliuffi: This is how we're finding objects, they're bright and they're young and all of these are very different systems, but the positive looking for. I mean we have to fit them in one of these few boxes of which formation mechanism. They came from.

130
00:22:20.070 --> 00:22:27.690
Daniella Bardalez Gagliuffi: So we can connect the population of orbital parameters to information pathway says, Well, here's

131
00:22:29.430 --> 00:22:39.060
Daniella Bardalez Gagliuffi: If we look at the systems as an ensemble here subplot from 2010 from killing crowd. Right. Oh, and this was following the discovery of the HR 8799 planets.

132
00:22:39.570 --> 00:22:48.540
Daniella Bardalez Gagliuffi: Which are shown in magenta these boxes, the x axis sorry is separation Y axis is mass ratio and these boxes were meant to indicate

133
00:22:49.260 --> 00:22:58.740
Daniella Bardalez Gagliuffi: A lack of systems sort of showing these pink systems must be an extreme of the top population or an extreme of the bottom population sort of imply in light.

134
00:22:59.370 --> 00:23:10.890
Daniella Bardalez Gagliuffi: Of the top. These are brown bear systems. We know they formed by accreditation fragmentation of the bottom we have planetary systems. We know they form a corporation. These things are in the mode and now

135
00:23:10.920 --> 00:23:12.120
Daniella Bardalez Gagliuffi: With 2020

136
00:23:12.930 --> 00:23:14.370
Daniella Bardalez Gagliuffi: Thank you. I need to rush

137
00:23:16.170 --> 00:23:28.890
Daniella Bardalez Gagliuffi: Now we put in 2020, we have a lot more objects. These boxes are full. It's still unclear what the limit is and the green points are the only brown dwarf muscles that we know very securely from dynamical masses.

138
00:23:30.330 --> 00:23:38.460
Daniella Bardalez Gagliuffi: And we think I'm possibly there could be a value between the two different populations. So we will know this until each section.

139
00:23:39.330 --> 00:23:49.500

Daniella Bardalez Gagliuffi: As I mentioned, each the touch company sensitive to orange separation. Some we will know we need to map our selection functions very carefully, especially for young

140
00:23:50.820 --> 00:24:04.770
Daniella Bardalez Gagliuffi: Well, and, and both for separation and also for mass ratio. So in order to get better to quantify the population of binary systems in a better way. That is not dependent separation.

141
00:24:05.730 --> 00:24:16.860
Daniella Bardalez Gagliuffi: Here so technique where you can identify binary systems based on their blended light spectrum. The show's peculiarities, so if you focus on the 1.6

142
00:24:17.430 --> 00:24:36.210
Daniella Bardalez Gagliuffi: Micron inset in this in this plot, there's a little dip and the corresponds to methane absorption in the spectrum of a hotter object that shouldn't have my phone in their sphere. So this is how we're identifying systems that are over that are

143
00:24:37.980 --> 00:24:47.760
Daniella Bardalez Gagliuffi: We're one object is above the hydra and Bernie limit and the other objects below the headroom. But in London and the added. Well, there's this separation dependent. So

144
00:24:49.290 --> 00:24:53.940
Daniella Bardalez Gagliuffi: I compiled a sample of all of these objects of all

145
00:24:55.020 --> 00:25:01.590
Daniella Bardalez Gagliuffi: All high most brown dwarfs that were struggling to headroom Brennan limit started at him seven all the way to L five

146
00:25:02.610 --> 00:25:20.220
Daniella Bardalez Gagliuffi: The sort of that color points in the in the color mining to diagram and within 25 or six. So with the Malian limited sample. I can actually get robust statistics within this only limited sample. I counted how many of these spectral binaries were identified and

147
00:25:21.270 --> 00:25:37.950
Daniella Bardalez Gagliuffi: And I developed simulations of the population in order to extract the true binary fraction. So assuming that I know my bias is really well for the techniques that I'm using, I can recover the true binary fraction. So just browse through this really quick.

148
00:25:39.420 --> 00:25:53.640
Daniella Bardalez Gagliuffi: I can talk about this later. Different. These are the input distributions. I use different primary mass different IMS H distributions mass ratio distributions and evolutionary models in order to derive

149
00:25:54.930 --> 00:25:56.310
Daniella Bardalez Gagliuffi: Populations of

150
00:25:57.510 --> 00:26:00.750
Daniella Bardalez Gagliuffi: Of brand wars and um

151
00:26:02.160 --> 00:26:06.240
Daniella Bardalez Gagliuffi: And as you can see they're all different. I can, I can talk about this in detail later.

152
00:26:07.980 --> 00:26:13.020
Daniella Bardalez Gagliuffi: And also estimating the selection function of the spectral binary technique.

153
00:26:14.220 --> 00:26:16.020
Daniella Bardalez Gagliuffi: And based on that.

154
00:26:17.430 --> 00:26:21.870
Daniella Bardalez Gagliuffi: We can I have a very, very preliminary results, suggesting that

155
00:26:23.100 --> 00:26:32.910
Daniella Bardalez Gagliuffi: The population that is most consistent with the observed population came from a log normal initial mass function and

156
00:26:33.420 --> 00:26:42.450
Daniella Bardalez Gagliuffi: Uniform H estimation. This is very preliminary. There's a lot of analysis to be done with this, but it's it's interesting to see that that is the direction in which is going

157
00:26:42.720 --> 00:26:47.700
Daniella Bardalez Gagliuffi: And the binary fractions should be somewhere around nine to 25% which we already knew.

158
00:26:48.300 --> 00:27:03.030

Daniella Bardalez Gagliuffi: But at least with this technique we were understanding the limits of this we're understanding the selection function of this technique. Very well. And we have we have measure the right direction in a volume limited sample which makes our

159
00:27:04.890 --> 00:27:09.930
Daniella Bardalez Gagliuffi: Our statistics also makes them robust. So in summary,

160
00:27:11.400 --> 00:27:22.830
Daniella Bardalez Gagliuffi: The system architectures, the multiplicity statistics and compositions can constrain formation mechanisms for browsers and giant planets and we have measured minor infraction for

161
00:27:24.090 --> 00:27:26.220
Daniella Bardalez Gagliuffi: Works in a volume limited sample.

162
00:27:27.450 --> 00:27:38.280
Daniella Bardalez Gagliuffi: And finally, the preliminary analysis suggests a look normal IMF and a uniform H distribution. So, I am sorry I have to rush through it and I'm happy to take any questions.

163
00:27:49.260 --> 00:27:49.920
Ana Bonaca: At a time.

164
00:27:51.930 --> 00:27:52.560
Daniella Bardalez Gagliuffi: When I heard the rain.

165
00:27:55.980 --> 00:27:57.360
Ana Bonaca: Okay, maybe then migrate.

166
00:27:58.920 --> 00:28:01.590
Ana Bonaca: Immediately, go back to like this.

167
00:28:02.340 --> 00:28:10.440
Ana Bonaca: interesting tidbits about them constraints you get on the on the IMF. So I guess my first question is,

168
00:28:11.220 --> 00:28:27.960
Ana Bonaca: How can you distinguish it sounds like you prefer a lock normal solution but thing is interesting complex of stars. It looks like that. The normal is like pretty similar to the broken parallel. So can you really distinguish between like Groupon and sharply a

169
00:28:29.370 --> 00:28:40.170
Daniella Bardalez Gagliuffi: Know quite that is a really good question. So I think that um when I did this analyses. Let me go back a few slides like on the

170
00:28:41.700 --> 00:28:43.170
Daniella Bardalez Gagliuffi: The info distributions.

171
00:28:44.310 --> 00:29:00.480
Daniella Bardalez Gagliuffi: Are use three different IMS the chair, very much. Let's woman or Malta Krupa MF that is there's a broken IMF and sorry to broken power loss and the CARE, PATRICK empirically derived. I met that is also a

172
00:29:02.010 --> 00:29:06.390
Daniella Bardalez Gagliuffi: Power loan, but with a slightly steeper. So it less steep.

173
00:29:07.560 --> 00:29:22.110
Daniella Bardalez Gagliuffi: Exponent and I did a so between these and the different ages regions and the different mass ratio is two regions and then the different evolutionary models. I ended up with 72 populations all

174
00:29:25.020 --> 00:29:34.200
Daniella Bardalez Gagliuffi: Binaries each. And, um, and from those I I found these the simulated populations.

175
00:29:34.680 --> 00:29:48.300
Daniella Bardalez Gagliuffi: And I compare the distribution of spectral dive primary spiritual types from the simulations to the surf primers virtual dose, because that's what I had for my sample. Um, I did model selection with the chaos test and

176
00:29:49.110 --> 00:30:01.440
Daniella Bardalez Gagliuffi: And found that the there were six sensor. So we're indistinguishable. And they were all logged normal IMF and an HP distribution that went from from zero to 10 giga years

177
00:30:01.710 --> 00:30:13.590
Daniella Bardalez Gagliuffi: Because I also tried on a distribution that was like from zero to seven giga years thinking that's live in a plane was things on younger, but, um, but that seemed to be the most consistent one

178
00:30:17.520 --> 00:30:18.630
Ana Bonaca: Grateful after

179
00:30:19.980 --> 00:30:20.940
Ana Bonaca: What I was getting

180
00:30:22.620 --> 00:30:23.250
Ana Bonaca: Next,

181
00:30:24.690 --> 00:30:25.500
Ana Bonaca: Yeah, it's

182
00:30:25.620 --> 00:30:26.490
Ana Bonaca: Like how much

183
00:30:26.790 --> 00:30:29.070
Ana Bonaca: Flexibility was there at the age models.

184
00:30:29.700 --> 00:30:30.570
Ana Bonaca: Are guessing.

185
00:30:30.930 --> 00:30:32.280
Daniella Bardalez Gagliuffi: In another way of asking

186
00:30:32.340 --> 00:30:37.650
Ana Bonaca: Like how strong artists constraints of it is a uniform like age distribution.

187
00:30:41.430 --> 00:30:51.180
Daniella Bardalez Gagliuffi: Here to different yes so I can show my mouse but if you see on the top right corner that those are the different age distribution for us.

188
00:30:52.560 --> 00:31:02.070
Daniella Bardalez Gagliuffi: There and you can see how the uniform 10 goes all the way to 10 years unit from setting those 270 armor distribution.

189
00:31:03.450 --> 00:31:18.360
Daniella Bardalez Gagliuffi: assumes a star formation rate was higher in the past, and then the region apart and distribution assumes a higher

star formation rate but happened very far away in the past like a sea of a wretched one or two can remember

190
00:31:19.530 --> 00:31:24.900
Daniella Bardalez Gagliuffi: So you see the, the mean age of the mean of the ages age distributions.

191
00:31:26.190 --> 00:31:27.120
Daniella Bardalez Gagliuffi: Determine

192
00:31:30.960 --> 00:31:41.970
Daniella Bardalez Gagliuffi: Maybe I can show you this better. If you look at the top left, that's the primary spectral type distributions and they're very different because brown or school over time.

193
00:31:42.300 --> 00:31:49.080
Daniella Bardalez Gagliuffi: When we when we assume a population and we've been will masses, and then we give them all ages and then let them evolve.

194
00:31:50.550 --> 00:32:02.250
Daniella Bardalez Gagliuffi: This is a mixed population of very, very low mass stars that are not going to change their spectral type under temperature that much because they are stars, and then a big population of brown doors that will actually cool over time.

195
00:32:03.030 --> 00:32:14.070
Daniella Bardalez Gagliuffi: So it's, there's a lot of detail analysis that can go into describing these distributions. Um, but, yes, to answer your question of

196
00:32:15.420 --> 00:32:33.420
Daniella Bardalez Gagliuffi: The age distribution how sure I am of the uniform 10 all I know at this point because analysis is still ongoing, is that, that is that is the one that I could reject with the with the chaos test. It is, but it's less predictable one

197
00:32:36.540 --> 00:32:39.990
Ana Bonaca: Yeah, this like this bigger shows like kind of the power of this

198
00:32:41.190 --> 00:32:52.650
Ana Bonaca: Of this space and kind of modeling the whole set of populations. And so I'll turn out to the questions from the audience. And I have a question about this.

199
00:32:53.610 --> 00:33:06.210
Ana Bonaca: Kind of population approach saying that some of the architectures must have been affected by gravitational interactions among objects or expulsion of some objects and migration of others.

200
00:33:06.900 --> 00:33:10.080
Ana Bonaca: So his question is how do your comfort is complication.

201
00:33:11.610 --> 00:33:21.570
Daniella Bardalez Gagliuffi: Haven't I yes i haven't accounted for that complication because I'm starting to the point I'm starting on the initial mass function point. So, if there were

202
00:33:24.900 --> 00:33:33.000
Daniella Bardalez Gagliuffi: Two parts of your on the sort of a one one part is that I haven't accounted for that because I am started up initial mass function point

203
00:33:34.080 --> 00:33:38.880
Daniella Bardalez Gagliuffi: Which already assumes that there were processes, changing the

204
00:33:39.450 --> 00:33:47.130
Daniella Bardalez Gagliuffi: The masses of clumps into the final product that is self replicating. So I'm starting at that point. So, I have no knowledge of what happened before.

205
00:33:47.430 --> 00:34:01.170
Daniella Bardalez Gagliuffi: You know if they were nearby objects are creating us though we're in your reserve or ended up with Lomas or someplace that that's that should be accounted for in the initial most function. And second, that system architecture Weiss.

206
00:34:03.060 --> 00:34:20.340
Daniella Bardalez Gagliuffi: I'm considering here objects because I'm trying to recover the turbine your freshman from the spectral binary technique. Then I have turned all of these binary systems that I created on this population into spectral binary the piece that was missing here when I explain this is that

207
00:34:21.510 --> 00:34:34.140
Daniella Bardalez Gagliuffi: I've made the primary and secondary I made I drew premier muscles from the IMF ages from this age distribution, a mass

ratio from the mass ratio distribution and then that's how I got the secondary messages.

208
00:34:35.400 --> 00:34:41.160
Daniella Bardalez Gagliuffi: Based on and then those two masses with the ages were able to two days.

209
00:34:42.120 --> 00:34:48.810
Daniella Bardalez Gagliuffi: You know, depending on the age or go to a certain temperature and based on those temperatures that are translated to special types.

210
00:34:49.110 --> 00:35:03.840
Daniella Bardalez Gagliuffi: I am able to draw real spectra from a library and then add those two together scaling to think about parsecs pretend that it's a binary system, but it's unresolved, and then test it on my technique and then see if my Timmy can recover that

211
00:35:04.380 --> 00:35:20.370
Daniella Bardalez Gagliuffi: Binary the true specter library as such. And so, by, by doing that, what I'm, what I'm doing is this bar. I'm trying to understand what is the selection function of the binary technique of the spectrum binary technique.

212
00:35:21.930 --> 00:35:23.100
Daniella Bardalez Gagliuffi: Does that answer your question.

213
00:35:24.810 --> 00:35:27.360
Abraham Loeb: Yeah, I mean, as long as

214
00:35:28.560 --> 00:35:35.490
Abraham Loeb: What you're starting point incorporates the fact that the word expeditions and some migrations and so

215
00:35:36.300 --> 00:35:46.650
Abraham Loeb: I guess we don't know much about it, but then you can see if the mapping of your initial conditions to what we observe is matching the data that that's what you're telling me. So yes, thank you.

216
00:35:48.630 --> 00:35:50.100
Daniella Bardalez Gagliuffi: Okay, I think we

217
00:35:50.520 --> 00:35:52.890
Daniella Bardalez Gagliuffi: Started with a system architectures part

218
00:35:54.000 --> 00:35:58.020
Daniella Bardalez Gagliuffi: Because I'm using the spectral binary technique, it is independent of separation.

219
00:35:59.070 --> 00:36:12.570
Daniella Bardalez Gagliuffi: But also because I'm using a volume limited sample for the observed population, then I am sensitive to binary separations out to a 12.5 a use

220
00:36:13.140 --> 00:36:31.110
Daniella Bardalez Gagliuffi: For the systems because of the width of the slit that I use in order to observe the spectrum, and that is that is beyond the peak of the separations revision of brown dwarf binaries. So I should be taking most of the other systems that are possibly formed

221
00:36:33.510 --> 00:36:34.230
Thank you. Thank you.

222
00:36:35.400 --> 00:36:55.080
Ana Bonaca: Okay. And are you just set as a close up so Morgan asked about the implications for the formation mechanisms. So, since you're deriving that many of these distributions are continuous. What does this mean for the formation mechanisms overlapping face face.

223
00:36:56.370 --> 00:37:00.120
Ana Bonaca: And Morgan is like if you feel free to elaborate

224
00:37:02.160 --> 00:37:08.490
Daniella Bardalez Gagliuffi: Um, Morgan. Let me see if I understood your question. So are you asking about, um,

225
00:37:09.060 --> 00:37:26.430
Morgan Elowe MacLeod: I guess I'm interested in the idea that, like, it seems, because of the eventual combined distribution from all these processes seems to be kind of continuous. Does that mean that multiple processes can form objects with similar properties.

226
00:37:27.480 --> 00:37:28.350
Or how do we

227
00:37:30.840 --> 00:37:31.470
Morgan Elowe MacLeod: Interesting.

228
00:37:31.770 --> 00:37:53.370
Daniella Bardalez Gagliuffi: Yeah. Um, yes. In this simulations I my minimum masters around point or one of these, are these lines are Colonel density estimates. So they're not. They're nice and smooth. But at the edges are not reliable and

229
00:37:55.020 --> 00:38:01.230
Daniella Bardalez Gagliuffi: And based on the, I mean, based on the code that I'm working with, I can make masses down to

230
00:38:03.240 --> 00:38:22.320
Daniella Bardalez Gagliuffi: Down to one Jupiter massive thing and that is also or a regime were work for creation can easily make objects and this fragmentation can also make objects like bad but all of the systems that I have simulated here are because they're coming from this, from this different

231
00:38:23.340 --> 00:38:30.510
Daniella Bardalez Gagliuffi: Stellar brown dwarf IMS, then I am assuming for all of them and they're being formed us

232
00:38:32.580 --> 00:38:39.210
Daniella Bardalez Gagliuffi: Like from Brighton on fermentation. And in fact, I'm also assuming that the secondary mass distribution is

233
00:38:40.020 --> 00:38:49.770
Daniella Bardalez Gagliuffi: Dependent on the first because I am not drawing the secondaries from the first from the IMF from drawing the secondaries from a mass ratio distribution. So that could be an interesting experiment to do as well.

234
00:38:51.630 --> 00:38:53.100
Morgan Elowe MacLeod: Try with fascinating. Thank you.

235
00:38:55.020 --> 00:38:56.190
Daniella Bardalez Gagliuffi: I apologize, but I'm rushing the

236
00:38:56.820 --> 00:38:58.080
Morgan Elowe MacLeod: Know this is really wonderful.

237
00:38:59.370 --> 00:39:03.540
Ana Bonaca: Thank you so much. This is yes, very interesting. And we don't really get to hear much about

238
00:39:04.860 --> 00:39:05.910
Ana Bonaca: Very often, so thank you.

239
00:39:05.910 --> 00:39:06.420
Ana Bonaca: So much

240
00:39:07.620 --> 00:39:11.100
Morgan Elowe MacLeod: Yeah, I guess, like the unpopular middle

241
00:39:12.780 --> 00:39:13.350
Daniella Bardalez Gagliuffi: I don't know why.

242
00:39:16.260 --> 00:39:17.340
Morgan Elowe MacLeod: Okay, so

243
00:39:18.510 --> 00:39:23.760
Morgan Elowe MacLeod: Thank you so much. I'm delighted to introduce our second speaker Evan Bauer, who is

244
00:39:26.490 --> 00:39:27.120
Morgan Elowe MacLeod: I

245
00:39:27.750 --> 00:39:32.640
Morgan Elowe MacLeod: ITC member and a CFA postdoctoral fellow starting this this year.

246
00:39:34.020 --> 00:39:43.620
Morgan Elowe MacLeod: He is an expert on Stellar and binary evolution. And it's going to talk to us today about white dwarfs and some dwarfs and

247
00:39:44.760 --> 00:39:48.150
Morgan Elowe MacLeod: And then what did his PhD at UC Santa Barbara and

248
00:39:49.170 --> 00:39:50.130
Morgan Elowe MacLeod: A postdoc

249
00:39:51.240 --> 00:39:57.840
Morgan Elowe MacLeod: At K TP before before coming here at least virtually

250
00:39:59.520 --> 00:40:02.370

Morgan Elowe MacLeod: So we're delighted to have you today and thank you so much.

251
00:40:04.080 --> 00:40:10.050
Evan Bauer: Thanks for Morgan. I'm really happy to be here and actually here. I really am in perking up to 16

252
00:40:10.230 --> 00:40:11.160
Morgan Elowe MacLeod: Okay. I thought so.

253
00:40:11.310 --> 00:40:13.710
Morgan Elowe MacLeod: But I didn't know in case I was wrong.

254
00:40:15.000 --> 00:40:16.800
Evan Bauer: So yeah, great to be here. I'm

255
00:40:17.010 --> 00:40:26.370
Evan Bauer: Glad to have a chance to introduce myself more broadly to the ITC so for this talk, it's a little less digging into a really specific science.

256
00:40:27.000 --> 00:40:37.950
Evan Bauer: Problem and more an attempt to give a broad overview of some of the science that I've been doing and plans for what I intend to do over the next few years while I'm here.

257
00:40:38.430 --> 00:40:47.220
Evan Bauer: So hopefully that just gives everyone a better idea of, of what I do and maybe opportunities to collaborate or think about new ideas. So

258
00:40:48.360 --> 00:41:03.900
Evan Bauer: I'm theorist, or maybe a computational list. I work on Stellar Evolution models, especially sub dwarfs and white dwarfs. I often use the code Mesa every once in a while and end up doing development of Mesa when I need new features for the science that I'm working on.

259
00:41:05.250 --> 00:41:11.250
Evan Bauer: And today I'm going to talk about the many topics involving runaway stars and supernovae.

260
00:41:12.270 --> 00:41:15.060
Evan Bauer: That I'm interested in with these kinds of stars.

261
00:41:16.830 --> 00:41:33.000
Evan Bauer: And I guess I should also mention, so my collaborators on this particular work worked a lot with Chris white and Matt Coleman, especially when it comes to the hydro parts of models. They're both Athena plus plus experts and so they've done a lot of really helpful work in

262
00:41:34.980 --> 00:41:50.190
Evan Bauer: Doing hydrodynamic models involving supernovae at the polling is a postdoc now a part of getting Caltech. She does a lot of detonation models for thermonuclear supernovae, and first large Wilson was my PhD advisor at UCSB

263
00:41:51.660 --> 00:41:51.840
Evan Bauer: Oh,

264
00:41:53.010 --> 00:42:02.250
Evan Bauer: There we go. Okay, before I actually get into runaways I did want to quickly mention one other topic that I've done some work on and I'm very interested in white dwarf pollution, so

265
00:42:02.940 --> 00:42:16.470
Evan Bauer: White dwarfs have a lot of really interesting things going on at their surfaces. It turns out, a lot of them show signatures of accretion of planetesimals that somehow get scattered close to the white dwarfs and then totally disrupted created on the whiteboard surfaces.

266
00:42:17.730 --> 00:42:25.410
Evan Bauer: And the physics of that problem is really interesting. I won't really get into it that much today, but I wanted to mention that I work on it.

267
00:42:26.310 --> 00:42:29.820
Evan Bauer: I think the most interesting aspect to me is when you have a steely stratified

268
00:42:30.420 --> 00:42:39.330
Evan Bauer: Stellar structure but you end up with kind of inverted composition, you get interesting physics. So when you have heavy elements sitting on top of light elements.

269
00:42:39.750 --> 00:42:43.260
Evan Bauer: Were white dwarfs tend to want a stratified. The other way, of course, because they're trying gravity.

270
00:42:43.890 --> 00:42:52.530
Evan Bauer: There's lots of interesting physics to do there. And you can see actually the very easy terrestrial analog is if you put a warm saltwater on top of

271
00:42:53.130 --> 00:43:01.440
Evan Bauer: Cold freshwater, you get the same kinds of instabilities I believe it or not, this cool relate to run away stars. I'll try to tie that back in at the end.

272
00:43:02.730 --> 00:43:11.760
Evan Bauer: But getting around to run away stars, I first want to start by kind of defining what I'm really referring to, because the term runaway gets used in a lot of different contexts for

273
00:43:12.390 --> 00:43:29.700
Evan Bauer: Stellar astrophysics. So when I say runaway I really mean pretty fast runaway so people would characterize these as hyper runaways stars moving more than about 500 kilometers per second. In other words, unbound from the galaxy, leaving the galaxy, at least in our neighborhood within the

274
00:43:30.720 --> 00:43:33.420
Evan Bauer: Within a kilo per sec or two where the sunsets.

275
00:43:34.710 --> 00:43:45.990
Evan Bauer: And I want to be careful not to use the term hyper a lot of City Star, especially with Warren brown in the audience that often has connotations of stars coming from the galactic center.

276
00:43:46.380 --> 00:43:53.910
Evan Bauer: That are moving faster than 1000 followers per second. Probably associated with the hills mechanism and the supermassive black hole at the black center.

277
00:43:54.480 --> 00:44:09.390
Evan Bauer: So I'm not talking about that sort of mechanism, but I am talking about stars that move almost that fast, or in some cases, just as fast as what you might have read about in sort of hypervelocity star.

278
00:44:10.650 --> 00:44:25.920
Evan Bauer: Literature, but I'm going to mostly stick to the term runaway for these kinds of stars. And the reason I'm interested in them is, I think, because there are now classes of stars.

279
00:44:26.640 --> 00:44:35.940
Evan Bauer: That with Gaia, Dr. To have been discovered that are moving at these kind of fast velocities, leaving the galaxy 500 up to even 3000 kilometers per second.

280
00:44:36.810 --> 00:44:44.550
Evan Bauer: Their trajectory is don't point anywhere near the galactic center. So the hills mechanism is out unless you believe there supermassive black holes floating around everywhere.

281
00:44:45.390 --> 00:45:02.940
Evan Bauer: Really what has to produce these kinds of stars is binary systems in which you have compact binary is fast orbital velocities center supernova explosion thermonuclear explosion has to occur to destroy one of the stars and liberate the other one or the other one into

282
00:45:04.080 --> 00:45:05.850
Evan Bauer: High Velocity trajectory

283
00:45:07.230 --> 00:45:13.950
Evan Bauer: So just in the last couple of years. A couple distinct classes. I think I would pretty strongly argue that there are multiple classes of these

284
00:45:14.430 --> 00:45:18.390
Evan Bauer: New types of stars have been discovered things to data from Gaia.

285
00:45:19.020 --> 00:45:38.910
Evan Bauer: One of these is so called the six that's named after a mechanism. I think James You Sean did a lot of work on this can Shen lead particular paper discovering these so they even d six for their poetic dynamically driven double degenerate double detonation type one, a supernova scenario.

286
00:45:40.170 --> 00:45:49.560
Evan Bauer: The argument is that this is a double a core system experiences a particular destination mechanism. And since one of the stars, the one that doesn't explode off at a very high velocity

287
00:45:51.000 --> 00:46:00.000
Evan Bauer: And then there's another class of stars that also sort of have some distinctive features that seem to be produced by thermonuclear supernovae and binaries.

288
00:46:00.540 --> 00:46:06.690
Evan Bauer: The name that we kind of ended up as a community is LP 40 just naming them after

289
00:46:07.350 --> 00:46:21.690
Evan Bauer: The first type of star discovered in this class. These are moving a little slower. They're moving sort of in the 500 to 800 kilometers per second range. So they're probably not produced by double Wake of systems, but they do need something

290
00:46:22.770 --> 00:46:33.030
Evan Bauer: pretty dramatic happened in a stellar binary system to produce them. And so just a quick overview, a really nice.

291
00:46:34.170 --> 00:46:39.240
Evan Bauer: illustrations from the website. The idea here is you have a compact binary again.

292
00:46:40.380 --> 00:46:54.180
Evan Bauer: That will spiral together and mass transfer will occur in some way that will cause a thermonuclear supernova. I'm going to stick to being pretty agnostic about the sort of observational classes so

293
00:46:54.660 --> 00:47:04.380
Evan Bauer: Generally, I mean a detonation in a white dwarf is a thermonuclear supernova. I'm not going to be too concerned if it's necessarily, you know, a type one, a

294
00:47:05.160 --> 00:47:19.470
Evan Bauer: Classic Normal Type one a, or maybe a peculiar one day. And then, of course, once that star goes up it liberates the other companions star maybe hits it, and kicks it as well. And that's what is producing these hypervelocity stars we think

295
00:47:21.780 --> 00:47:34.290
Evan Bauer: Okay. One of the most interesting questions that immediately came out when these classes of stars were discovered actually was not really expected. They didn't select them based on where they sound the HR diagram. They mostly went looking for

296
00:47:34.890 --> 00:47:44.880
Evan Bauer: high velocities from proper motion data and Gaia, but they ended up kind of sitting in a consistent place in nature diagram. So here's the guy HR diagram right here is the

297
00:47:45.480 --> 00:47:58.080
Evan Bauer: main sequence white doors are all the way down here, much more compact and these classes of stars are kind of more generally in the sub Dorf regime in there, you know, maybe up to a few tenths of the solar radius.

298
00:47:58.500 --> 00:48:13.350
Evan Bauer: Definitely not as as puffy as a sequence star, not as compact as a white dwarf. And that's actually a big problem for the velocities that they found because the velocity requires

299
00:48:13.920 --> 00:48:21.600
Evan Bauer: Binary orbits that are very, very compact for the for the started actually sit within fit within that binary system, it has to have a radius.

300
00:48:22.080 --> 00:48:31.740
Evan Bauer: Much closer to where white dwarfs would sit to produce the orbital velocity is that are observed with Guy promotion data. And so the first physics problem.

301
00:48:32.310 --> 00:48:44.970
Evan Bauer: I think from a theoretical perspective is to understand how you get from the compact state that they must have been in when the thermonuclear explosion occurred to the currently observed state where we think it's probably

302
00:48:45.900 --> 00:48:52.950
Evan Bauer: Hundreds of thousands or maybe a few million years later. While these stars are on their way out of the galaxy where we're observing them now.

303
00:48:54.810 --> 00:49:07.110
Evan Bauer: So just to quantify that a little more. It's actually pretty straightforward. Using the Roche geometry to write down the requirement of what the radius of the star has to be as a function of its orbital velocity

304
00:49:07.890 --> 00:49:18.030
Evan Bauer: So you see, for every thousand kilometers per second orbital velocity that you want to produce, you need to be smaller than a few hundreds of a solar radius.

305
00:49:19.410 --> 00:49:32.400

Evan Bauer: And the most obvious piece of physics to look at is, can the shock from the supernova ejecta have a large impact on the star. And one way to maybe write down a quick estimate

306
00:49:33.510 --> 00:49:36.390
Evan Bauer: For answering that question is what's the ram pressure in the shock.

307
00:49:37.830 --> 00:49:43.170
Evan Bauer: For you know supernova ejected moving in 10,000 kilometers per second versus sort of the average pressure

308
00:49:43.830 --> 00:49:56.550
Evan Bauer: In the companion star and indeed that's that ratio is pretty high. And so it does seem you seem like you could excite a shock that would have a pretty large impact on the structure of the star. So,

309
00:49:58.020 --> 00:50:02.430
Evan Bauer: One of the kinds of projects I've worked on recently is

310
00:50:03.600 --> 00:50:11.070
Evan Bauer: Looking at pursuing that in more detail with some of the models. So we started with.

311
00:50:12.450 --> 00:50:23.610
Evan Bauer: A family of models largely motivated by compact systems involving a white dwarf and a sub dwarf. So this is kind of my my crude

312
00:50:24.330 --> 00:50:33.030
Evan Bauer: Illustration crucially drawn to scale. So this larger star would be a sub dwarf donors are about half a solar mass helium pops up Dorf

313
00:50:33.780 --> 00:50:44.460
Evan Bauer: Burning helium and its core over here on the left would be a white dwarf. That's about three quarters of a solar mass and these these correspond to actually observed systems that we've seen in our galaxy.

314
00:50:45.240 --> 00:50:54.660
Evan Bauer: If the telephone number of the most famous one up here and we think we know how to evolve that forward in time into a configuration that is very likely to produce some sort of thermonuclear detonation.

315
00:50:55.260 --> 00:51:01.980

Evan Bauer: Because it's a helium sub door star, it will stabilize transfer about point to solar masses.

316
00:51:02.250 --> 00:51:13.650
Evan Bauer: Of helium from the sub North onto the white dwarf. That's very likely to detonate and because the detonation that transitions into the core of the white dwarf and cause a thermonuclear supernova at them at this moment.

317
00:51:14.730 --> 00:51:24.990
Evan Bauer: You can see the supernova is going to occur very close by to the donor star and the donor star has an orbital velocity of 700 kilometers per second for this particular model.

318
00:51:26.460 --> 00:51:40.710
Evan Bauer: And so working with Chris white, who's an expert in Athena, plus, plus, this is a fairly straightforward. In the sense of sort of vanilla. Vanilla ideal 3D hydrodynamic with soft gravity.

319
00:51:41.490 --> 00:51:49.680
Evan Bauer: We mapped from our Mesa models of the binary to Athena, where we put the donor star. The, the remnant of the helium sub Dorf

320
00:51:50.280 --> 00:51:59.160
Evan Bauer: Here in the Athena grid. And what you're going to see when I play this movie is ejected coming from just off the grid to the left and slamming into that donor star.

321
00:51:59.910 --> 00:52:10.020
Evan Bauer: And you see a shock traverses through the star some material is stripped away the stars kicked a little bit. This is, by the way, in the frame of the

322
00:52:10.740 --> 00:52:19.050
Evan Bauer: Initial orbit of the donor star. So you don't see any of its orbital velocity here but you do see some of the perpendicular kick velocity away from where the supernova occurred.

323
00:52:20.610 --> 00:52:30.720
Evan Bauer: So this particular model is somewhat affected by the shock. It's not very strongly affected but this actually we think is really a family of possible

324
00:52:31.530 --> 00:52:44.940

Evan Bauer: Explosions with explosion energies on the order of 10 and 51 herbs and donor masses that range from sort of point two to maybe point three five solar masses. So

325
00:52:45.540 --> 00:52:53.040
Evan Bauer: If we crank this up to a different model with a little bit more explosion of energy and a system that has actually donated more helium. So it's been shaved down

326
00:52:53.640 --> 00:53:01.680
Evan Bauer: To about point two solar masses actually point two five before the explosion occurs, it has a higher orbital velocity is 900 kilometers per second.

327
00:53:02.430 --> 00:53:13.380
Evan Bauer: This system when it gets hit by the supernova shock really is stripped of a lot of mass, it loses almost half of its mass and the strong track that travels through the interior

328
00:53:14.040 --> 00:53:23.640
Evan Bauer: Deposits, a lot of entropy heating the interior material and and really rearranging the structure of the star. So then we also developed a procedure to map.

329
00:53:24.180 --> 00:53:32.160
Evan Bauer: These kinds of models back into Mesa to do long term stellar evolution, again using these entropy profiles from this family of explosions.

330
00:53:32.700 --> 00:53:47.070
Evan Bauer: So we published a paper about this last year. And because I don't think I have a whole lot of time left, I'll probably go through this pretty quickly. But the upshot is for this class of models, we found that the sub Dorf donor stars could be pretty strongly impacted by the shock.

331
00:53:48.540 --> 00:53:56.430
Evan Bauer: It actually takes some time for the shock heating to sort of develop into something that

332
00:53:56.850 --> 00:54:13.170
Evan Bauer: Adjust the star over thermal timescales and causes it to inflate but we think on the timescales, a few million years where we actually observe these stars, they will be pretty significantly inflated relative to where they were at the moment of explosion. Here's what they look like.

333
00:54:16.620 --> 00:54:17.280
Evan Bauer: Perfect timing.

334
00:54:17.310 --> 00:54:20.730
Evan Bauer: So this is one of those classes of stars that we think

335
00:54:20.730 --> 00:54:36.360
Evan Bauer: Probably the, the lower velocity fast the LP 40 stars probably nicely corresponds to this scenario, involving some dwarf donors that are compact enough to get up to maybe eight or 900 kilometers per second, but not compact enough to get up to the thousands of kilometers per second.

336
00:54:38.040 --> 00:54:50.970
Evan Bauer: So to explain the second class of hypervelocity stars that has been observed, you really need double white door systems. And so we're in the process of working to extend some of that modeling to

337
00:54:52.320 --> 00:55:02.490
Evan Bauer: Do white dwarfs interacting with supernova ejecta which is a harder problem that actually involves a lot of Athena development to have an equation state suitable

338
00:55:03.090 --> 00:55:17.610
Evan Bauer: For white dwarf. So this is a very preliminary model qualitatively will show you the kinds of things we're working on, I think we have a long way to go here. Still, but this is something that Matt Coleman ran with some new equation of state capabilities that he's developed for Athena.

339
00:55:19.200 --> 00:55:24.600
Evan Bauer: And you can see, you know, qualitatively. A similar model where you have a white dwarf.

340
00:55:24.990 --> 00:55:35.700
Evan Bauer: Getting hit by supernova ejected from nearby supernova. I think the most fun thing about this movie is the time scale is different because this is so much more of a compact system.

341
00:55:36.630 --> 00:55:44.610
Evan Bauer: That the the time you'll notice is actually running in real time, which corresponds to simulation time as well.

342

00:55:44.970 --> 00:55:51.450
Evan Bauer: So turns out that you know the time scale for this whole process in a compact white door system really is a few minutes.

343
00:55:52.080 --> 00:56:01.140
Evan Bauer: So you can watch the watch the video in real time. It turns out for this particular model is the shock does not affect the white dwarf nearly as strongly so

344
00:56:01.740 --> 00:56:17.730
Evan Bauer: In attempting to explain the observed structure of these really high velocity d six white dwarf what we think we're once white dwarfs the shock is not enough to explain it. And that's really because when I wrote down that sort of simple little formula I assumed

345
00:56:18.870 --> 00:56:26.730
Evan Bauer: More or less than ideal gas equation and state, the pressure in the center of a white dwarf is dominated by degeneracy pressure is much higher. And so the refresher of the shock is not enough.

346
00:56:27.360 --> 00:56:35.640
Evan Bauer: To really significantly perturb it so for this set of models so far it looks like pure hydrodynamic is not enough to explain

347
00:56:36.660 --> 00:56:49.620
Evan Bauer: What is going to cause this white dwarf to end up significantly inflated into the state that we see for the observed objects today. So there's a lot more work that we think needs to be done to figure out what kind of

348
00:56:51.480 --> 00:56:54.930
Evan Bauer: What kind of explanations are left for those objects.

349
00:56:56.550 --> 00:57:06.420
Evan Bauer: And then switching gears just a little bit. So this is going back to one of the sub work models plotting it in a slightly different color scale to show you the composition of that.

350
00:57:07.500 --> 00:57:17.850
Evan Bauer: Model. So if you track the composition of what is supernova ejecta and red. And what is the donor star or material being stripped away from the donor start and blue.

351
00:57:19.140 --> 00:57:26.850

Evan Bauer: This is kind of the beginning step of what we want to do to understand what ends up being the composition of the final object.

352
00:57:28.170 --> 00:57:40.230
Evan Bauer: And so I'm working with, again, Matt Coleman and Chris white and also Abby Poland to really understand what kind of supernova director profiles are the right things to us here to try to start calculating

353
00:57:40.830 --> 00:57:53.880
Evan Bauer: The mixing that will occur, kind of at the end of this shock. There should be some lower velocity tail of material from the supernova that gets created on to the final bound remnant, even after you strip away a lot of material from the initial surface.

354
00:57:55.200 --> 00:58:09.930
Evan Bauer: And that's important because these classes of stars, they definitely show signs of you might call it pollution. Here's a figure from Caltrans paper a couple years ago, comparing low resolution spectrum of the

355
00:58:10.620 --> 00:58:22.080
Evan Bauer: High Velocity runaway d six candidates, he's comparing That's The Black low risk factor down here, comparing actually depleted white dwarfs showing in some sense, they look like just

356
00:58:22.590 --> 00:58:28.050
Evan Bauer: Heavily extra polluted white dwarfs. There's clearly going to be a lot of information in the spectrum to my now.

357
00:58:28.620 --> 00:58:33.240
Evan Bauer: That hasn't been done yet, but we'd like to understand how they get to that state.

358
00:58:33.810 --> 00:58:40.500
Evan Bauer: For the other class the LP 40 stars actually some of the composition analysis has been done, they got high resolution spectra and spent

359
00:58:41.190 --> 00:58:51.810
Evan Bauer: Quite a lot of effort trying to understand what is the composition of these objects and a really strange answer, actually. So this figure is a little bit

360
00:58:52.710 --> 00:59:09.090

Evan Bauer: Much to walk through maybe in a few minutes. But I would focus on the three bars on the left here are the actual observed objects for what their model came out saying that the surface composition is dominated by and it's actually mostly neon and oxygen.

361
00:59:10.200 --> 00:59:16.830
Evan Bauer: Absolutely no hydrogen really no sign of helium. And so there's a lot of

362
00:59:17.340 --> 00:59:29.580
Evan Bauer: I think speculation out there still about how you can produce this structure. And I just want to point out, you really have to do a lot of stellar evolution modeling to get from the moment of some particular supernova explosion model to

363
00:59:30.120 --> 00:59:39.210
Evan Bauer: What we would observe now because presumably if you have heavy elements at the surface. There's going to be a lot of rearranging for sedimentation, you know, these are compact objects, they have

364
00:59:39.810 --> 00:59:56.070
Evan Bauer: fairly strong surface gravity's. And so there's a lot of different mixing physics that you have to account for to understand what are we observing. How do we map that from, you know, an initial supernova explosion model into something that will be observed a few million years later.

365
00:59:57.480 --> 01:00:09.750
Evan Bauer: So yeah, I guess I'll close by trying to wrap back around to, in some ways, I do think it's it's similar physical modeling to be done. That has not yet been done to polluted white births.

366
01:00:10.200 --> 01:00:19.590
Evan Bauer: But just under much more extreme conditions when you have an atmosphere that's actually dominated by these heavy, heavy elements, rather than just having traces

367
01:00:20.940 --> 01:00:32.640
Evan Bauer: That are being observed. But I also think that the the prospects for rewards from this work could be even greater if you care about supernovae, especially because I think they could tell us a lot about

368
01:00:33.660 --> 01:00:41.610
Evan Bauer: The supernova explosion mechanism that is producing these kinds of stars. So yeah, I think I should wrap up there. Thanks.

369
01:00:44.580 --> 01:00:45.150
Ana Bonaca: So much

370
01:00:47.730 --> 01:01:02.580
Ana Bonaca: Definitely a rich area that has many connections through his interest at the FTC as well and to kick us off on the ass. If you have consider the impact of supernova inject on closing planets.

371
01:01:05.250 --> 01:01:09.480
Evan Bauer: Um, I have not personally consider that effect.

372
01:01:12.870 --> 01:01:21.900
Evan Bauer: I think I once I ran across an old Nature paper by Sterling Colgate about that. So that might be the place to start. But yeah, I haven't looked at that particular topic.

373
01:01:22.680 --> 01:01:41.220
Ana Bonaca: Do you have any information as to what would happen if the nila as our first speaker. I'm kind of afterwards separation with a planet or companion THE ACTIVES by the supernova is blessed and way to push the object closer to do like or or further away from it.

374
01:01:42.270 --> 01:01:51.030
Evan Bauer: Oh yeah. Well, one thing we do see that there's a cake away from, from where the white dwarf sits

375
01:01:54.180 --> 01:02:10.260
Evan Bauer: Yeah, I mean I think in general planets are probably going to be further away and experience less of a shock. Right. Yeah. I mean this these binary stars are probably about us as close as Kim as an object can be and so

376
01:02:11.580 --> 01:02:13.650
Evan Bauer: What that means that there's actually

377
01:02:15.570 --> 01:02:18.660
Evan Bauer: If you talk about filling the Rocio before you have to

378
01:02:18.660 --> 01:02:20.550
Evan Bauer: Serve going and accreting onto the

379
01:02:22.200 --> 01:02:31.350

Evan Bauer: Front of the white dwarf companion that tends to happen at a fairly constant solid angle fraction, meaning

380
01:02:31.740 --> 01:02:42.240
Evan Bauer: you're presenting a constant cross section to the supernova, whether you move further than, you know, if you take a main sequence star feeling it's Russia much further away, it will actually be sort of similarly impacted

381
01:02:43.170 --> 01:02:47.460
Evan Bauer: Or kick it objective, because it presents the same overall cross section.

382
01:02:48.600 --> 01:02:55.080
Evan Bauer: So then extending that to planets. I think you would only see things further away and less less impacted

383
01:02:59.430 --> 01:03:03.300
Ana Bonaca: Looks like we have a couple of race 10 so Amy Jo Raymond

384
01:03:04.500 --> 01:03:04.980
Ana Bonaca: Go ahead.

385
01:03:06.120 --> 01:03:06.480
John C. Raymond: Hi.

386
01:03:07.860 --> 01:03:20.310
John C. Raymond: There is 196 star that's associated with 100,000 year old supermodel remnant is under thousand years long enough for the rainy supernova rejected on the surface and

387
01:03:21.360 --> 01:03:24.480
John C. Raymond: White dwarf to potentially something or not.

388
01:03:26.070 --> 01:03:36.000
Evan Bauer: Yeah, I think that is definitely the probably the right time scale for things for interesting things to happen.

389
01:03:37.260 --> 01:03:44.520
Evan Bauer: So yeah, I think it's long enough, because these objects are fairly compact.

390
01:03:46.800 --> 01:03:51.960

Evan Bauer: That you know if if it were a white dwarf actually singing timescales can be as short as

391
01:03:52.920 --> 01:04:01.440
Evan Bauer: Just a few years because they're somewhat puffy, or I think the the overall settling timescale is maybe hundreds of thousands of years.

392
01:04:01.950 --> 01:04:08.430
Evan Bauer: But then there's also probably important fluid instabilities like thermal healing mixing that will operate on even shorter timescales to rearrange things

393
01:04:12.210 --> 01:04:15.000
Ana Bonaca: Have one more question for open care center.

394
01:04:16.020 --> 01:04:26.280
Wolfgang Kerzendorf: Hi, thank you so much for the talk and and someone invited me to this thing. I'm coming in from for Michigan State University and and I've been very interested. Obviously in surviving companions.

395
01:04:27.120 --> 01:04:35.250
Wolfgang Kerzendorf: Most of my career, I've looked for surviving companions one A remnants. And now you've sort of made a new candidate or new new proposed.

396
01:04:36.450 --> 01:04:42.300
Wolfgang Kerzendorf: Sort of surviving companion. And I'm wondering how deep do we need to search to

397
01:04:42.900 --> 01:04:56.070
Wolfgang Kerzendorf: Find them and like what are your faintest model, if you would sort of go in and say like, Oh, no, we would go to this step, and I saw 10,000 Calvin and roughly so luminosity pop is that the faintest you get funny things or

398
01:04:58.890 --> 01:05:04.140
Evan Bauer: Scroll back to, you know, this particular family of models.

399
01:05:09.330 --> 01:05:15.780
Evan Bauer: Yeah, so I mean one thing i definitely skipped over here is I, there are different tracks for, you know,

400

01:05:16.260 --> 01:05:30.870
Evan Bauer: Different. This is kind of a set of models with different explosion energies and different amounts of impact by the object to the slack X your marks were on the track. It has the lifetime since the explosion has been 10 million years.

401
01:05:32.580 --> 01:05:41.790
Evan Bauer: So for some of them. Yeah, you do end up with with fainter objects that never really inflate quite as much and they they sort of start pulling down

402
01:05:43.590 --> 01:05:55.590
Evan Bauer: On timescales of roughly 10 million years. I think there is an upper limit of these kinds of objects tend to leave the galaxy within a few 10s of millions of years. Right.

403
01:05:56.640 --> 01:06:02.310
Wolfgang Kerzendorf: Now I'm looking at like 1006 like 1000 years old or 2000 years old so I

404
01:06:03.930 --> 01:06:04.350
Evan Bauer: Don't mean

405
01:06:04.680 --> 01:06:05.460
Evan Bauer: Like what yeah

406
01:06:05.700 --> 01:06:13.260
Wolfgang Kerzendorf: Temperatures will be low temperatures and luminosity will be be looking there so 10 million years is not something where we can see some know remember

407
01:06:13.440 --> 01:06:23.430
Evan Bauer: Superman. Yeah, so that's actually, that's it. Yeah, you're really talking about the trying to associate stars with the remnants. Um, that's right. That's short enough

408
01:06:24.090 --> 01:06:35.760
Evan Bauer: That I think that would be long before the shock ends up really causing the star to be inflated and so it would be pretty low luminosity.

409
01:06:37.080 --> 01:06:47.820
Evan Bauer: So in this bigger and the what's happening is there's a thermal wave. There was entropy deposited deeper in the core of the star that takes time before it can

410
01:06:48.450 --> 01:07:02.250
Evan Bauer: Diffuse outward and then we rearrange the structure of the star and depending on the model, you know, you see, here's there's a set of models where that happens within a few thousand years. And there's a set him off. So it takes up to a few million years.

411
01:07:03.420 --> 01:07:14.970
Evan Bauer: So we did do some work on estimating that. But yeah, I think, actually, in your case, waiting longer would be the the best chance of seeing brighter objects.

412
01:07:15.000 --> 01:07:16.200
Wolfgang Kerzendorf: I unfortunately don't have

413
01:07:16.620 --> 01:07:17.190
Yeah.

414
01:07:19.170 --> 01:07:33.090
Evan Bauer: Yeah, but I don't. Maybe, I don't know how long. Yeah. Older supernova remnants. I think you know things on the order of 1000 years. There are some families of models where that can emerge. I guess it's the way to frame it

415
01:07:38.250 --> 01:07:52.050
Ana Bonaca: Just as a final question and the think there will be new types of Runaway Stars found in a Gaya likely your model theoretically predict some sometimes that haven't been observed, yes.

416
01:07:54.120 --> 01:08:09.990
Evan Bauer: Well, I think the thing that I'm really most excited about is getting more analysis of the stars that have been observed. So because they have such complicated spectra, it's pretty hard to understand.

417
01:08:12.630 --> 01:08:22.110
Evan Bauer: Yeah, I think there's there's a lot. There's just a lot more information to be gleaned I think with coming guy data releases, we probably will start to get

418
01:08:23.160 --> 01:08:29.220
Evan Bauer: Better constraints on exactly what the orbital parameters of those systems are

419
01:08:30.330 --> 01:08:40.740

Evan Bauer: I can't remember if there's an estimate that will see many more in the very near future but but we might I think we haven't really searched exhaustively for these stars.

420
01:08:42.060 --> 01:08:57.090
Ana Bonaca: Well, I'm looking forward to continuing this conversation as a carrot m&s here coming into the CSA so please feel free to reach out and if there are more Christians yet. There's also a Slack channel where we can continue this discussion.

421
01:08:57.450 --> 01:08:59.010
Evan Bauer: Although hanging out on Slack, but

422
01:09:01.110 --> 01:09:02.610
Morgan Elowe MacLeod: Thank you know speakers.

423
01:09:04.290 --> 01:09:04.530
Ana Bonaca: And

424
01:09:04.590 --> 01:09:05.790
Ana Bonaca: Thank you for coming.

425
01:09:05.940 --> 01:09:11.070
Ana Bonaca: And being so engaged today and like for more than an hour. So I thank you all so much.

426
01:09:12.360 --> 01:09:12.810
Morgan Elowe MacLeod: Bye bye.

427
01:09:13.260 --> 01:09:15.450
Ana Bonaca: See you next week. Bye.

428
01:09:25.740 --> 01:09:26.310
Morgan Elowe MacLeod: Thank you again.

429
01:09:27.600 --> 01:09:35.910
Daniella Bardalez Gagliuffi: Thank you again, sorry. Oh yeah, thank you. I just, I always say, mentally, and sometimes just for discussion. It's just

430
01:09:37.230 --> 01:09:37.590
Morgan Elowe MacLeod: No.

431
01:09:37.650 --> 01:09:38.580
Ana Bonaca: Yeah, that makes sense.

432
01:09:39.210 --> 01:09:47.790
Ana Bonaca: Yeah, actually. Yeah, I, I'm kind of session before it should probably write it up on Slack. So there's just like her this question.

433
01:09:49.080 --> 01:09:51.000
Ana Bonaca: But, uh, yeah, I'll do that.

434
01:09:51.810 --> 01:09:52.200
Okay.

435
01:09:53.400 --> 01:09:55.140
Daniella Bardalez Gagliuffi: Cool, thank you so much for inviting me know

436
01:09:55.410 --> 01:09:56.730
Morgan Elowe MacLeod: Yeah, we're really great

437
01:09:58.350 --> 01:10:03.360
Daniella Bardalez Gagliuffi: Can I, can I get the link to a talk at some point. Yes, yes.

438
01:10:04.320 --> 01:10:07.410
Morgan Elowe MacLeod: Yeah definitely send it along. It'll be

439
01:10:07.590 --> 01:10:09.720
Morgan Elowe MacLeod: Not immediately but like

440
01:10:09.900 --> 01:10:10.170
Ana Bonaca: That's

441
01:10:10.740 --> 01:10:14.580
Ana Bonaca: Actually pretty quick. I think Marty within a base so yeah

442
01:10:14.640 --> 01:10:14.910
Okay.

443
01:10:16.020 --> 01:10:18.150
Daniella Bardalez Gagliuffi: All right, well thanks a bunch and

444
01:10:18.210 --> 01:10:21.750
Ana Bonaca: Yeah, I think internally and I don't stretch, but I think if I guess.

445
01:10:22.800 --> 01:10:23.130
We can