WEBVTT

1
00:00:02.010 --> 00:00:08.730
Morgan Elowe MacLeod: Well, wonderful welcome Rodrigo and we're delighted to get to talk to you today, so thank you so much.

2
00:00:09.179 --> 00:00:09.719
Rodrigo Ibata: Thank you very much.

3
00:00:11.070 --> 00:00:11.940
Rodrigo Ibata: So.

4
00:00:14.910 --> 00:00:24.480
Rodrigo Ibata: Stop this up oops and, yes, so good morning to everyone, I guess, it is over this late afternoon over here.

5
00:00:25.440 --> 00:00:44.250
Rodrigo Ibata: So, today I was going to tell you about you know the work that that we've been doing, trying to use style streams from the lucky way to understand how the Milky Way built up and it's and the distribution of dark matter around it, and this is this is work i've been doing with this.

6
00:00:45.330 --> 00:00:58.980
Rodrigo Ibata: group of friends that that i'm showing over here and kind of what we want to do is to to get a feeling of you know power, just to see what we can we can attain in terms of the.

7
00:01:00.480 --> 00:01:06.150
Rodrigo Ibata: constraints on on how the Milky Way built our power well the the accretions came into what time.

8
00:01:07.260 --> 00:01:11.910
Rodrigo Ibata: We want to to to figure out what the role of the environment, might be and.

9
00:01:12.600 --> 00:01:30.690
Rodrigo Ibata: And, in the end, what we'd really like to do is to place constraints on the on the dark matter distribution around the Milky Way and and in other galaxies of the local group and to try and confirm that, with the theories of you know other theories of dark matter and and gravity.

10
00:01:32.160 --> 00:01:34.530

Rodrigo Ibata: So if I can.

11
00:01:35.610 --> 00:01:39.660
Rodrigo Ibata: So what i'd like to talk to you today, then, is summarized here.

12
00:01:42.060 --> 00:01:54.060
Rodrigo Ibata: So i'd like to give you a brief introduction to to Stella streams and how they pertain to the dogmatic problem and then i'm going to tell you about some work, the work we've done to to find these structures.

13
00:01:55.170 --> 00:02:08.340
Rodrigo Ibata: And then, finally, the the i'm really very excited about the possibility now of using deep learning as a means to to implement problems in dynamic so i'll tell you about that towards the end.

14
00:02:09.690 --> 00:02:17.880
Rodrigo Ibata: And so you know, as we all know, this is the picture that the current cosmological picture galaxies like the Milky Way you're surrounded by these.

15
00:02:19.140 --> 00:02:35.550
Rodrigo Ibata: Probably 10s of thousands of not matter so payloads and inside of this, of course, we have our Milky Way right and with with many cold very fragile structures that are orbiting around you and, most of these saw pay those so.

16
00:02:36.930 --> 00:02:50.850
Rodrigo Ibata: We we know we're not filled with with stars, if this picture is is correct, but nevertheless they will have some sort of dynamical influence upon the these dynamically cold structures in our galaxy.

17
00:02:52.230 --> 00:03:02.190
Rodrigo Ibata: And so, essentially what we'd like to do is to be able then to to see you know, is this consistent of the observations that that we have.

18
00:03:02.520 --> 00:03:18.570
Rodrigo Ibata: Consistent with the standard picture, or indeed are the alternatives for for dogmatic and gravity on can can they can can they also work and, of course, some of these theories actually what they do is they predict accelerations.

19

00:03:19.770 --> 00:03:33.780
Rodrigo Ibata: But generally we can't actually go and measure the acceleration in the outer parts of the galaxies in the HALO just simply because the you know the differences in velocity over time, a very, very, very small.

20
00:03:35.010 --> 00:03:42.600
Rodrigo Ibata: And so, typically what people have done over the years, of course, is to to implement equilibrium analyses, such as.

21
00:03:43.830 --> 00:03:53.220
Rodrigo Ibata: The genes equations and so on, and this works nicely there was in, for instance justin Reid and people's Dr janice and.

22
00:03:54.030 --> 00:04:10.050
Rodrigo Ibata: collaborators have made some some very powerful piece of software, but the same time, we know that the galaxy is not an equilibrium structure, this has been shown very nicely played this server facing spiral in the in the local disk.

23
00:04:11.130 --> 00:04:19.500
Rodrigo Ibata: And so we will be nice to be able to to to understand the or to derive the acceleration field using some other means.

24
00:04:20.040 --> 00:04:28.350
Rodrigo Ibata: And this is really where where streams come into into their own and the point really here is that of course if we had you know the.

25
00:04:29.190 --> 00:04:39.450
Rodrigo Ibata: The motions of stars through time we could just obviously we would have the the orbit of the structure and then we immediately be able to derive further the force field.

26
00:04:40.890 --> 00:04:54.240
Rodrigo Ibata: Now we don't really get that with the stream, but what we get is the we as as a stream as a massive the string becomes smaller and smaller what we what we know from embodies simulations is that the.

27
00:04:55.080 --> 00:05:04.440
Rodrigo Ibata: Is that the the path of the of that or that stream on the sky resembles more and more the path of the orbit of the progenitor.

28
00:05:05.520 --> 00:05:15.930

Rodrigo Ibata: And even though this isn't precisely true, we can always run them body simulations to make the correction back to the to the to the orbit of the progenitor over time.

29
00:05:17.310 --> 00:05:25.800
Rodrigo Ibata: So then, this allows us to to get the acceleration field, and so this will be less the reasons why we would like to.

30
00:05:26.850 --> 00:05:36.210
Rodrigo Ibata: use other streams of very obviously they you know the structures that we now see are showing us how the galaxy built up over time.

31
00:05:36.780 --> 00:05:46.140
Rodrigo Ibata: They give us this probe of the acceleration field that, for which we don't need to assume equilibrium dynamics and they retain this or memory of their past interactions and so.

32
00:05:47.820 --> 00:05:54.120
Rodrigo Ibata: As as these as the progenitors orbited through the galaxy they will have interacted with the.

33
00:05:54.450 --> 00:06:13.080
Rodrigo Ibata: With soft structures within the disk of the galaxies such as chairman like $1,000 contract with the bb with spiral arms and so on, and these retain that the the these will influence the the path of the of the stream, but still the the information on.

34
00:06:14.940 --> 00:06:25.500
Rodrigo Ibata: The on the acceleration field is still kept and also the information of these of these interactions and something that i've whole bunch of us have had.

35
00:06:26.280 --> 00:06:37.110
Rodrigo Ibata: Almost 20 years ago proposed is that the streams, I will say these excellent accelerometers that can be used to to to probe whether the the dark self halos exist, often.

36
00:06:38.340 --> 00:06:41.220
Rodrigo Ibata: i'll come back to this in a few minutes.

37
00:06:42.600 --> 00:06:54.480
Rodrigo Ibata: So people because of these reasons and others, people have been trying to detect stellar streams for many years now, and the the large sky surveys, the fetch metrics sky surveys.

38
00:06:55.680 --> 00:07:06.960
Rodrigo Ibata: came up with probably something close to 60 stellar streams before Gaia and this the show you the results from from sloan from pan-starrs and from the dark energy survey.

39
00:07:07.920 --> 00:07:16.110
Rodrigo Ibata: And, basically, what the the method that was used, it was a match filter analysis, so you have a you have a template of the of the magnitude.

40
00:07:18.030 --> 00:07:28.530
Rodrigo Ibata: Of a of a system that you actually trying to find you have another color magnitude diagram of the of the contaminating Milky Milky Way.

41
00:07:29.400 --> 00:07:40.770
Rodrigo Ibata: You divide the template by the contamination and that gives you a filter that then enhances the significance of the of the object kind of optimally enhances that that.

42
00:07:41.880 --> 00:07:46.980
Rodrigo Ibata: Those counts and that this is how you you then are able to make these.

43
00:07:48.180 --> 00:07:57.300
Rodrigo Ibata: These these maps, though the sky maps, in which, with English, the star these these stellar streams show up.

44
00:07:59.070 --> 00:08:14.880
Rodrigo Ibata: So we thought this was very nice, of course, and I myself played this this game we're trying to find streams with with match filter techniques, but given the the the incredible power that we now have with with Gaia it seemed to me that.

45
00:08:16.140 --> 00:08:26.430
Rodrigo Ibata: That there were better ways of approaching the problem so basically, the question is how do we best find screams in in a data set such as such as guides.

46
00:08:28.530 --> 00:08:30.600
Rodrigo Ibata: And, of course, what we have here is, we have.

47
00:08:31.650 --> 00:08:42.840

Rodrigo Ibata: positions on the sky, we have we have parallax is we have problem notions and some and some photometer tree for almost 2 billion stars now with Gaia ED or three.

48
00:08:43.260 --> 00:08:55.560
Rodrigo Ibata: But only a small amount of information in terms of their radio velocities, and so we have this this data set but it's actually fairly heterogeneous and its quality in the different in the different dimensions.

49
00:08:56.550 --> 00:09:06.510
Rodrigo Ibata: And so the essentially what we did was to was to implement a friends, a friend Finder where we we look at each star in turn in the in the galaxy.

50
00:09:07.950 --> 00:09:21.840
Rodrigo Ibata: And we shoot orbits of using the the guy or the gods positions and proper motions and parallax is and photometer tree, which then gives us a distance and we essentially marginalize we.

51
00:09:22.290 --> 00:09:34.980
Rodrigo Ibata: We should many, many, many such robots that are consistent with these with these measurements and to each one of these orbits we we smear them out in in the kind of obvious kelsey and waivers can, as is.

52
00:09:36.300 --> 00:09:37.500
Rodrigo Ibata: As is depicted here.

53
00:09:38.970 --> 00:09:48.900
Rodrigo Ibata: And, and we do this, as I say, many times for so many, many hundreds of different orbits for each style and essentially what we construct is a is a likelihood.

54
00:09:50.550 --> 00:10:00.390
Rodrigo Ibata: Like likes like this, where we have the stream model, which contains all of these all of these parameters and a contamination or so Milky Way foreground and background model.

55
00:10:00.840 --> 00:10:10.530
Rodrigo Ibata: That also is a function of all of these observable and then what we do is we try and we find the most likely fraction of stream stars.

56
00:10:11.010 --> 00:10:27.330

Rodrigo Ibata: And calculate for that most likely value of veto, here we we calculate the likelihood of of that star being being a stream so essentially This allows us to make screams 30 hip maps of screaming so the of Gaia stars.

57
00:10:28.560 --> 00:10:50.070
Rodrigo Ibata: And so, if you do this, using a like a killer pasik wide or African RC car wider template so essentially how how we have the smear out those those orbits what you what you get is this, and so it immediately shows up that superhighway significance, the the sagittarius dwarf galaxy.

58
00:10:51.180 --> 00:10:55.860
Rodrigo Ibata: This is a really interesting structure for many reasons, also because I think it has some.

59
00:10:57.270 --> 00:10:58.380
Rodrigo Ibata: Some potential trophy.

60
00:11:01.110 --> 00:11:11.190
Rodrigo Ibata: To to allow us to determine whether whether dynamical friction takes place, which is in itself kind of like a smoking gun of particle dark matter.

61
00:11:12.840 --> 00:11:17.940
Rodrigo Ibata: And if we if we use much thinner a much thinner template.

62
00:11:18.990 --> 00:11:29.520
Rodrigo Ibata: With with Dr to have a guy TRT we found this series of 32 streams of the sky, which we then went and followed up with high high resolution spectroscopy.

63
00:11:30.120 --> 00:11:36.750
Rodrigo Ibata: Both at the FST and VI lt and you can see that, with the with the radio velocities that we that we obtain these.

64
00:11:37.260 --> 00:11:56.640
Rodrigo Ibata: That they show very, very clear can imagine go here and showing that these these structures are real and the most recent maps look like this, so there's we're seeing this this is showing us now the 10 Sigma detections of streams in the Milky Way with a 5050 per SEC half width of these.

65
00:11:57.840 --> 00:11:59.160
Rodrigo Ibata: Of these structures.

66
00:12:01.020 --> 00:12:21.720
Rodrigo Ibata: In this case, between three and 12 killer parsecs in the galaxy and then going out now between 10 and 36 so again finding these these very thin screams and, as you can see, this the Milky way's has this lacework criss crossing of of the stream like structures.

67
00:12:23.130 --> 00:12:23.640
Rodrigo Ibata: There are.

68
00:12:25.650 --> 00:12:28.620
Rodrigo Ibata: Many dozens of these various levels of.

69
00:12:29.880 --> 00:12:40.080
Rodrigo Ibata: significance, and I could really give a talk on almost each one of these, as one of them, that is, the we found is the lowest metal the city most pristine.

70
00:12:41.040 --> 00:12:49.650
Rodrigo Ibata: stellar system that has yet been discovered this over here, this is the stream of Omega sandwich actually comes really, really close to us in the.

71
00:12:51.690 --> 00:12:55.080
Rodrigo Ibata: In if we if we take another map of the.

72
00:12:56.820 --> 00:12:58.110
Rodrigo Ibata: even closer distances.

73
00:13:00.300 --> 00:13:00.630
Rodrigo Ibata: and

74
00:13:01.890 --> 00:13:17.670
Rodrigo Ibata: Given that we don't have all that much time i'm going to concentrate for a couple of minutes on on this screen here, this is the GD one stream, that is, has been studying in great detail by many people live, and including Anna.

75
00:13:18.870 --> 00:13:19.860
Rodrigo Ibata: At your Institute.

76
00:13:21.120 --> 00:13:29.220

Rodrigo Ibata: And so, when yeah i'd like to i'd like to spend a couple of minutes on this structure, so the point here is that.

77
00:13:29.820 --> 00:13:39.630
Rodrigo Ibata: God, one of these other objects can be used as a as a means to try and see whether the weather streams are being heated by the the cold dark matter sub structures.

78
00:13:40.080 --> 00:13:48.180
Rodrigo Ibata: And originally when we propose this idea back back in 2002 we were thinking of a sort of kinematic eating so essentially trying to see how the.

79
00:13:49.530 --> 00:13:57.660
Rodrigo Ibata: How the velocity dispersion changed along a stream and that shouldn't be the color here is showing us the the radio velocity and you can see that.

80
00:13:58.200 --> 00:14:06.060
Rodrigo Ibata: Compared to the to the know cdn last month case, you can see, local heating of the of the stream.

81
00:14:06.480 --> 00:14:19.740
Rodrigo Ibata: And Ray kohlberg a couple of years ago, actually almost a decade ago suggested that the instead of doing this, which is difficult to measure you can you could try and find gaps and streams and this is really taken on.

82
00:14:21.180 --> 00:14:34.410
Rodrigo Ibata: Re published in the initial works and some his study of power five and suggested that maybe some of these apparent gaps here in power five could be due to the lander cdn.

83
00:14:36.390 --> 00:14:39.810
Rodrigo Ibata: soap halos interacting with that with that stream.

84
00:14:41.160 --> 00:14:48.420
Rodrigo Ibata: And the case of GD one, though, is really quite Nice because it's the apart from sagittarius among.

85
00:14:49.530 --> 00:15:04.050
Rodrigo Ibata: Among the the the thing streams that probably confirmed all the clusters it's it's it's the, the most significant of the of the features out there and in this paper bye bye panic and collaborators that they they looked at the.

86
00:15:06.030 --> 00:15:16.830
Rodrigo Ibata: density of stars along the stream, so this is angle along the stream on this this this GD one stream, you can see it so it's attends a huge track on the on the sky of.

87
00:15:18.060 --> 00:15:21.960
Rodrigo Ibata: Many 10s of degrees and curiously, it has these.

88
00:15:23.160 --> 00:15:33.900
Rodrigo Ibata: These pants and wiggles in the in the density profile and so when they ran simulations and in a smooth potential they like they found.

89
00:15:34.260 --> 00:15:48.120
Rodrigo Ibata: They showing us here again as a function of angle on the stream that the counts, and you can see that the the the profile is quite smooth as soon as you put in bars and spiral and spiral arms into the.

90
00:15:49.170 --> 00:15:53.790
Rodrigo Ibata: into the into the Milky Way model, you get something that these.

91
00:15:55.110 --> 00:15:58.380
Rodrigo Ibata: has some variations, but nowhere near what you see in the data.

92
00:16:00.210 --> 00:16:04.530
Rodrigo Ibata: And so they they use the same they use this data, then of.

93
00:16:06.150 --> 00:16:13.380
Rodrigo Ibata: From Gaia or along the along the stellar stream to to construct these the these.

94
00:16:15.390 --> 00:16:29.580
Rodrigo Ibata: The the density power spectrum of the of the arms in the leading our mental training and then this This is shown here with these with these black dots, these are the data.

95
00:16:31.560 --> 00:16:41.730
Rodrigo Ibata: In the leading ominous the trailing arm and they compared to the models here which, which was shown in these colored lines for embody streams of different ages.

96
00:16:43.860 --> 00:16:50.970
Rodrigo Ibata: of three, five and seven good years, and you can see here when they when they use only the baryonic sub structures, they.

97
00:16:52.260 --> 00:16:57.750
Rodrigo Ibata: The claim is that the lumpiness that you that you see in these models doesn't.

98
00:16:58.800 --> 00:17:07.830
Rodrigo Ibata: isn't as high as what what you actually see and they are what you measure in in Gaia and it's only after you've put in all after they put in the.

99
00:17:08.730 --> 00:17:17.670
Rodrigo Ibata: The Lambda called not matter SUP halos that you get something that's that approximates the what is actually measured.

100
00:17:18.450 --> 00:17:33.690
Rodrigo Ibata: And so they use this to to claim that there's there is an incident that there's a significant number of calls that matches up halos out there about no point for compared to the predictions of cdn.

101
00:17:34.800 --> 00:17:47.340
Rodrigo Ibata: So, so we looked into this as well, using the samples that came out of our own stream find a software so having found the the stream we within.

102
00:17:47.850 --> 00:18:00.570
Rodrigo Ibata: measure the the the the track of the stream on the sky and what's shown in this diagram, so this is angled along the stream and he every year, we have the angle perpendicular to the stream.

103
00:18:01.830 --> 00:18:03.600
Rodrigo Ibata: This is now showing us the.

104
00:18:05.250 --> 00:18:09.990
Rodrigo Ibata: showing the the three Sigma of detections here, using only Gaia data.

105
00:18:11.430 --> 00:18:25.350
Rodrigo Ibata: In red and the contaminants so shown in in blue, and you can see that it's a you know it's a very it's a very thin structure on the sky, so if we also include the information from pan sauce we get a very similar.

106
00:18:26.490 --> 00:18:36.000
Rodrigo Ibata: very similar diagram of over here very similar distribution on this guy, and these are very well behaved this, these are very well behaved samples.

107
00:18:36.780 --> 00:18:47.160
Rodrigo Ibata: If you if you go and measure the radio velocities along the stream of the of the of the stream Members, you can see a very clear very cold kinematic stream.

108
00:18:47.760 --> 00:19:06.540
Rodrigo Ibata: Here in black in proper motion and in in the two components of population it's beautifully thin and we also measure the distance to the stream in using the pan styles for telemetry which is shown here in with with this fit in in red.

109
00:19:08.190 --> 00:19:15.660
Rodrigo Ibata: And, incidentally, this is the, these are the, this is a parallel structure of the GDP on spur that the Anna has.

110
00:19:16.800 --> 00:19:18.660
Rodrigo Ibata: has been using for in her work.

111
00:19:20.100 --> 00:19:33.720
Rodrigo Ibata: And so, when we can think construct the density along the along the stream, which has shown in these these are three different samples that we obtain from from our end software and then using essentially a very.

112
00:19:35.280 --> 00:19:43.920
Rodrigo Ibata: Conservative way to to to construct your sample using only Gaia and then guy a plus pan-starrs and we obtain pretty much the same.

113
00:19:44.520 --> 00:19:55.920
Rodrigo Ibata: The same distribution in all three of them, and this is then the density power spectrum that we obtained and it's kind of similar to to what panic and collaborators at found.

114
00:19:56.640 --> 00:20:12.420
Rodrigo Ibata: You can see that it's it's reasonably flat as a function of inverse wave number in degrees, however, if we plot if we we have we have the the distance to the streamers and we can then use that distance to correct.

115
00:20:13.500 --> 00:20:16.290
Rodrigo Ibata: This this plot to.

116
00:20:17.580 --> 00:20:23.130
Rodrigo Ibata: To the wave number in terms of killer parsecs and you can see that there's.

117
00:20:24.390 --> 00:20:38.670
Rodrigo Ibata: Instead of being instead of being flat we see this very large peak here at two and a half killer parsecs, and so this, this means that these these bumps and wiggles and all these Spikes here which are which are exceedingly.

118
00:20:40.140 --> 00:20:43.830
Rodrigo Ibata: which have very large contrast have up to five to one.

119
00:20:45.240 --> 00:20:46.740
Rodrigo Ibata: They all align with.

120
00:20:47.790 --> 00:20:48.990
Rodrigo Ibata: With with the same.

121
00:20:50.040 --> 00:21:08.850
Rodrigo Ibata: With the same gap spacing, which is exactly what you expect of the system that is slowly disrupting and who stars on emanating out and then forming these episodic peaks This is something that the was explored in great detail by Dr Cooper.

122
00:21:10.620 --> 00:21:17.370
Rodrigo Ibata: And so what these what we think these are is not not some halos but but actually.

123
00:21:19.200 --> 00:21:27.780
Rodrigo Ibata: don't just simple at the cyclic peaks from from the progenitor just slowly disrupting.

124
00:21:31.050 --> 00:21:31.590
Rodrigo Ibata: So now.

125
00:21:32.670 --> 00:21:48.180
Rodrigo Ibata: I can see i'm going running a little bit late so i'd like to tell you a little bit about the work we've been doing on machine

learning trying to use trying to use the the streams in order to to to figure out what the.

126
00:21:50.610 --> 00:21:51.600
Rodrigo Ibata: What the the.

127
00:21:53.040 --> 00:21:59.310
Rodrigo Ibata: The transformation from from angles from from positions and velocities to actions and angles.

128
00:22:00.720 --> 00:22:02.820
Rodrigo Ibata: And so, basically, the idea here is that.

129
00:22:04.230 --> 00:22:05.430
Rodrigo Ibata: What we're doing is measuring.

130
00:22:07.050 --> 00:22:21.630
Rodrigo Ibata: we're detecting streams in the Milky Way, but these these allow us to to get back to the to the orbit on on the sky and the point being that on on an orbit the reactions remain constant.

131
00:22:22.890 --> 00:22:32.850
Rodrigo Ibata: So can we can we use the our observations to try and to try and determine what the what the real actions of the of the stars are.

132
00:22:34.980 --> 00:22:51.690
Rodrigo Ibata: And I just like to do a brief recap here of the action angle formalism and basically what it is, is that these these very convenient very special canonical coordinates that instead of, for instance, if you have an orbit in a normal position and.

133
00:22:53.010 --> 00:23:08.730
Rodrigo Ibata: And and velocity space in action and an angle this this this this becomes really very simple we just have a single action and the different points along this or better than just different different angles.

134
00:23:09.930 --> 00:23:23.130
Rodrigo Ibata: And they're really very convenient because they're they're bashing variance and so essentially the the the best archaeological coordinates you can have for understanding the structures of the Milky Way.

135
00:23:24.150 --> 00:23:31.530

Rodrigo Ibata: And so, for instance, it as you what the different actions mean the J Phi which is just.

136
00:23:33.000 --> 00:23:43.170
Rodrigo Ibata: it's that component of angular momentum, as you increase jr you can see, this little bit here just becomes more extended has greater oscillations in the art direction and.

137
00:23:43.860 --> 00:23:57.060
Rodrigo Ibata: Increasing Jay Jay said gives a crater oscillations and in the set direction So these are very nice very convenient coordinates, but the problem is they're very hard to find and so the.

138
00:23:58.680 --> 00:24:06.930
Rodrigo Ibata: Essentially, the this was this was pioneered by been the guillen beneath the year and we were the first to to.

139
00:24:08.670 --> 00:24:17.550
Rodrigo Ibata: To to figure out an algorithm to measure these in general potentials and so the way that that the machinery works.

140
00:24:18.330 --> 00:24:31.710
Rodrigo Ibata: Is that you start off with a you start off with with with an action and you're trying to get towards the positions and velocities and what you do is you, you take a stepping stone via a toy system.

141
00:24:32.280 --> 00:24:40.710
Rodrigo Ibata: Which is just a simple license Crown and you, and if you use a generating function for this.

142
00:24:41.790 --> 00:24:47.820
Rodrigo Ibata: For this canonical transformation which is is given is given here and so.

143
00:24:49.290 --> 00:24:59.280
Rodrigo Ibata: You so essentially what you're doing is you, you take a an initial an initial action you use a whole series of.

144
00:25:00.810 --> 00:25:02.730
Rodrigo Ibata: of angles on the.

145
00:25:04.260 --> 00:25:29.340
Rodrigo Ibata: On in the toy system and then this allows you to to then to to to derive a series of for each one of these these positions in the

on the toy system tourists you take in a position of velocity in an x and wii space and what you and the algorithm then tries to to to make this.

146
00:25:30.360 --> 00:25:31.560
Rodrigo Ibata: aims to make the.

147
00:25:32.610 --> 00:25:40.170
Rodrigo Ibata: To obtain this the same values of the hamiltonian for each point in in X and wii space.

148
00:25:41.610 --> 00:25:49.410
Rodrigo Ibata: And so, there are some disadvantages with this with this technique basically one of them is that you need to know the hamiltonian in advance.

149
00:25:49.710 --> 00:26:02.820
Rodrigo Ibata: And you can see that you're actually doing this backwards, generally, what you want is to go from positions and velocities to actions and angles and it actually goes the other way and you might need quite a large number for your terms to get this to work.

150
00:26:04.320 --> 00:26:11.790
Rodrigo Ibata: And so what we did during the first lockdown was to develop the an algorithm to do this in a completely automated way.

151
00:26:13.110 --> 00:26:17.160
Rodrigo Ibata: Where we where we go from from the observed.

152
00:26:18.480 --> 00:26:34.740
Rodrigo Ibata: positions and velocities of points along along robots we use, then an analytic ice cream to go into position interactions and angles, space and then what we get what we do is to the important step is to to use a.

153
00:26:36.090 --> 00:26:53.730
Rodrigo Ibata: neural net for regenerating function that allows us to go from from this toy system into closer approximations to the real system, so our the objective This, then, is to obtain essentially flat actions here for each one of these of these orbits.

154
00:26:54.780 --> 00:27:08.940
Rodrigo Ibata: And this this works, and then the very nice thing about this is that we haven't had to to assume a functional form for the for the for the hamiltonian or the potential, and indeed we haven't had to assume any symmetry.

155
00:27:10.890 --> 00:27:20.670
Rodrigo Ibata: And, once this once this once once you once you, you make the first run through this you can also use it, because you have.

156
00:27:21.870 --> 00:27:23.850
Rodrigo Ibata: Once you determine what the actions are.

157
00:27:25.080 --> 00:27:32.400
Rodrigo Ibata: You can you can just use the the total derivative then to derive what the what the acceleration field is.

158
00:27:34.620 --> 00:27:41.250
Rodrigo Ibata: And the reverse transformation is also completely possible so, how does this work.

159
00:27:42.600 --> 00:27:57.690
Rodrigo Ibata: So we're comparing it here to the to the tourists machine and with just 1000 points, if we had 1000 points in the Milky Way like potential, we can get much better than 1% uncertainties so.

160
00:27:59.130 --> 00:28:05.640
Rodrigo Ibata: So you know if we had 1000 points in the Milky Way in orbits.

161
00:28:06.720 --> 00:28:21.210
Rodrigo Ibata: So in this in this particular case, it was 128 all with each with each with eight points we get no point 4% errors and very, very much lower errors if if we increase the number of points that we.

162
00:28:22.260 --> 00:28:25.620
Rodrigo Ibata: That we give them, it also worked for in body simulations.

163
00:28:27.360 --> 00:28:31.200
Rodrigo Ibata: We also tried it on some test orbits that have been defined by Saunders and vinny.

164
00:28:32.370 --> 00:28:42.720
Rodrigo Ibata: And this shows you the the evolution of the of the three components of the actions over time of this is integrated over 10 giga years.

165
00:28:43.980 --> 00:28:48.990

Rodrigo Ibata: In blue, we have the results of the tourist machine as implemented in Ghana.

166
00:28:50.460 --> 00:28:56.670
Rodrigo Ibata: And you can see that in many cases of in fact most cases we do better than the than the tourist machine and Ghana.

167
00:28:58.560 --> 00:29:03.840
Rodrigo Ibata: One of the interesting points is that you can see, each one of these and Jay Pfizer straight line that's because.

168
00:29:04.920 --> 00:29:13.110
Rodrigo Ibata: The tourists machine knows what the potential is, whereas action Finder has to actually discovered that the system is actually symmetric.

169
00:29:16.200 --> 00:29:20.010
Rodrigo Ibata: And so the basic the basic architecture that's going behind this is kind of.

170
00:29:22.230 --> 00:29:33.300
Rodrigo Ibata: shown in cartoon form here, essentially, we have a data set we go through some sort of toy model, or we implement a correction to that time on, in the form of the new neural net and that's then.

171
00:29:35.640 --> 00:29:36.330
Rodrigo Ibata: Then we.

172
00:29:37.770 --> 00:29:43.650
Rodrigo Ibata: it's constrained by then the the the the physics, that we put in the form of differential equations.

173
00:29:45.240 --> 00:29:48.840
Rodrigo Ibata: And I see i'm going way of board so have it.

174
00:29:49.500 --> 00:29:51.150
Morgan Elowe MacLeod: it's no problem, you can feel free to.

175
00:29:51.720 --> 00:29:54.060
Morgan Elowe MacLeod: Take your time is what i'm trying to say.

176
00:29:54.840 --> 00:29:55.710
Rodrigo Ibata: Well, thank you very much.

177
00:29:56.670 --> 00:30:09.900
Rodrigo Ibata: So yeah so with my my my my students was him and he what we're doing is trying to see if we can use exactly this this sort of machinery to to then also apply these.

178
00:30:11.940 --> 00:30:29.100
Rodrigo Ibata: These techniques to the field populations of the Milky Way, and so the idea here is to try and discover what the what the mass distribution is in the Milky Way a window of galaxies and So here we imagine starting off with some real data in position velocity.

179
00:30:31.530 --> 00:30:42.450
Rodrigo Ibata: We use a trial a trial potential we start with some trial potential winter gate these points in that trial potential, then we use the our action Finder software.

180
00:30:43.380 --> 00:31:03.150
Rodrigo Ibata: To deliver the the actions and angles, corresponding to that data set in this trial potential, and then we use a normalizing flow to determine what the what what the distribution function is in terms of the of the actions we redraw.

181
00:31:04.200 --> 00:31:19.020
Rodrigo Ibata: Random random angles and then use the the inverse of the of the action Finder then to to make these tonight random data sets in which the.

182
00:31:20.520 --> 00:31:29.850
Rodrigo Ibata: Which which are completely phase mixed and finally we bring these things through to make a new distribution function here.

183
00:31:30.960 --> 00:31:46.740
Rodrigo Ibata: which we can then compare directly to to the observed data set in via the the price on likelihood, and then you know this thing he just goes round and round updating the updating the the the mass distribution effectively.

184
00:31:47.910 --> 00:31:54.150
Rodrigo Ibata: So we're hoping to to be able to implement this on on on real systems in the future.

185
00:31:55.620 --> 00:31:57.240
Rodrigo Ibata: So we're just wrapping up.

186
00:31:59.070 --> 00:32:05.880
Rodrigo Ibata: The the the stellar streams, though I think are extremely useful as probes of the of the time natural.

187
00:32:06.900 --> 00:32:09.300
Rodrigo Ibata: Alternatives to to CD and.

188
00:32:10.470 --> 00:32:29.550
Rodrigo Ibata: What we're finding in the case of GD one is that we, we believe the the what we see that that that are very, very periodic density peaks when you look at it in in in actual physical space along the along the screen rather than an angle.

189
00:32:30.840 --> 00:32:48.090
Rodrigo Ibata: And we've developed this this this tool to make the the canonical translation between position and velocity and action an angle, which works in a completely automated way you so essentially it's just learning this transformation from the physics, rather than from from examples.

190
00:32:50.070 --> 00:32:54.420
Rodrigo Ibata: what's new about this is that we haven't actually needed to to to give it the.

191
00:32:55.860 --> 00:33:00.570
Rodrigo Ibata: Either the potential war or the hamiltonian but it figures in that for for itself.

192
00:33:01.590 --> 00:33:06.960
Rodrigo Ibata: And it works with with asteroids set up to work with astral metric observable tonight right now.

193
00:33:08.100 --> 00:33:19.680
Rodrigo Ibata: But in order to try to get this to work on screens, we need to be able to provide the correction that allows you to go from from a stream to an orbit, and so we need effectively in body simulations for each one of.

194
00:33:20.100 --> 00:33:35.400
Rodrigo Ibata: Each one of these these stream like objects that we've been finding in the Milky Way and then the future what we intend to do, obviously, is to confront these these observations, with different theories of dark matter and gravity but that'll come later.

195

00:33:36.720 --> 00:33:37.200
Morgan Elowe MacLeod: Thanks.

196
00:33:40.680 --> 00:33:41.640
Morgan Elowe MacLeod: Thank you so much.

197
00:33:43.380 --> 00:33:46.920
Morgan Elowe MacLeod: Castle so towards starting a conversation everyone.

198
00:33:48.810 --> 00:34:00.750
Morgan Elowe MacLeod: Ping me with your in the chat with a private message about the topic of your questions sorry I was opening the chat at the same time, as I was trying to speak.

199
00:34:01.950 --> 00:34:03.810
Morgan Elowe MacLeod: So i'm wondering.

200
00:34:05.340 --> 00:34:10.680
Morgan Elowe MacLeod: If I can start things off with a little bit of a conversation about like.

201
00:34:13.710 --> 00:34:16.440
Morgan Elowe MacLeod: Just the computational aspect of this so.

202
00:34:18.510 --> 00:34:35.490
Morgan Elowe MacLeod: It seems like at each step, we still need to integrate the ordinary differential equation of the orbit for for many sort of trial objects to evaluate one likelihood in something like action Finder is that.

203
00:34:36.930 --> 00:34:37.890
Morgan Elowe MacLeod: Something that.

204
00:34:39.300 --> 00:34:45.240
Morgan Elowe MacLeod: ends up being expensive when you're evaluating sort of a very large number of sources or is that.

205
00:34:45.810 --> 00:34:48.210
Morgan Elowe MacLeod: A lot of Chelsea so In fact it doesn't.

206
00:34:49.410 --> 00:34:55.680
Rodrigo Ibata: mean the idea behind it was to be able to use it eventually on on unreal systems in the Milky Way.

207
00:34:57.090 --> 00:35:03.690
Rodrigo Ibata: And so it doesn't actually integrate orbits at all it's just using it as a.

208
00:35:07.500 --> 00:35:19.650
Rodrigo Ibata: So I mean we do integrate all bits in order to test it so essentially we when when we give this this this software a data set to to try.

209
00:35:20.700 --> 00:35:27.690
Rodrigo Ibata: To try to recover the the actions and angles, that we know from some other source we do actually integrate the orbits but.

210
00:35:29.280 --> 00:35:33.900
Rodrigo Ibata: there's no integration within the within the algorithm itself.

211
00:35:36.240 --> 00:35:40.410
Rodrigo Ibata: But this this generating function is kind of complicated and.

212
00:35:41.910 --> 00:35:47.370
Rodrigo Ibata: Typically, with something like 10,000 points it takes a few hours to run.

213
00:35:47.520 --> 00:35:48.630
Rodrigo Ibata: Our credits really.

214
00:35:49.020 --> 00:35:53.580
Rodrigo Ibata: yeah the the the expensive part about it is that it's confusing the.

215
00:35:55.980 --> 00:36:07.200
Rodrigo Ibata: ball essentially lots and lots of derivatives, because, in the mean it's all written in Python which and service is using the the the point automatic derivative engine.

216
00:36:08.460 --> 00:36:11.910
Rodrigo Ibata: Which is, in fact, taking second derivatives.

217
00:36:13.680 --> 00:36:15.840
Rodrigo Ibata: On so now that that takes a bit of time.

218
00:36:17.370 --> 00:36:24.840
Morgan Elowe MacLeod: Okay amazing so I had misunderstood some of the logistics of that but but that's wonderful to hear Anthony would you like to go ahead and unmute.

219
00:36:27.840 --> 00:36:32.670
Antony Stark: and ask your question oh so are just for the sake of.

220
00:36:34.470 --> 00:36:40.830
Antony Stark: A rough understanding what fact fraction of all the stars in our galaxy or industry.

221
00:36:42.990 --> 00:36:48.450
Rodrigo Ibata: yeah That was a really interesting question and i've been trying to look into that night bye.

222
00:36:50.700 --> 00:37:03.210
Rodrigo Ibata: bye bye kind of co editing style so stalking them with with a certain recipe to just get them all to match up along the same direction, and I think, is something like 3%.

223
00:37:04.110 --> 00:37:17.520
Rodrigo Ibata: Based on on those Games i've been playing I haven't actually written that up, but essentially if you just sort of take you know you take every guy a star, and then you try and you, you try and use it a safe.

224
00:37:18.720 --> 00:37:35.130
Rodrigo Ibata: photo metric parallax to all the actual method parallax from Gaia to place them into certain distance and then you rotate them all, so that they will moving say in the direction that certain emotions are aligned in the X direction, and you can just sort of stack them on top of the other.

225
00:37:36.570 --> 00:37:40.560
Rodrigo Ibata: And then you see you see interesting structure on different scales actually.

226
00:37:41.580 --> 00:37:52.650
Rodrigo Ibata: But it's something like 3% I believe or beyond what you consider to be a you know possible binaries and you do see you a clear correlation.

227

00:37:56.430 --> 00:38:01.170
Rohan Naidu: We are fine client Rodrigo by stream do this mean coherent.

228
00:38:02.460 --> 00:38:07.560
Rohan Naidu: Phase space structures right like you're not saying that 3% is from globular clusters.

229
00:38:07.890 --> 00:38:15.630
Rodrigo Ibata: No, no i'm not saying that i'm just saying that if you yeah so I guess it really depends what you mean by streams.

230
00:38:20.070 --> 00:38:21.030
Rodrigo Ibata: So.

231
00:38:22.080 --> 00:38:31.950
Rodrigo Ibata: Yes, if you and this particular selection that I just mentioned, was for stars and beyond a certain distance which I can't really remember.

232
00:38:33.030 --> 00:38:35.070
Rodrigo Ibata: Because I did this of this work, a couple of years ago.

233
00:38:38.490 --> 00:38:49.800
Rodrigo Ibata: But essentially they there was there was selected not being the disc and so it's a it's kind of a correlation between stars in the in the thick disk and HALO.

234
00:38:50.550 --> 00:38:59.310
Rodrigo Ibata: Is what it would have been, but I think yet is almost certainly going to change as a as a function of position in the galaxy writers you.

235
00:39:01.590 --> 00:39:17.910
Rodrigo Ibata: know in some regions, I mean i'm probably all stars form in in groups right and so at some level there's going to be some there's going to be some correlation there but eventually they get phase mix and you can't actually detect them as in as coherent structures.

236
00:39:19.530 --> 00:39:21.300
Morgan Elowe MacLeod: So there's like a lifetime aspect.

237
00:39:21.360 --> 00:39:24.600
Rodrigo Ibata: To that question, so there was a long time, I expect, and then the HALO you.

238
00:39:25.080 --> 00:39:29.730
Rodrigo Ibata: know the the the time scale for this for this mixing is that much longer.

239
00:39:31.770 --> 00:39:44.190
Rodrigo Ibata: I mean if you were to ask the question you know the outer HALO then and probably the you know the the fraction of stars in streams and the outer HALO is quite high because you know it's dominated by side of the sagittarius stream.

240
00:39:46.620 --> 00:39:52.290
Rodrigo Ibata: that's going to be dependent on ethnicity, too, so it's a difficult question to answer, I think.

241
00:39:53.490 --> 00:39:58.740
Morgan Elowe MacLeod: So let's talk time bit more about stream finding some sonic do you want to go ahead.

242
00:40:01.200 --> 00:40:04.410
Sownak Bose: Oh sure Hello Rodrigo, thank you for very interesting so.

243
00:40:05.430 --> 00:40:08.880
Sownak Bose: I was wondering what you thought were the prospects of.

244
00:40:09.930 --> 00:40:16.560
Sownak Bose: augmenting the stream finding algorithms beyond six dimensional information to include things like.

245
00:40:17.370 --> 00:40:27.390
Sownak Bose: Chemical abundances and you know those sorts of things that we might be able to measure with increasing precision with spss five and and stuff like that, so can.

246
00:40:27.900 --> 00:40:34.740
Sownak Bose: These stream funding algorithms kind of fold in that kind of information to learn more about the progenitors of the streams, for example.

247
00:40:36.330 --> 00:40:39.360
Rodrigo Ibata: Yes, so I mean currently set up in such a way that.

248
00:40:40.380 --> 00:40:43.950

Rodrigo Ibata: I mean, as long as you provide a I.

249
00:40:44.970 --> 00:40:54.000
Rodrigo Ibata: mean I have updated this this software several times to provide new information on and so something like what we have.

250
00:40:56.340 --> 00:41:05.250
Rodrigo Ibata: Can just you we can just essentially append another probability, and so, if you if you were to provide it with.

251
00:41:07.710 --> 00:41:19.440
Rodrigo Ibata: With chemical abundances which effectively just you know would imply in an extra P, to add onto the whole string of the ones that are currently there, then it would work in principle.

252
00:41:20.490 --> 00:41:26.880
Rodrigo Ibata: The problem is that, as the data set becomes less and less i'm watching this, I think it becomes harder to to interpret it.

253
00:41:28.440 --> 00:41:28.950
Obviously.

254
00:41:30.660 --> 00:41:32.730
Sownak Bose: Okay that's interesting to know, thank you.

255
00:41:33.990 --> 00:41:34.320
Rodrigo Ibata: But.

256
00:41:37.020 --> 00:41:41.580
Rodrigo Ibata: I mean, I presume we're not going to have many of those stars right and so it's.

257
00:41:43.560 --> 00:41:57.870
Rodrigo Ibata: I mean what one thing that we have been doing is, for instance with with Radio velocities for which we don't have many stars, but they you can still use them to to to anchor down the the orbital solutions and so they're always very useful right.

258
00:41:59.490 --> 00:42:07.650
Sownak Bose: yeah I was, I was kind of wondering it from almost the spectrum of you know you you obviously brought up the links with the nature of dark matter.

259

00:42:08.220 --> 00:42:17.070
Sownak Bose: And how the streams can tell us something about that, and if you if you thought, for example, that dwarf galaxies and different theories of masa underwent.

260
00:42:17.580 --> 00:42:26.940
Sownak Bose: subtly different kinds of star formation history is because of the manner of their formation, if that might in some way be imprinted in their chemical patterns.

261
00:42:28.710 --> 00:42:29.700
Sownak Bose: as well, so.

262
00:42:29.970 --> 00:42:35.370
Rodrigo Ibata: yeah yeah almost certainly, but I just seen in terms of actually the detection of these objects you.

263
00:42:37.980 --> 00:42:38.310
Rodrigo Ibata: It.

264
00:42:42.180 --> 00:42:53.040
Rodrigo Ibata: might be hard to to introduce that at the detection stage, I think you know if you just if you have a sample of your candidates and then you're able to see.

265
00:42:54.240 --> 00:42:56.220
Rodrigo Ibata: To then.

266
00:42:57.450 --> 00:43:13.920
Rodrigo Ibata: You know, bring in some additional information, then that allows you to to to then more easily determine whether you whether, whether the detection is is what you thought it was so I I suspect that's probably more the way that we would tend to proceed.

267
00:43:16.410 --> 00:43:18.090
Rodrigo Ibata: Good because that's actually happening with.

268
00:43:19.710 --> 00:43:35.340
Rodrigo Ibata: An equinox been working with the pristine survey, which is an aeroplane survey in the calcium h&k vines and which has some metal city sensitivity and so you essentially the.

269
00:43:36.900 --> 00:43:46.170

Rodrigo Ibata: He took the detection is that we found with the the stream Finder and then just cross correlated them with cross match them with is mapped.

270
00:43:47.460 --> 00:43:51.150
Rodrigo Ibata: And then you could pick out the structures that were very low metal s&t.

271
00:43:52.710 --> 00:44:03.750
Rodrigo Ibata: And and actually we managed to confirm pretty much all of the old old of these tiny little screen like features that we found previously because not only do they appear.

272
00:44:04.950 --> 00:44:13.260
Rodrigo Ibata: In the guy maps, but then they they confirmed as objects of a certain metal a city and in the telemetry.

273
00:44:15.720 --> 00:44:16.890
Sownak Bose: Okay that's really interesting.

274
00:44:20.280 --> 00:44:21.900
Morgan Elowe MacLeod: Totally do you want to go ahead and.

275
00:44:22.950 --> 00:44:25.680
Charles Conroy: forth so great talk when we go.

276
00:44:28.020 --> 00:44:39.360
Charles Conroy: As you know, there's been a lot of interest in a realization in the last couple years that the llc right induces a lot of large scale effects in the galaxy both for predicted to at least.

277
00:44:40.200 --> 00:44:53.970
Charles Conroy: In terms of the shape of the potential and also movement at the very Center relative to the HALO So how are you thinking about those effects in the context of modeling streams, you know the effects on velocity and in terms of more complicated potentials.

278
00:44:55.080 --> 00:44:55.920
Charles Conroy: This i'm curious as.

279
00:44:57.000 --> 00:44:58.770
Rodrigo Ibata: The nmc is a real hassle.

280

00:45:00.480 --> 00:45:01.860
Rodrigo Ibata: It makes life a lot harder.

281
00:45:03.000 --> 00:45:04.350
Rodrigo Ibata: Nice, a very good point and.

282
00:45:06.000 --> 00:45:14.130
Rodrigo Ibata: You know the I think we're kind of hoping that, for these in a galaxy structures it's it's not too problematic.

283
00:45:15.570 --> 00:45:25.170
Rodrigo Ibata: Clearly that's not the case in once you go out and I don't know beyond probably something like 30 K PC I mean it doesn't make any sense not to take the llc into account now.

284
00:45:28.950 --> 00:45:29.280
Rodrigo Ibata: But.

285
00:45:30.780 --> 00:45:36.690
Rodrigo Ibata: i'm hoping at some level will be able to get by with having a kind of like a perturbation but.

286
00:45:39.120 --> 00:45:44.220
Rodrigo Ibata: So there are some people in our team in a similar was here who's been kind of.

287
00:45:45.960 --> 00:45:53.070
Rodrigo Ibata: he's been updating some that the matrix method to to try and figure out whether the.

288
00:45:54.570 --> 00:46:02.190
Rodrigo Ibata: You know, you know the the trying to to to figure out the the the stability of the galaxy and.

289
00:46:05.130 --> 00:46:09.180
Rodrigo Ibata: it's it's just pretty hard right when once the nmc comes in.

290
00:46:10.410 --> 00:46:13.260
Rodrigo Ibata: To to model things correctly in and.

291
00:46:15.660 --> 00:46:19.530

Rodrigo Ibata: I suspect really nobody knows how to do this, the present day right.

292
00:46:22.260 --> 00:46:30.210
Rodrigo Ibata: And so you know, there was quite a lot of discussion in the stream conference precisely about how we how we go about modeling the nmc.

293
00:46:31.980 --> 00:46:34.230
Rodrigo Ibata: night, I think it really is working progress.

294
00:46:36.510 --> 00:46:38.070
Rodrigo Ibata: Thanks, what do you suggest.

295
00:46:38.340 --> 00:46:39.720
Charles Conroy: No, I don't know that's why I asked.

296
00:46:43.290 --> 00:46:44.310
Rodrigo Ibata: I think it's just hard.

297
00:46:44.520 --> 00:46:45.510
Charles Conroy: yeah it's a hard problem.

298
00:46:48.990 --> 00:46:50.700
Morgan Elowe MacLeod: along the lines of hard problems.

299
00:46:52.530 --> 00:47:04.620
Morgan Elowe MacLeod: And, and to sort of mix things up a little bit Okay, so I think Nelson called on Avi both have very related questions so would you like to both unmute and you can ask your questions.

300
00:47:04.830 --> 00:47:07.650
Morgan Elowe MacLeod: And then Rodrigo same times are both all at once.

301
00:47:10.800 --> 00:47:18.180
Nelson Caldwell: mine's pretty short so what's the difference between the let's call it the Carl Burke signature of Sub halos.

302
00:47:18.690 --> 00:47:34.080
Nelson Caldwell: And what you find or what you find in GD one is the wavelength, the depth of the gaps, the regularity, what should we be looking for in the other streams to to identify some halos is causing some structural differences in streams.

303
00:47:36.570 --> 00:47:44.490
Rodrigo Ibata: Well, I think yeah so the regularity is a bad thing right, I mean that suggests something else so.

304
00:47:46.710 --> 00:47:47.370
Rodrigo Ibata: So the.

305
00:47:48.690 --> 00:48:00.480
Rodrigo Ibata: I think that's the that's one thing that we should be, we should be looking for, I mean to be quite honest, some rather taken with with res picture, where you know the.

306
00:48:01.170 --> 00:48:17.250
Rodrigo Ibata: least some fraction of the globular clusters come in within within dark matter SUP halos within small dark matter self haters because I really don't see why that the HALO one globular clusters shouldn't be formed in in some way like that either in you know launch galaxies or.

307
00:48:18.720 --> 00:48:31.080
Rodrigo Ibata: or for with their with their own dark matter so pay those and, in which case they sort of start disrupting before they come in and then you get a whole next right, and so I.

308
00:48:33.000 --> 00:48:38.940
Rodrigo Ibata: But at the same time, so, even though I find that compelling I think it makes them makes it very hard to.

309
00:48:41.250 --> 00:48:51.090
Rodrigo Ibata: To actually analyze them right because they they they become very, very complicated structures and so some of those, including GD one we kind of think.

310
00:48:53.010 --> 00:48:58.740
Rodrigo Ibata: resemble that picture, there is a kiss GD one I think I have it here.

311
00:49:00.510 --> 00:49:01.320
Rodrigo Ibata: just go back.

312
00:49:02.910 --> 00:49:04.020
Rodrigo Ibata: yeah so there's.

313
00:49:05.250 --> 00:49:10.680
Rodrigo Ibata: That is GD one, for instance, and there's this little parallel stream that has almost exactly the same.

314
00:49:11.700 --> 00:49:16.830
Rodrigo Ibata: The same actions for instances as GD one.

315
00:49:20.100 --> 00:49:20.940
Rodrigo Ibata: And so.

316
00:49:22.260 --> 00:49:30.360
Rodrigo Ibata: If they're clearly not systems that have formed I think in isolation and they're not they're not systems that are.

317
00:49:31.380 --> 00:49:31.710
Rodrigo Ibata: Around.

318
00:49:33.810 --> 00:49:46.110
Rodrigo Ibata: As Anna has shown you know but they're also there are features within within GD one this is this famous spur structure, which I think she's quite compellingly.

319
00:49:47.190 --> 00:50:10.770
Rodrigo Ibata: argued is due to do an interaction with with another dynamical but due to the dynamical interaction with with another object, and we see also sort of parallel structures in in several of these that I mean these two objects here, for instance, a very close orbitz and.

320
00:50:14.520 --> 00:50:18.780
Rodrigo Ibata: I so all of that to say that I don't think.

321
00:50:20.640 --> 00:50:30.360
Rodrigo Ibata: We can get by with saying that the galaxy has a has a smooth potential that that just simply won't work well, on the other hand, whether.

322
00:50:31.740 --> 00:50:43.620
Rodrigo Ibata: Whether there are dark matter lump, so I think my feeling is that we, it would be nice to to take a sort of skeptical approach and see how far that goes.

323
00:50:44.640 --> 00:50:48.150
Rodrigo Ibata: I mean just how far can we try to to push.

324
00:50:51.240 --> 00:50:57.870
Rodrigo Ibata: You know other sort of more mundane ways of causing the the structures that we see in the streams.

325
00:51:02.100 --> 00:51:09.930
Rodrigo Ibata: And so, is there a I think we're probably going to have to look at these in a, you know as as a population to.

326
00:51:12.630 --> 00:51:22.710
Rodrigo Ibata: But I don't think that there's a there's a symbol there's there's a simple signature, that we can say right now Okay, this is nothing else would do this all.

327
00:51:24.210 --> 00:51:25.470
Rodrigo Ibata: The cdn.

328
00:51:27.030 --> 00:51:28.140
Rodrigo Ibata: Sub ALA fly by.

329
00:51:29.430 --> 00:51:29.820
night.

330
00:51:32.010 --> 00:51:38.670
Rodrigo Ibata: I mean, I think it really has to be a sort of like a population study it Okay, thank you.

331
00:51:43.560 --> 00:51:47.670
Morgan Elowe MacLeod: Sorry, I was muted go ahead Ivy and along those lines.

332
00:51:48.360 --> 00:51:58.620
Abraham Loeb: yeah and also my question was can we turn it around and perhaps constrain the nature of dark matter in the sense of see them not being consistent with the lack of.

333
00:52:00.900 --> 00:52:18.930
Abraham Loeb: clumps that you would because already it was 40% and now you're saying I don't necessarily see evidence for clumps in addition to the the periodic structures, so the question is can can you say something about see them not being compatible with with the current date.

334
00:52:21.000 --> 00:52:26.370

Rodrigo Ibata: Well yeah I mean I think one can go about doing that, eventually, I mean the.

335
00:52:27.660 --> 00:52:37.680
Rodrigo Ibata: This work that I mentioned here, it was using the the lumpiness that we were observing and i'm claimed that that could only be due to.

336
00:52:38.790 --> 00:52:39.210
Rodrigo Ibata: The.

337
00:52:40.560 --> 00:52:42.210
Rodrigo Ibata: To the fly by eating.

338
00:52:45.930 --> 00:52:53.160
Rodrigo Ibata: Now, turning this around, of course, I think, requires a because this isn't I mean this after all, is the default or.

339
00:52:55.290 --> 00:53:07.500
Rodrigo Ibata: theory right, I mean and so it's much easier to to convince oneself that something that everybody agrees on works and actually turning it around and saying that you know the.

340
00:53:09.330 --> 00:53:13.530
Rodrigo Ibata: The fact that we see, you know that we're able to produce these peaks.

341
00:53:15.300 --> 00:53:31.920
Rodrigo Ibata: A ball a that they that they're very periodic when you look at them in the right way, and also that you know and then body simulation can produce something that looks vaguely like that which is actually shown in this flow diagram here I mean this isn't a perfect match to the to.

342
00:53:33.420 --> 00:53:44.490
Rodrigo Ibata: The to the to the lumpiness that we do see in GD one we weren't able to make an body simulation that did that it reproduces to some extent, but I think this is not enough.

343
00:53:45.990 --> 00:53:50.070
Rodrigo Ibata: by any means not enough evidence to throw out cdn.

344
00:53:52.140 --> 00:54:02.070

Rodrigo Ibata: I think we'll have to go through this dataset with a fine tooth comb looking at all of these objects modeling them in great detail.

345
00:54:03.690 --> 00:54:06.210
Rodrigo Ibata: Probably modeling them also with you know.

346
00:54:07.440 --> 00:54:16.860
Rodrigo Ibata: Come such as embodies six taken you know where you're able to follow the carefully the the the collision all aspects of the of the progenitors.

347
00:54:17.970 --> 00:54:36.120
Rodrigo Ibata: Before one can make such a statement, so I think it's still years off is my feeling right, I mean this this certainly makes me feel uncomfortable with respect to to these predictions bye bye panic and collaborators I think they've done a very they're modeling Okay, I think is very good.

348
00:54:37.830 --> 00:54:40.740
Rodrigo Ibata: I think they jumped to conclusions is my feeling but.

349
00:54:43.410 --> 00:54:50.520
Rodrigo Ibata: But then turning that around and saying that it doesn't that number CD and doesn't work is is still way off, I think, thank you.

350
00:54:52.320 --> 00:55:06.960
Morgan Elowe MacLeod: Thank you so much in the closing couple of minutes we wanted to give a chance to have have the last word about you know something you're excited about something you're looking forward to our or just to wrap up the discussion.

351
00:55:09.900 --> 00:55:11.310
Rodrigo Ibata: Oh, I wasn't expecting that.

352
00:55:15.390 --> 00:55:16.950
Morgan Elowe MacLeod: Or, I can ask you another question.

353
00:55:18.990 --> 00:55:20.400
Rodrigo Ibata: Well she'll go ahead, but.

354
00:55:20.820 --> 00:55:37.050
Morgan Elowe MacLeod: So Okay, so do you anticipate an epic where we have enough samples in something like action Finder to define the potential at

of granularity that would inform our understanding of dark matter substructure.

355
00:55:38.040 --> 00:55:38.730
Morgan Elowe MacLeod: Right so.

356
00:55:38.880 --> 00:55:48.900
Morgan Elowe MacLeod: In a sense, like we could be noise limited or like we could be resolving the potential and I don't have a sense of like what it would take or whether we could ever get there with the.

357
00:55:49.440 --> 00:55:53.160
Rodrigo Ibata: The only stuff that's exactly what what we intended to do with this right.

358
00:55:54.750 --> 00:56:13.950
Rodrigo Ibata: And so the the idea with it with it was to to essentially try, you know the potential on all scales going from the very outer reaches of the HALO all the way down to the size of the you know the width of these these streams all throughout the galaxy.

359
00:56:15.390 --> 00:56:15.810
Rodrigo Ibata: So.

360
00:56:17.460 --> 00:56:19.380
Rodrigo Ibata: I was actually quite.

361
00:56:20.550 --> 00:56:31.170
Rodrigo Ibata: Quite quite surprised and pleasantly surprised that you know when I hear I gave you the you know what we were obtaining for the the uncertainties, for instance on the actions.

362
00:56:31.770 --> 00:56:41.310
Rodrigo Ibata: This is, you know, we have more than 1000 points in streams already we have any more than that right, I mean this does actually require a full six dimensional face face information.

363
00:56:43.770 --> 00:56:44.130
Rodrigo Ibata: But.

364
00:56:46.260 --> 00:56:54.390
Rodrigo Ibata: But you know the radio velocities are easy to get once we've identified the the stars, I mean we don't have loads and loads and loads of.

365
00:56:55.860 --> 00:57:02.850
Rodrigo Ibata: Radio velocities and in general for the for these guy measurements, but you know getting the follow up is easy distance is a harder, mind you.

366
00:57:03.570 --> 00:57:15.360
Rodrigo Ibata: And so i'm not i'm not entirely sure to what extent we were limited by the by a lack of distance information to to these structures which are typically like angular parsecs away.

367
00:57:17.070 --> 00:57:22.530
Rodrigo Ibata: But that's, certainly where we're going to do what's right that's and we're hoping that this you know.

368
00:57:23.670 --> 00:57:35.340
Rodrigo Ibata: This machinery will then allow us to do that, because it gives us, you know essentially a means to provide to build a neural net.

369
00:57:36.780 --> 00:57:41.280
Rodrigo Ibata: That represents, then the the acceleration field, and all those scales.

370
00:57:42.990 --> 00:57:44.760
Rodrigo Ibata: But ya know that there's there's some.

371
00:57:44.820 --> 00:57:45.960
Morgan Elowe MacLeod: extremely exciting.

372
00:57:47.160 --> 00:57:53.850
Rodrigo Ibata: But yeah so the the difficulty really is now you know, going from streams to orbits right and.

373
00:57:55.290 --> 00:58:03.420
Rodrigo Ibata: That will require some effort and then correcting for all of these possible you know all the flybys and stuff and all the other complications.

374
00:58:06.090 --> 00:58:06.480
Morgan Elowe MacLeod: yeah.

375
00:58:08.100 --> 00:58:15.360

Morgan Elowe MacLeod: Well, that I think is an exciting note to end on, thank you for sharing sort of all of these these prospects and and.

376
00:58:16.230 --> 00:58:18.480
Morgan Elowe MacLeod: You know, ways we can use these new methods to get.

377
00:58:18.570 --> 00:58:19.650
Morgan Elowe MacLeod: Can a lot of insight.

378
00:58:21.420 --> 00:58:24.540
Rodrigo Ibata: Thank you so much for your questions really very interesting.