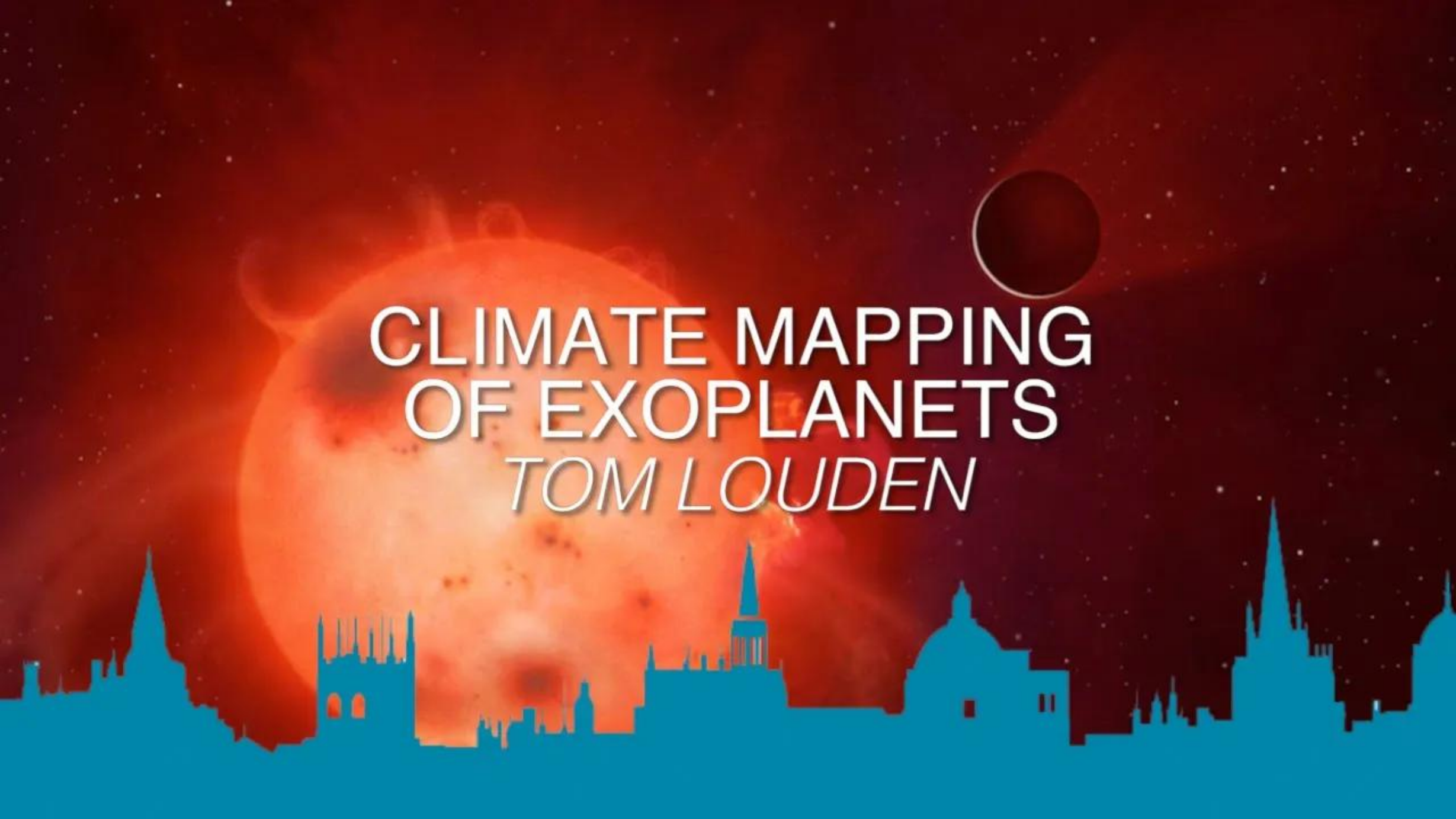
CLIMATE MAPPING
OF EXOPLANETS
TOM LOUDEN

1
00:00:01,350 --> 00:00:05,280
[Music]

2
00:00:11,490 --> 00:00:09,990
I thinks the introduction see I'm a

3
00:00:12,930 --> 00:00:11,500
winking fellow at the University of

4
00:00:15,179 --> 00:00:12,940
Warwick so I feel like I just need one

5
00:00:16,470 --> 00:00:15,189
more stylized w like a symbol at the

6
00:00:17,250 --> 00:00:16,480
bottom of my screen that so I'm working

7
00:00:18,990 --> 00:00:17,260
on it

8
00:00:20,279 --> 00:00:19,000
see I'm talking today about the climate

9
00:00:23,850 --> 00:00:20,289
mapping of exoplanet work I've been

10
00:00:24,840 --> 00:00:23,860
doing so I want to start off with a nice

11
00:00:26,189 --> 00:00:24,850
picture of Jupiter

12
00:00:27,450 --> 00:00:26,199
although not quite as nice as some of

13
00:00:29,340 --> 00:00:27,460

the ones we saw this morning those a

14
00:00:31,590 --> 00:00:29,350
really brilliant update these two this

15
00:00:32,790 --> 00:00:31,600
talk a little bit no reason I'm starting

16
00:00:35,910 --> 00:00:32,800
here is because you can see to you but

17
00:00:37,559 --> 00:00:35,920
there is a dynamic and interesting and

18
00:00:39,930 --> 00:00:37,569
very variable object across the whole of

19
00:00:42,419 --> 00:00:39,940
the disk and there if when independent

20
00:00:44,309 --> 00:00:42,429
cloud formations and dynamics going on

21
00:00:47,669 --> 00:00:44,319
that really the point I'm trying to make

22
00:00:49,439 --> 00:00:47,679
is that planets are not points so why do

23
00:00:53,389 --> 00:00:49,449
we treat them in X upon us as if they

24
00:00:55,439 --> 00:00:53,399
are we quite often talk about a singular

25
00:00:58,349 --> 00:00:55,449
equilibrium temperature for a planet a

26
00:01:01,079 --> 00:00:58,359
singular abundance of a certain element

27
00:01:02,430 --> 00:01:01,089
and really it doesn't make sense to talk

28
00:01:03,989 --> 00:01:02,440
about finances points because they are

29
00:01:07,289 --> 00:01:03,999
of course like dynamic and interesting

30
00:01:09,390 --> 00:01:07,299
objects just like you did on one way the

31
00:01:10,860 --> 00:01:09,400
planets are not one-dimensional is in

32
00:01:12,810 --> 00:01:10,870
their velocity field so I've just

33
00:01:16,770 --> 00:01:12,820
brought up a plot from showman at bell

34
00:01:18,480 --> 00:01:16,780
2012 which shows this is a planet of

35
00:01:20,130 --> 00:01:18,490
looking in is a trend looking in on a

36
00:01:21,750 --> 00:01:20,140
planet as it transits or the expanded

37
00:01:23,490 --> 00:01:21,760
out the atmosphere so this is how the

38
00:01:24,960 --> 00:01:23,500

velocity field of the planet's

39
00:01:26,070 --> 00:01:24,970
atmosphere would look to an observer in

40
00:01:28,650 --> 00:01:26,080
here so you can see you've got this

41
00:01:30,390 --> 00:01:28,660
classic equatorial jet and also some

42
00:01:31,740 --> 00:01:30,400
polar flow coming towards you as well so

43
00:01:34,500 --> 00:01:31,750
there's this large blue ship coming

44
00:01:36,860 --> 00:01:34,510
towards you so planets are certainly not

45
00:01:39,450 --> 00:01:36,870
one-dimensional in their velocity field

46
00:01:41,040 --> 00:01:39,460
and there's a lot more you can get out

47
00:01:42,840 --> 00:01:41,050
of these predictions from these models

48
00:01:44,160 --> 00:01:42,850
and I feel like this talk is called

49
00:01:45,630 --> 00:01:44,170
place now because you just had an hour

50
00:01:47,190 --> 00:01:45,640
of hearing about all of this from

51
00:01:48,330 --> 00:01:47,200
remember Lee so that was a really good

52
00:01:51,360 --> 00:01:48,340
introduction for me so thank you very

53
00:01:53,130 --> 00:01:51,370
much so these models predict not a lot

54
00:01:55,410 --> 00:01:53,140
about their dynamics at the planet

55
00:01:57,630 --> 00:01:55,420
atmosphere so they make specific and

56
00:02:00,420 --> 00:01:57,640
testable predictions about the velocity

57
00:02:02,969 --> 00:02:00,430
field and about the presence of clouds

58
00:02:05,430 --> 00:02:02,979
and all sorts of other things but how do

59
00:02:06,630 --> 00:02:05,440
you test this in real life and to do

60
00:02:10,139 --> 00:02:06,640
that you're going to need some form of

61
00:02:13,649 --> 00:02:10,149
spatial resolution so this is why Emily

62
00:02:15,059 --> 00:02:13,659
was talking about the the spatial

63
00:02:16,259 --> 00:02:15,069

scanning during secondary Eclipse that's

64
00:02:19,839 --> 00:02:16,269
one way of doing it

65
00:02:22,030 --> 00:02:19,849
and that you need

66
00:02:24,760 --> 00:02:22,040
you need some way of spatially resolving

67
00:02:26,110 --> 00:02:24,770
the exit point atmosphere and what I

68
00:02:28,240 --> 00:02:26,120
really want to do is do this during

69
00:02:30,070 --> 00:02:28,250
transmission because transmission is

70
00:02:33,309 --> 00:02:30,080
what my specialty is what I'm interested

71
00:02:34,479 --> 00:02:33,319
in so is there a way to break down the

72
00:02:36,550 --> 00:02:34,489
spatial resolution of the planet during

73
00:02:38,770 --> 00:02:36,560
primary transit so as the planet moves

74
00:02:40,720 --> 00:02:38,780
in front of the star so it's gonna spend

75
00:02:46,059 --> 00:02:40,730
a portion of its time with only one limb

76
00:02:48,070 --> 00:02:46,069
in front of the star there's a little

77
00:02:49,420 --> 00:02:48,080
bit of dark maybe you can see this star

78
00:02:50,949 --> 00:02:49,430
in the background there and at the

79
00:02:53,770 --> 00:02:50,959
beginning of the transit the planet is

80
00:02:55,000 --> 00:02:53,780
only one limb is over the star and as

81
00:02:56,559 --> 00:02:55,010
you go food with transit you have a

82
00:02:58,390 --> 00:02:56,569
center where the whole thing is covered

83
00:03:00,250 --> 00:02:58,400
and then the other end of the transit

84
00:03:01,509 --> 00:03:00,260
the other limb of the planet is now

85
00:03:03,490 --> 00:03:01,519
transiting and the other ones off the

86
00:03:05,080 --> 00:03:03,500
star so throughout the transi you're

87
00:03:07,150 --> 00:03:05,090
gonna have a differential weighting of

88
00:03:09,640 --> 00:03:07,160

what parts of the planet atmosphere of

89
00:03:12,100 --> 00:03:09,650
being having your transmission spectrum

90
00:03:14,170 --> 00:03:12,110
from as a function of time so can you

91
00:03:17,830 --> 00:03:14,180
use this to probe the two limbs

92
00:03:19,410 --> 00:03:17,840
independently so there's a problem of

93
00:03:21,610 --> 00:03:19,420
course there always is I mean

94
00:03:24,280 --> 00:03:21,620
spectroscopy is complicated and

95
00:03:26,440 --> 00:03:24,290
difficult and you've got the you've got

96
00:03:28,180 --> 00:03:26,450
issues with the velocity field of

97
00:03:29,979 --> 00:03:28,190
everything else in the system so the

98
00:03:31,150 --> 00:03:29,989
planet is moving the earth is moving

99
00:03:32,979 --> 00:03:31,160
with respect to the planet you're

100
00:03:35,140 --> 00:03:32,989
looking at and the star itself is

101
00:03:37,360 --> 00:03:35,150
rotating so this is the rasta McLoughlin

102
00:03:38,949 --> 00:03:37,370
effect where the velocity of the star

103
00:03:41,710 --> 00:03:38,959
they are passing over as a function of

104
00:03:43,270 --> 00:03:41,720
time is changing so this can contaminate

105
00:03:44,319 --> 00:03:43,280
your transmission spectrum so it's

106
00:03:45,640 --> 00:03:44,329
something that you have to take into

107
00:03:47,140 --> 00:03:45,650
account

108
00:03:48,729 --> 00:03:47,150
there's absorption in the Earth's

109
00:03:50,349 --> 00:03:48,739
atmosphere of course so for example if

110
00:03:51,849 --> 00:03:50,359
you're looking at sodium like I like I

111
00:03:53,560 --> 00:03:51,859
will be the Earth's atmosphere has

112
00:03:55,810 --> 00:03:53,570
sodium as well and it also has water

113
00:03:57,220 --> 00:03:55,820

features near the sodium feature so you

114
00:03:58,150 --> 00:03:57,230
have to take into account the the

115
00:04:03,130 --> 00:03:58,160
transmission of the Earth's atmosphere

116
00:04:05,020 --> 00:04:03,140
but luckily the solution is it is high

117
00:04:05,710 --> 00:04:05,030
resolution spectroscopy so because

118
00:04:08,199 --> 00:04:05,720
you've got all of these different

119
00:04:10,479 --> 00:04:08,209
velocities if you look at it with a high

120
00:04:13,090 --> 00:04:10,489
enough resolution spectrograph then the

121
00:04:15,610 --> 00:04:13,100
the velocities all separate out the

122
00:04:17,319 --> 00:04:15,620
features and the changes in time so pre

123
00:04:18,699 --> 00:04:17,329
how the features and you can quite

124
00:04:19,990 --> 00:04:18,709
easily separate out the bits they are

125
00:04:21,699 --> 00:04:20,000
interested in the bits the annoying

126
00:04:25,779 --> 00:04:21,709
trusted him but you have to take care of

127
00:04:27,159 --> 00:04:25,789
the model incorrectly so I did a study

128
00:04:30,010 --> 00:04:27,169
on history one eight nine seven pre

129
00:04:32,140 --> 00:04:30,020
freebie a couple years back and so this

130
00:04:33,010 --> 00:04:32,150
was to see if this technique was viable

131
00:04:34,720 --> 00:04:33,020
whether you

132
00:04:39,040 --> 00:04:34,730
scan the limb of the planet as it

133
00:04:40,660 --> 00:04:39,050
transits so I am taking me all of these

134
00:04:42,280 --> 00:04:40,670
things into account it was possible that

135
00:04:44,410 --> 00:04:42,290
you could separate out the eastern and

136
00:04:45,910 --> 00:04:44,420
western limb contributions and I was

137
00:04:48,550 --> 00:04:45,920
looking specifically if the absorption

138
00:04:50,920 --> 00:04:48,560

from sodium and seeing how the velocity

139
00:04:53,530 --> 00:04:50,930
of this absorbed sodium line changes as

140
00:04:55,930 --> 00:04:53,540
a function of time and I found that you

141
00:04:57,460 --> 00:04:55,940
could separate out their velocity from

142
00:04:59,590 --> 00:04:57,470
the eastern and western limbs to

143
00:05:01,480 --> 00:04:59,600
actually you find on the trailing or

144
00:05:03,310 --> 00:05:01,490
western limb you have a lot a of about

145
00:05:06,490 --> 00:05:03,320
500 meters per second coming towards you

146
00:05:08,740 --> 00:05:06,500
and on the other side 2 kilometers per

147
00:05:10,780 --> 00:05:08,750
second going away so you have this this

148
00:05:13,660 --> 00:05:10,790
rotation of the planet and eastward just

149
00:05:15,400 --> 00:05:13,670
as predicted in the models that if you

150
00:05:17,170 --> 00:05:15,410
average that out to bring it down to one

151
00:05:18,940 --> 00:05:17,180
dimensional point again you get an

152
00:05:21,880 --> 00:05:18,950
average of a two kilometer blue shift

153
00:05:23,830 --> 00:05:21,890
and this is very similar to what's now

154
00:05:26,230 --> 00:05:23,840
that's now found in 2010 when they

155
00:05:28,240 --> 00:05:26,240
looked at 82 or nine four five maybe now

156
00:05:29,800 --> 00:05:28,250
they didn't spectrally resolve it like I

157
00:05:32,050 --> 00:05:29,810
did they just looked at this singular

158
00:05:33,850 --> 00:05:32,060
one dimensional point and they got minus

159
00:05:36,700 --> 00:05:33,860
two kilometers per second so it looks

160
00:05:38,290 --> 00:05:36,710
like you can this two point of the

161
00:05:39,670 --> 00:05:38,300
second if you break it out you start

162
00:05:47,080 --> 00:05:39,680
seeing this equatorial jet and the

163
00:05:48,909 --> 00:05:47,090

sexual rotation and this is a very close

164
00:05:50,800 --> 00:05:48,919
map to the kind of velocities and also

165
00:05:53,250 --> 00:05:50,810
the asymmetry in the velocities that

166
00:05:56,409 --> 00:05:53,260
were expected from theory so this is a

167
00:05:57,460 --> 00:05:56,419
bottom that thing is gone at the bottom

168
00:06:01,870 --> 00:05:57,470
there's another clock from German I

169
00:06:03,580 --> 00:06:01,880
think so the velocity signal is is

170
00:06:05,080 --> 00:06:03,590
higher in the blue shift because you've

171
00:06:08,200 --> 00:06:05,090
also got this polar region coming

172
00:06:11,110 --> 00:06:08,210
towards you as well so where to go next

173
00:06:13,480 --> 00:06:11,120
from here so I've known now from this

174
00:06:15,790 --> 00:06:13,490
technique works and I want to extend

175
00:06:18,690 --> 00:06:15,800
this analysis to more hot Jupiters also

176
00:06:20,770 --> 00:06:18,700
to search for trends in wind velocity

177
00:06:22,630 --> 00:06:20,780
increase the spatial resolution a little

178
00:06:25,450 --> 00:06:22,640
further and expand from certain to over

179
00:06:27,550 --> 00:06:25,460
absorbers and also one thing that really

180
00:06:29,740 --> 00:06:27,560
bugged me the last time around is my

181
00:06:31,719 --> 00:06:29,750
plots apparently weren't very photogenic

182
00:06:33,790 --> 00:06:31,729
for pleasing to some of the press

183
00:06:36,370 --> 00:06:33,800
releases and I got this wonderful quote

184
00:06:38,780 --> 00:06:36,380
from the register that my graphics were

185
00:06:40,610 --> 00:06:38,790
charmingly crew

186
00:06:43,610 --> 00:06:40,620
so that's kind of bugged me for years

187
00:06:44,870 --> 00:06:43,620
and I okay I just want to I want to

188
00:06:46,940 --> 00:06:44,880

correct the record and make some

189
00:06:52,760 --> 00:06:46,950
nice-looking plots to demonstrate this

190
00:06:53,990 --> 00:06:52,770
effect in the future so the base but I'm

191
00:06:55,670 --> 00:06:54,000
going to use to do this with is

192
00:06:57,470 --> 00:06:55,680
spider-man so some of you may have heard

193
00:07:00,320 --> 00:06:57,480
of this this is the previous project I

194
00:07:02,840 --> 00:07:00,330
worked on it's for mapping mapping

195
00:07:05,030 --> 00:07:02,850
exoplanets during phase curve and and

196
00:07:07,310 --> 00:07:05,040
transit lands and secondary flip

197
00:07:08,960 --> 00:07:07,320
scanning if I think I should get some

198
00:07:11,510 --> 00:07:08,970
sort of award for the most convoluted

199
00:07:12,830 --> 00:07:11,520
acronym ever all backronym where I'll be

200
00:07:14,960 --> 00:07:12,840
you can just sort of see it over top

201
00:07:17,300 --> 00:07:14,970
there so it's the secondary Eclipse and

202
00:07:21,680 --> 00:07:17,310
phase of integrated booty temperature

203
00:07:22,970 --> 00:07:21,690
mapping just about works so spider-man

204
00:07:24,380 --> 00:07:22,980
is the base but I did get into a little

205
00:07:25,400 --> 00:07:24,390
bit of issues with the editor of the

206
00:07:27,409 --> 00:07:25,410
journal where they were worried that

207
00:07:29,930 --> 00:07:27,419
there might be a copyright claim for

208
00:07:31,550 --> 00:07:29,940
Marvel so far okay so my next project

209
00:07:33,170 --> 00:07:31,560
I'm looking now at transmission

210
00:07:34,850 --> 00:07:33,180
spectroscopy I should be a bit more

211
00:07:36,860 --> 00:07:34,860
careful with my name selection so I

212
00:07:40,310 --> 00:07:36,870
thought you know the dividing line

213
00:07:43,540 --> 00:07:40,320

between the light and dark that's that's

214
00:07:46,250 --> 00:07:43,550
a good start so that is the Terminator

215
00:07:47,870 --> 00:07:46,260
there's no way that anyone is going to

216
00:07:50,510 --> 00:07:47,880
get this confuse of any sort of cultural

217
00:07:52,600 --> 00:07:50,520
reference so I don't have to worry about

218
00:07:56,150 --> 00:07:52,610
getting in trouble

219
00:07:57,710 --> 00:07:56,160
anyway so yeah the basic outline of the

220
00:08:00,380 --> 00:07:57,720
code is it works in the same way that

221
00:08:02,779 --> 00:08:00,390
spider-man death which is an analytical

222
00:08:04,940 --> 00:08:02,789
with geometric integrate there so but it

223
00:08:08,150 --> 00:08:04,950
simply the planet that you're looking at

224
00:08:13,340 --> 00:08:08,160
is split out into a small mm-hmm into a

225
00:08:14,900 --> 00:08:13,350
small number of a segments and then you

226
00:08:18,080 --> 00:08:14,910
go through and you see as a function of

227
00:08:19,790 --> 00:08:18,090
time what portion of the segment is

228
00:08:21,500 --> 00:08:19,800
covered up by the star and you can

229
00:08:22,700 --> 00:08:21,510
calculate this exactly and analytically

230
00:08:24,050 --> 00:08:22,710
so it means you can make the code very

231
00:08:26,120 --> 00:08:24,060
fast which means that you can do

232
00:08:27,529 --> 00:08:26,130
retrievals with it so in this example in

233
00:08:30,140 --> 00:08:27,539
the top right K you see the planet is

234
00:08:32,089 --> 00:08:30,150
represented by this orange disc and the

235
00:08:34,579 --> 00:08:32,099
star is a blue disc and then in you've

236
00:08:36,740 --> 00:08:34,589
got these exact geometric shapes that I

237
00:08:40,130 --> 00:08:36,750
mark down between you can calculate the

238
00:08:42,829 --> 00:08:40,140

area's very quickly so in terminator you

239
00:08:44,089 --> 00:08:42,839
can you can set up the phlume

240
00:08:46,460 --> 00:08:44,099
architecture however you like

241
00:08:48,850 --> 00:08:46,470
so here i have an example of jupiter

242
00:08:51,170 --> 00:08:48,860
where i've split up so you have these

243
00:08:51,570 --> 00:08:51,180
enhanced velocity regions around the

244
00:08:53,730 --> 00:08:51,580
attack

245
00:08:56,910 --> 00:08:53,740
toriel yet and then the rest of the

246
00:08:58,860 --> 00:08:56,920
planet is represented by two polar

247
00:09:00,180 --> 00:08:58,870
regions so you can set up however you

248
00:09:01,860 --> 00:09:00,190
like and you can put different velocity

249
00:09:05,220 --> 00:09:01,870
fields in these sections for broadening

250
00:09:07,470 --> 00:09:05,230
the via the transmission spectrum how do

251
00:09:09,540 --> 00:09:07,480
you like of course you've got to worry

252
00:09:12,510 --> 00:09:09,550
about the star so the limb darken has to

253
00:09:14,280 --> 00:09:12,520
be taken into account so I have a I have

254
00:09:17,240 --> 00:09:14,290
a full stellar model underneath that the

255
00:09:20,130 --> 00:09:17,250
transit spectrum so you can correctly

256
00:09:21,360 --> 00:09:20,140
calculate the effects of the star this

257
00:09:23,130 --> 00:09:21,370
also means that you take into account

258
00:09:25,680 --> 00:09:23,140
things like the center to limb variation

259
00:09:30,120 --> 00:09:25,690
in stellar lines so you have this issue

260
00:09:32,550 --> 00:09:30,130
where where the trans musician where the

261
00:09:34,590 --> 00:09:32,560
limb darkening changes as you go through

262
00:09:35,490 --> 00:09:34,600
a spectral line so the limb darkening in

263
00:09:36,750 --> 00:09:35,500

the middle of the spectral line is

264
00:09:39,600 --> 00:09:36,760
different to the limb darkening outside

265
00:09:41,520 --> 00:09:39,610
the spectral line so if you have a if

266
00:09:43,230 --> 00:09:41,530
you have a planet moving with a

267
00:09:45,390 --> 00:09:43,240
differential velocity and it goes

268
00:09:46,890 --> 00:09:45,400
basically the limb darkening that it's

269
00:09:48,300 --> 00:09:46,900
experiencing changes as a function of

270
00:09:50,760 --> 00:09:48,310
time so you have to take that into

271
00:09:52,500 --> 00:09:50,770
account and it looks people to go the

272
00:09:54,060 --> 00:09:52,510
rest of McLoughlin effect so the star

273
00:09:57,360 --> 00:09:54,070
enemy has a velocity field have had it

274
00:09:59,790 --> 00:09:57,370
as well so people all this together I've

275
00:10:02,790 --> 00:09:59,800
got a short movie here you can see the

276
00:10:05,490 --> 00:10:02,800
planet moving in both the input velocity

277
00:10:07,260 --> 00:10:05,500
and flux space and any moment now as it

278
00:10:08,790 --> 00:10:07,270
comes in front of the star you can see

279
00:10:10,770 --> 00:10:08,800
the transmission spectrum on the bottom

280
00:10:13,050 --> 00:10:10,780
left starts to change and you'll start

281
00:10:15,630 --> 00:10:13,060
seeing the sodium feature come in and

282
00:10:17,190 --> 00:10:15,640
then on the VG gets deeper you've got a

283
00:10:18,180 --> 00:10:17,200
contamination from the star and also

284
00:10:20,580 --> 00:10:18,190
from the planet's atmosphere in this

285
00:10:22,890 --> 00:10:20,590
example and then on the right is just a

286
00:10:24,690 --> 00:10:22,900
trail plot so it's showing this in two

287
00:10:27,030 --> 00:10:24,700
dimensions so time is moving from top to

288
00:10:29,580 --> 00:10:27,040

bottom so all these effects are taken

289
00:10:33,150 --> 00:10:29,590
into account in the model so I went back

290
00:10:34,650 --> 00:10:33,160
and it worked by analyzing the same

291
00:10:36,510 --> 00:10:34,660
dataset that I did initially in my pilot

292
00:10:39,060 --> 00:10:36,520
study so hey do you wanna nice having

293
00:10:40,350 --> 00:10:39,070
proofread B again now this time all of

294
00:10:42,000 --> 00:10:40,360
the stellar effects are taking properly

295
00:10:44,130 --> 00:10:42,010
into account in ways that they weren't

296
00:10:45,270 --> 00:10:44,140
necessarily the first time around but I

297
00:10:48,060 --> 00:10:45,280
found that this did not significantly

298
00:10:49,920 --> 00:10:48,070
affect my results in this instance so

299
00:10:53,850 --> 00:10:49,930
the velocity stayed pretty similar to

300
00:10:56,430 --> 00:10:53,860
what I reported before so there's a blue

301
00:10:59,220 --> 00:10:56,440
shift coming towards you from the from

302
00:11:01,560 --> 00:10:59,230
the days from the west side and a red

303
00:11:03,390 --> 00:11:01,570
shift moving away on the eastern side so

304
00:11:05,040 --> 00:11:03,400
that's all the same and I'll be

305
00:11:07,140 --> 00:11:05,050
reporting with you

306
00:11:09,570 --> 00:11:07,150
and then I moved on and I want to look

307
00:11:10,770 --> 00:11:09,580
at another planet and I wanted to try

308
00:11:13,200 --> 00:11:10,780
something a bit different as well

309
00:11:14,790 --> 00:11:13,210
so what's 49 B is another good testbed

310
00:11:17,520 --> 00:11:14,800
scenario because it's a but this

311
00:11:19,380 --> 00:11:17,530
enormous extremely deep sodium signal so

312
00:11:21,180 --> 00:11:19,390
I've putted it to scale the bottom left

313
00:11:22,470 --> 00:11:21,190

there you can see the atmosphere which

314
00:11:24,630 --> 00:11:22,480
is highlighted in red and blue for the

315
00:11:26,340 --> 00:11:24,640
velocity field if the radius of the

316
00:11:28,470 --> 00:11:26,350
atmosphere is as big as the radius of

317
00:11:30,090 --> 00:11:28,480
the planet itself so this is an enormous

318
00:11:32,370 --> 00:11:30,100
more like an exosphere really been

319
00:11:35,280 --> 00:11:32,380
announced there so there's this huge big

320
00:11:38,820 --> 00:11:35,290
feature which was reporting wooden back

321
00:11:41,010 --> 00:11:38,830
adele 2017 and so is it possible to not

322
00:11:42,750 --> 00:11:41,020
only separate out the equatorial jet but

323
00:11:45,000 --> 00:11:42,760
also to separate out and get another

324
00:11:46,980 --> 00:11:45,010
sore point in your spatial resolution

325
00:11:50,070 --> 00:11:46,990
and separate out the polar regions from

326
00:11:52,320 --> 00:11:50,080
the equatorial regions so I updated my

327
00:11:54,570 --> 00:11:52,330
model a little bit and so I've now got

328
00:11:57,360 --> 00:11:54,580
three velocities so there's a velocity

329
00:11:58,680 --> 00:11:57,370
for the trailing and leading equatorial

330
00:12:00,720 --> 00:11:58,690
regions of the planet and then a

331
00:12:03,120 --> 00:12:00,730
singular polar velocity which is for the

332
00:12:04,560 --> 00:12:03,130
North and South Poles and I applied this

333
00:12:06,560 --> 00:12:04,570
to the model and I did a Bayesian

334
00:12:08,760 --> 00:12:06,570
retrieval and I found that you get a

335
00:12:10,950 --> 00:12:08,770
significantly improved bit I'm having

336
00:12:12,720 --> 00:12:10,960
this velocity component so now I find

337
00:12:14,310 --> 00:12:12,730
that there in this case there's a

338
00:12:16,050 --> 00:12:14,320

trailing and leading velocity for this

339
00:12:17,700 --> 00:12:16,060
planet of both about four kilometers per

340
00:12:19,500 --> 00:12:17,710
second so moving the way in towards you

341
00:12:22,230 --> 00:12:19,510
you also get this separate blue-shifted

342
00:12:24,000 --> 00:12:22,240
polar region moving towards you at one

343
00:12:25,410 --> 00:12:24,010
kilometer per second and if you remember

344
00:12:26,760 --> 00:12:25,420
back to the beginning where I showed

345
00:12:28,320 --> 00:12:26,770
those plots from the theory papers

346
00:12:29,760 --> 00:12:28,330
that's pretty much exactly what was

347
00:12:32,400 --> 00:12:29,770
expected was that you would have this

348
00:12:34,020 --> 00:12:32,410
polar flow which come which ends up

349
00:12:36,140 --> 00:12:34,030
together with the actual Jets to get

350
00:12:39,600 --> 00:12:36,150
there the full signal together full

351
00:12:41,070 --> 00:12:39,610
velocity space as a function of time so

352
00:12:43,830 --> 00:12:41,080
you can see that it's the model as well

353
00:12:46,650 --> 00:12:43,840
and the bottom left there this is just a

354
00:12:48,600 --> 00:12:46,660
single frame so there are there are 40

355
00:12:50,700 --> 00:12:48,610
individual exposures over three nights

356
00:12:52,620 --> 00:12:50,710
and this data set and you can see that

357
00:12:54,900 --> 00:12:52,630
the sodium signal is visible and well

358
00:12:56,700 --> 00:12:54,910
fitted in in just one of these 40 frames

359
00:12:58,800 --> 00:12:56,710
igg measurement imagine the amount of

360
00:13:00,660 --> 00:12:58,810
extra day to be effectively from doing

361
00:13:04,050 --> 00:13:00,670
this 40 times and that's whether the

362
00:13:05,460 --> 00:13:04,060
power of this fit comes from so to put

363
00:13:08,160 --> 00:13:05,470

this in context I just want to pipe burn

364
00:13:10,080 --> 00:13:08,170
a nice pot from : commissary 2018 so

365
00:13:12,180 --> 00:13:10,090
this is a lot where I want to add more

366
00:13:15,330 --> 00:13:12,190
points to effectively because it's a

367
00:13:17,430 --> 00:13:15,340
it's looking at how the expected

368
00:13:18,689 --> 00:13:17,440
velocity of dekotora changes as a

369
00:13:20,850 --> 00:13:18,699
function of

370
00:13:22,679 --> 00:13:20,860
different drank mechanisms so this is

371
00:13:25,889 --> 00:13:22,689
what Emily was talking about how the the

372
00:13:28,799 --> 00:13:25,899
drag is affecting the velocity VC and

373
00:13:31,889 --> 00:13:28,809
that affects both the offset of hot

374
00:13:34,109 --> 00:13:31,899
spots but also the the boss T's that I

375
00:13:36,090 --> 00:13:34,119
can measure and so I see that in this

376
00:13:38,340 --> 00:13:36,100
case I Cornwall sporty freebie now is a

377
00:13:41,699 --> 00:13:38,350
yellow point and the other two points

378
00:13:44,789 --> 00:13:41,709
are 39 and 189 so that 189 is the one

379
00:13:46,410 --> 00:13:44,799
that I measured earlier so that's only

380
00:13:48,900 --> 00:13:46,420
three points here now I want to add a

381
00:13:50,729 --> 00:13:48,910
few more and that should be able to

382
00:13:52,710 --> 00:13:50,739
really is you imagine putting in more

383
00:13:54,239 --> 00:13:52,720
planets in different different regions

384
00:13:56,160 --> 00:13:54,249
of the parameter space they're going to

385
00:13:57,989 --> 00:13:56,170
be able to distinguish between the shear

386
00:14:00,329 --> 00:13:57,999
and instability model and the magnetars

387
00:14:01,650 --> 00:14:00,339
and the magnetic drag model so this will

388
00:14:03,629 --> 00:14:01,660

really allow you to look at different

389
00:14:06,689 --> 00:14:03,639
physical mechanisms for a dragon next

390
00:14:08,489 --> 00:14:06,699
one atmospheres and finally I just

391
00:14:11,939 --> 00:14:08,499
wanted to do a little advertisement for

392
00:14:13,769 --> 00:14:11,949
Diana so Donna Powell is leading a

393
00:14:14,789 --> 00:14:13,779
project which I've been working on with

394
00:14:18,139 --> 00:14:14,799
her recently

395
00:14:20,699 --> 00:14:18,149
so there's actually this really nice

396
00:14:23,159 --> 00:14:20,709
cloud model farik's of Planet search is

397
00:14:25,319 --> 00:14:23,169
a full micro physical model and she's

398
00:14:28,350 --> 00:14:25,329
done she's resolved around the limb of

399
00:14:29,879 --> 00:14:28,360
the planet their different cloud the

400
00:14:31,710 --> 00:14:29,889
different cloud covering fractions you

401
00:14:32,850 --> 00:14:31,720
get there's a function of Lingle so

402
00:14:36,059 --> 00:14:32,860
you've got this inhomogeneous kiled

403
00:14:38,460 --> 00:14:36,069
model and what I want you to this is to

404
00:14:40,949 --> 00:14:38,470
show how this signal would actually be

405
00:14:44,369 --> 00:14:40,959
observable as a function of time in a

406
00:14:45,840 --> 00:14:44,379
JWT transit so you can use Terminator to

407
00:14:47,189 --> 00:14:45,850
put different amounts of clouds on the

408
00:14:50,669 --> 00:14:47,199
two different sides of the planet coming

409
00:14:53,249 --> 00:14:50,679
from the model and then that if you're a

410
00:14:55,309 --> 00:14:53,259
time variable signal in a JWST transit

411
00:14:57,419 --> 00:14:55,319
which would lie to constantly detect

412
00:14:59,400 --> 00:14:57,429
inhomogeneous clouds but you want to

413
00:15:01,829 --> 00:14:59,410

talk about that more then go speak to

414
00:15:03,509 --> 00:15:01,839
Diana she's got a poster up today or is

415
00:15:05,489 --> 00:15:03,519
it two or is it the next session

416
00:15:07,979 --> 00:15:05,499
tomorrow it'll be up at some point so go

417
00:15:09,569 --> 00:15:07,989
chat to her about this so yeah I will

418
00:15:11,069 --> 00:15:09,579
just leave my conclusions up on the

419
00:15:19,229 --> 00:15:11,079
screen and I'll finish there so thank

420
00:15:25,119 --> 00:15:23,199
thanks so much Tom it's very amazing so

421
00:15:27,460 --> 00:15:25,129
I'm looking at the room for a lot of

422
00:15:32,859 --> 00:15:27,470
funds to raise please raise your hand if

423
00:15:39,129 --> 00:15:32,869
you want to ask questions okay okay show

424
00:15:40,449 --> 00:15:39,139
me share so for what 49 what is the

425
00:15:41,969 --> 00:15:40,459
pressure of the room that you're

426
00:15:45,609 --> 00:15:41,979
measuring do you have an idea of

427
00:15:48,069 --> 00:15:45,619
pressure linen it's gonna be lowered and

428
00:15:51,069 --> 00:15:48,079
or below the Milly bar it's it's it's

429
00:15:54,539 --> 00:15:51,079
way up in this exosphere so I yeah I

430
00:15:59,619 --> 00:15:54,549
don't have an exact Sager phase very low

431
00:16:02,019 --> 00:15:59,629
anymore so please don't forget to tell

432
00:16:04,479 --> 00:16:02,029
your name is the institution before

433
00:16:06,369 --> 00:16:04,489
asking a question Adam Sherman

434
00:16:07,869 --> 00:16:06,379
University of Arizona this is a really

435
00:16:10,089 --> 00:16:07,879
interesting I was curious to ask about

436
00:16:11,679 --> 00:16:10,099
data sets I Mazar recollect from your

437
00:16:13,479 --> 00:16:11,689
paper a few years ago you used harps and

438
00:16:14,679 --> 00:16:13,489

were looking at the sodium d-line and I

439
00:16:17,769 --> 00:16:14,689
was just curious to get your take on

440
00:16:20,619 --> 00:16:17,779
that versus like the cry res like really

441
00:16:23,109 --> 00:16:20,629
you know sort of near-infrared and then

442
00:16:24,639 --> 00:16:23,119
I guess also you didn't use cross

443
00:16:26,469 --> 00:16:24,649
correlation just because you're the line

444
00:16:29,799 --> 00:16:26,479
is so huge and committee users comment

445
00:16:32,289 --> 00:16:29,809
on that issue as well yeah that's one of

446
00:16:35,199 --> 00:16:32,299
them one of the advantages of working in

447
00:16:37,419 --> 00:16:35,209
the optical with with the sodium line is

448
00:16:38,649 --> 00:16:37,429
it's a very deep singular line you don't

449
00:16:41,589 --> 00:16:38,659
have to use cross correlation for

450
00:16:43,629 --> 00:16:41,599
unnecessarily and telluric contamination

451
00:16:45,189 --> 00:16:43,639
isn't as bad and isn't in the air

452
00:16:46,509 --> 00:16:45,199
infrared so there's there's a lot of

453
00:16:48,099 --> 00:16:46,519
things which should help you when

454
00:16:49,719 --> 00:16:48,109
looking at this one specific line and

455
00:16:51,639 --> 00:16:49,729
there's definitely possible to do in the

456
00:16:53,769 --> 00:16:51,649
infrared as well so I mean is your take

457
00:16:54,759 --> 00:16:53,779
that is there a preference of one versus

458
00:16:56,619 --> 00:16:54,769
the other or does it depend on the

459
00:16:58,389 --> 00:16:56,629
system or like how would you kind of

460
00:17:01,929 --> 00:16:58,399
judge that I would say it probably does

461
00:17:03,309 --> 00:17:01,939
depend some extent on the system the in

462
00:17:04,449 --> 00:17:03,319
some ways it is easier to use optical

463
00:17:07,749 --> 00:17:04,459

right now all the instruments we have

464
00:17:09,879 --> 00:17:07,759
it's not there's nothing stopping it

465
00:17:12,879 --> 00:17:09,889
being done in red it's something I'm

466
00:17:16,659 --> 00:17:12,889
looking in thank you

467
00:17:20,649 --> 00:17:16,669
any more questions because to and then I

468
00:17:23,139 --> 00:17:20,659
think we're gonna be done I just have a

469
00:17:24,970 --> 00:17:23,149
small question what's the lower limit of

470
00:17:26,799 --> 00:17:24,980
the wind speed that can be detected

471
00:17:27,730 --> 00:17:26,809
using these techniques

472
00:17:29,770 --> 00:17:27,740
what

473
00:17:31,740 --> 00:17:29,780
limits on a lower limit of the wind

474
00:17:35,560 --> 00:17:31,750
speed on the planet

475
00:17:37,570 --> 00:17:35,570
they said the arrow bars and I'm getting

476
00:17:39,310 --> 00:17:37,580
so it's probably probably about you

477
00:17:41,560 --> 00:17:39,320
could confidently detect sound to about

478
00:17:43,360 --> 00:17:41,570
a kilometer per second really any any

479
00:17:44,590 --> 00:17:43,370
lower than that and that that's pretty

480
00:17:46,660 --> 00:17:44,600
much the limit with the error bars I

481
00:17:48,310 --> 00:17:46,670
currently have but with with large

482
00:17:48,700 --> 00:17:48,320
telescopes new instrumentation to do

483
00:17:50,380 --> 00:17:48,710
that better

484
00:17:52,510 --> 00:17:50,390
so the LT you could go a bit lower

485
00:17:59,669 --> 00:17:52,520
expecting so with Part C how about me to

486
00:18:04,390 --> 00:18:02,500
Erica s University of Hawaii I guess for

487
00:18:07,870 --> 00:18:04,400
was forty nine be sort of continuing on

488
00:18:11,830 --> 00:18:07,880

the Adams query or I sure I think it was

489
00:18:15,610 --> 00:18:11,840
Michelle do we actually expect

490
00:18:17,830 --> 00:18:15,620
equatorial flow to continue up to the

491
00:18:21,010 --> 00:18:17,840
level where we see these extended

492
00:18:23,260 --> 00:18:21,020
atmospheres I am a little surprised yeah

493
00:18:25,750 --> 00:18:23,270
actually the flow structure is preserved

494
00:18:28,480 --> 00:18:25,760
at that level and then you can punt it

495
00:18:32,980 --> 00:18:28,490
that's I honestly I have the same

496
00:18:34,360 --> 00:18:32,990
question I don't know why this level in

497
00:18:36,040 --> 00:18:34,370
NamUs where I'm actually not sure what

498
00:18:42,260 --> 00:18:36,050
is expected but that's what I've