Ryan Felton

Study of Barnard's Star B as an Analog for Titan-like Exoplanets

1
00:00:00,240 --> 00:00:10,839
[Music]

2
00:00:16,760 --> 00:00:14,509
my title will changed a little bit and I

3
00:00:19,790 --> 00:00:16,770
will be talking about partner to star as

4
00:00:21,860 --> 00:00:19,800
an analog for Titan like exoplanets so

5
00:00:24,320 --> 00:00:21,870
I'm Ryan fault I'm a graduate student at

6
00:00:26,060 --> 00:00:24,330
Catholic University in DC and I do my

7
00:00:28,820 --> 00:00:26,070
research on NASA Goddard Space Flight

8
00:00:31,010 --> 00:00:28,830
Center in Maryland and I first want to

9
00:00:32,779 --> 00:00:31,020
lay out some ground lay out some reasons

10
00:00:35,090 --> 00:00:32,789
for why we should care about Titan in

11
00:00:37,490 --> 00:00:35,100
the regards to this search for life

12
00:00:39,860 --> 00:00:37,500
so as of that we have about 4,000 exit

13
00:00:42,410 --> 00:00:39,870

plants that we've detected it has and

14
00:00:45,549 --> 00:00:42,420
since we believe every star has at least

15
00:00:50,270 --> 00:00:45,559
one planet that means as telescope

16
00:00:53,419 --> 00:00:50,280
capabilities and mere size increase over

17
00:00:55,549 --> 00:00:53,429
the next year's and decades then the

18
00:00:57,410 --> 00:00:55,559
number of planets we have number of

19
00:00:59,829 --> 00:00:57,420
exoplanets that we have available to us

20
00:01:03,169 --> 00:00:59,839
to study this is going to expand

21
00:01:06,860 --> 00:01:03,179
exponentially and Titan with this very

22
00:01:10,520 --> 00:01:06,870
rates organic atmosphere and probably

23
00:01:12,560 --> 00:01:10,530
lifeless planet or lifeless moon means

24
00:01:15,140 --> 00:01:12,570
that we can use this to study and

25
00:01:16,670 --> 00:01:15,150
compare against exoplanets we find in

26
00:01:18,260 --> 00:01:16,680
future we're trying to look for that

27
00:01:22,040 --> 00:01:18,270
earth 2.0 essentially we're going to

28
00:01:25,340 --> 00:01:22,050
need to separate the lifeless from the

29
00:01:28,100 --> 00:01:25,350
life bearing or habitable once and Titan

30
00:01:30,530 --> 00:01:28,110
is a perfect place to find out more

31
00:01:32,210 --> 00:01:30,540
about what those extra plants may look

32
00:01:34,070 --> 00:01:32,220
like so if we see something that looks

33
00:01:35,900 --> 00:01:34,080
like a tight like EXO plant we can

34
00:01:38,870 --> 00:01:35,910
potentially remove it from this whole

35
00:01:41,210 --> 00:01:38,880
huge catalog of exoplanets and in the

36
00:01:43,670 --> 00:01:41,220
same vein learning about Titan can also

37
00:01:45,920 --> 00:01:43,680
tell us more about our own planets

38
00:01:48,860 --> 00:01:45,930

history specifically the prebiotic

39
00:01:50,840 --> 00:01:48,870
period of Earth in the same way that are

40
00:01:53,450 --> 00:01:50,850
learning about the prebiotic earth than

41
00:01:55,880 --> 00:01:53,460
any potential prebiotic type plants we

42
00:01:58,370 --> 00:01:55,890
find that at rocky potentially Earth's

43
00:02:00,920 --> 00:01:58,380
size we can also filter out from that

44
00:02:06,440 --> 00:02:00,930
huge catalogue while looking for earth

45
00:02:07,490 --> 00:02:06,450
2.0 background for Earth and Titan just

46
00:02:09,410 --> 00:02:07,500
can't get you from all right though

47
00:02:10,279 --> 00:02:09,420
you've already seen some Titan stuff in

48
00:02:12,390 --> 00:02:10,289
the previous talks

49
00:02:14,819 --> 00:02:12,400
the big takeaway once you

50
00:02:17,039 --> 00:02:14,829
to get from this is on earth we have

51
00:02:19,710 --> 00:02:17,049
liquid water and tiny we have liquid

52
00:02:22,020 --> 00:02:19,720
methane it's so cold that the methane is

53
00:02:24,569 --> 00:02:22,030
actually condensing and falling out of

54
00:02:25,830 --> 00:02:24,579
that Monsieur and then of course on

55
00:02:26,580 --> 00:02:25,840
earth we have dragons and Game of

56
00:02:29,250 --> 00:02:26,590
Thrones

57
00:02:32,179 --> 00:02:29,260
on Titan we have dragon fly the

58
00:02:35,300 --> 00:02:32,189
gyrocopter that's going to be allah

59
00:02:38,160 --> 00:02:35,310
going in about 2026

60
00:02:42,349 --> 00:02:38,170
and so are there any titan like extra

61
00:02:44,729 --> 00:02:42,359
planets out there well last year

62
00:02:47,479 --> 00:02:44,739
detectives were done for barnard star

63
00:02:51,449 --> 00:02:47,489

this is a system about six letters away

64
00:02:53,699 --> 00:02:51,459
and radio velocity detections showed

65
00:02:56,629 --> 00:02:53,709
evidence for a candidate planet called

66
00:02:59,129 --> 00:02:56,639
Barnard star B so the radio velocity

67
00:03:02,009 --> 00:02:59,139
detection method is simply if you have a

68
00:03:04,319 --> 00:03:02,019
star by itself it's got to rotate around

69
00:03:06,569 --> 00:03:04,329
its own set of bastards who are you be

70
00:03:08,069 --> 00:03:06,579
right down to taxes once you add in a

71
00:03:10,589 --> 00:03:08,079
plan there are a number of planets the

72
00:03:12,179 --> 00:03:10,599
center of mass is going to shift and so

73
00:03:15,479 --> 00:03:12,189
then the star will actually orbit that

74
00:03:19,140 --> 00:03:15,489
center of mass and as it shifts based on

75
00:03:21,569 --> 00:03:19,150
the geometry of the observer you're

76
00:03:23,729 --> 00:03:21,579
gonna have to start moving away and

77
00:03:25,349 --> 00:03:23,739
towards you causing a Doppler shift and

78
00:03:28,800 --> 00:03:25,359
from that Doppler shift you can actually

79
00:03:29,939 --> 00:03:28,810
pick out a planet and many exoplanets

80
00:03:31,349 --> 00:03:29,949
that we've already discovered where

81
00:03:34,589 --> 00:03:31,359
actually you've found this way this is

82
00:03:37,619 --> 00:03:34,599
one of the top ways so back to Barnard

83
00:03:39,720 --> 00:03:37,629
surbhi this is about 0.14 you from it's

84
00:03:42,030 --> 00:03:39,730
so star and that may sound pretty close

85
00:03:44,699 --> 00:03:42,040
concern we're one at you from a cheat

86
00:03:46,319 --> 00:03:44,709
class barnyard start Sam so that means

87
00:03:49,199 --> 00:03:46,329
it's going to be putting on less energy

88
00:03:51,539 --> 00:03:49,209

and so you can be closer and it still be

89
00:03:53,729 --> 00:03:51,549
pretty cold and that's one of the

90
00:03:55,649 --> 00:03:53,739
reasons we believe this may be a Titan

91
00:03:57,990 --> 00:03:55,659
like exoplanet because even though it's

92
00:04:00,869 --> 00:03:58,000
zero point for you away from its star

93
00:04:05,520 --> 00:04:00,879
it's so far enough away that is probably

94
00:04:06,990 --> 00:04:05,530
along this snow life and so that led our

95
00:04:09,360 --> 00:04:07,000
group to ask well could we actually

96
00:04:11,369 --> 00:04:09,370
image to this with a big Space Telescope

97
00:04:13,860 --> 00:04:11,379
and I'm now just going to go through the

98
00:04:17,219 --> 00:04:13,870
process that we did to answer that

99
00:04:20,159 --> 00:04:17,229
question so first off you're gonna need

100
00:04:22,650 --> 00:04:20,169
a big telescope specifically something

101
00:04:24,930 --> 00:04:22,660
on the range of probably fifteen meters

102
00:04:27,030 --> 00:04:24,940
so this is Lavar it's the large role for

103
00:04:30,960 --> 00:04:27,040
violent optical infrared telescope

104
00:04:33,360 --> 00:04:30,970
it's an astro 20:22 cable survey design

105
00:04:35,820 --> 00:04:33,370
concept so this has not been prioritized

106
00:04:37,650 --> 00:04:35,830
or anything like that if anything when

107
00:04:39,300 --> 00:04:37,660
it does if it is prioritized and

108
00:04:42,960 --> 00:04:39,310
launched it wouldn't launched until

109
00:04:45,690 --> 00:04:42,970
about 2040 but as I said it's a 15 meter

110
00:04:48,840 --> 00:04:45,700
this is louver RA there's also louver be

111
00:04:51,810 --> 00:04:48,850
version which is a 9 meter and here's

112
00:04:54,450 --> 00:04:51,820
this a size reference to so you can see

113
00:04:58,950 --> 00:04:54,460

you've had Hubble James weapon before so

114
00:05:01,200 --> 00:04:58,960
it's a pretty big telescope now looper

115
00:05:03,240 --> 00:05:01,210
has a whole slew of instruments on it

116
00:05:05,100 --> 00:05:03,250
one of them being Eclipse this is its

117
00:05:08,130 --> 00:05:05,110
coronagraph indirect imaging instrument

118
00:05:11,760 --> 00:05:08,140
and that's what will allow you to

119
00:05:15,810 --> 00:05:11,770
actually directly image the planet and

120
00:05:18,270 --> 00:05:15,820
this image here in the bottom left is an

121
00:05:21,480 --> 00:05:18,280
actual simulation of blue who are

122
00:05:23,580 --> 00:05:21,490
looking at our solar system 13 per

123
00:05:25,530 --> 00:05:23,590
second away and sure enough you can see

124
00:05:26,850 --> 00:05:25,540
your earth you can see earth Venus and

125
00:05:28,860 --> 00:05:26,860
Jupiter right there so that's where

126
00:05:30,360 --> 00:05:28,870
you're actually directly imaging you can

127
00:05:32,250 --> 00:05:30,370
see it where the coronagraph that's

128
00:05:36,000 --> 00:05:32,260
blocked out the light and you can see

129
00:05:39,570 --> 00:05:36,010
the planets so idea was then to take

130
00:05:41,700 --> 00:05:39,580
these tools and parameters and apply

131
00:05:43,920 --> 00:05:41,710
them to a web interface called the

132
00:05:47,550 --> 00:05:43,930
planetary spectrum generator this is a

133
00:05:49,650 --> 00:05:47,560
synthetic spectra simulator it's created

134
00:05:51,180 --> 00:05:49,660
by Geronimo Villanova if you want to

135
00:05:53,130 --> 00:05:51,190
check the website you can actually go to

136
00:05:57,090 --> 00:05:53,140
the link right now or write it down and

137
00:05:58,800 --> 00:05:57,100
check out later just psg and it gives

138
00:06:00,540 --> 00:05:58,810

you a whole slew of templates that you

139
00:06:03,120 --> 00:06:00,550
can pick from these are Planet templates

140
00:06:04,380 --> 00:06:03,130
and you can go in and edit them play

141
00:06:06,120 --> 00:06:04,390
around with them you can even create

142
00:06:09,300 --> 00:06:06,130
your own and load them up and run them

143
00:06:10,440 --> 00:06:09,310
to create your spectra if you can do

144
00:06:12,320 --> 00:06:10,450
things like play around with the

145
00:06:14,340 --> 00:06:12,330
geometry these are just some screenshots

146
00:06:16,860 --> 00:06:14,350
where you can

147
00:06:20,880 --> 00:06:16,870
you've got target challenging that you

148
00:06:22,950 --> 00:06:20,890
can adjust you can also mess around with

149
00:06:24,780 --> 00:06:22,960
atmospheric profiles so on the left this

150
00:06:26,790 --> 00:06:24,790
is just a pressure temperature profile

151
00:06:28,710 --> 00:06:26,800
for a random template that I took a

152
00:06:33,030 --> 00:06:28,720
screenshot of and then on the right

153
00:06:35,239 --> 00:06:33,040
you've got the altitude or pressure

154
00:06:37,409 --> 00:06:35,249
verse the abundance

155
00:06:39,929 --> 00:06:37,419
and in this one you can see there's a

156
00:06:41,700 --> 00:06:39,939
whole slew of gases that were put in

157
00:06:43,649 --> 00:06:41,710
there and you can remove these you can

158
00:06:47,279 --> 00:06:43,659
add them you can change the profile

159
00:06:50,429 --> 00:06:47,289
shape anything you want and so what we

160
00:06:52,589 --> 00:06:50,439
did was make a very simplified Titan was

161
00:06:55,019 --> 00:06:52,599
just nitrogen and methane as we saw it

162
00:06:58,019 --> 00:06:55,029
earlier toxicities remain the main

163
00:07:00,119 --> 00:06:58,029

pieces of Titan's atmosphere and we

164
00:07:02,279 --> 00:07:00,129
needed to validate the template we

165
00:07:04,140 --> 00:07:02,289
created first before we moved on to

166
00:07:06,420 --> 00:07:04,150
barnard star and so we took

167
00:07:08,850 --> 00:07:06,430
observational data from back in the 90s

168
00:07:10,159 --> 00:07:08,860
with a ground-based and then this

169
00:07:13,829 --> 00:07:10,169
century with the cassini-huygens mission

170
00:07:17,999 --> 00:07:13,839
and collected that day together and

171
00:07:21,329 --> 00:07:18,009
compared it against our spectra and

172
00:07:24,360 --> 00:07:21,339
these are the first results so this is a

173
00:07:25,860 --> 00:07:24,370
reflectance spectrum plot on the y-axis

174
00:07:27,719 --> 00:07:25,870
you've got that beat oh you can think

175
00:07:29,879 --> 00:07:27,729
this just is the shininess this is the

176
00:07:32,100 --> 00:07:29,889
light reflecting off of the planet and

177
00:07:34,110 --> 00:07:32,110
then the x-axis is just the wavelength

178
00:07:38,909 --> 00:07:34,120
is the light at whatever weights like

179
00:07:40,889 --> 00:07:38,919
you're talking about and we have the PSG

180
00:07:43,679 --> 00:07:40,899
or the planetary spectrum data in blue

181
00:07:47,040 --> 00:07:43,689
and then a combination of the ground and

182
00:07:48,990 --> 00:07:47,050
space-based in orange and then you can

183
00:07:50,909 --> 00:07:49,000
see the methane spikes here these are

184
00:07:52,740 --> 00:07:50,919
also thought it says the methane windows

185
00:07:55,740 --> 00:07:52,750
you can actually see down into Titan

186
00:07:59,369 --> 00:07:55,750
surface through these and it matches

187
00:08:01,290 --> 00:07:59,379
fairly well and another validation we

188
00:08:03,629 --> 00:08:01,300

did was look at the transit so ty

189
00:08:06,869 --> 00:08:03,639
Robinson took some of the transit some

190
00:08:08,429 --> 00:08:06,879
of the Titan data and analyzed that a

191
00:08:11,459 --> 00:08:08,439
point where Titan was actually passed

192
00:08:13,920 --> 00:08:11,469
between Cassini and the Sun so that

193
00:08:15,779 --> 00:08:13,930
meant the sun's Starlight was passing

194
00:08:17,730 --> 00:08:15,789
through Titan atmosphere and you could

195
00:08:19,920 --> 00:08:17,740
read it as though you agree is transit

196
00:08:23,010 --> 00:08:19,930
and that's what you did here same thing

197
00:08:26,999 --> 00:08:23,020
we set it up and plotted our data

198
00:08:28,829 --> 00:08:27,009
against some of Ty's observations now

199
00:08:30,029 --> 00:08:28,839
there are a few places where it's a

200
00:08:31,950 --> 00:08:30,039
little off and I wanted to first

201
00:08:32,939 --> 00:08:31,960
disappoint those out before we move on

202
00:08:35,519 --> 00:08:32,949
to the next part

203
00:08:38,850 --> 00:08:35,529
so around three microns there is this

204
00:08:42,000 --> 00:08:38,860
region where the PSG spikes but there's

205
00:08:43,740 --> 00:08:42,010
no spike in actual data and we believe

206
00:08:45,800 --> 00:08:43,750
that that's just due to missing ammonia

207
00:08:49,079 --> 00:08:45,810
and ethane the idea is that those

208
00:08:52,350 --> 00:08:49,089
species were added to our profile then

209
00:08:55,199 --> 00:08:52,360
this spike would drop back down and then

210
00:08:57,689 --> 00:08:55,209
in another region around 1 micron you

211
00:09:01,319 --> 00:08:57,699
can see here where the amplitude of some

212
00:09:02,970 --> 00:09:01,329
of the peaks don't match and we believe

213
00:09:04,500 --> 00:09:02,980

that's actually due to missing high

214
00:09:07,079 --> 00:09:04,510
train data high transduce high

215
00:09:10,829 --> 00:09:07,089
resolution transmission molecular

216
00:09:14,300 --> 00:09:10,839
database this is a database of observed

217
00:09:17,699 --> 00:09:14,310
and calculated quantum mechanical and

218
00:09:20,429 --> 00:09:17,709
solutions to these different molecules

219
00:09:22,949 --> 00:09:20,439
and it's used for radiative transfer

220
00:09:24,870 --> 00:09:22,959
codes usually so that is psg would get

221
00:09:27,960 --> 00:09:24,880
this data and use it when it does its

222
00:09:30,329 --> 00:09:27,970
radiative transfer calculations and sure

223
00:09:32,429 --> 00:09:30,339
enough you can see around 1 micron

224
00:09:34,559 --> 00:09:32,439
there's there's two black bands where

225
00:09:36,559 --> 00:09:34,569
there's no data and that matches very

226
00:09:38,880 --> 00:09:36,569
well with the peaks that had the

227
00:09:41,340 --> 00:09:38,890
different amplitudes in the previous

228
00:09:43,829 --> 00:09:41,350
plot so idea is if this count if this

229
00:09:45,840 --> 00:09:43,839
data was there those Peaks were matched

230
00:09:47,819 --> 00:09:45,850
now these quantum mechanical solutions

231
00:09:49,679 --> 00:09:47,829
are fairly hard to solve for certain

232
00:09:52,130 --> 00:09:49,689
species and at certain wavelengths is

233
00:09:55,160 --> 00:09:52,140
essentially this becomes incredibly

234
00:09:58,590 --> 00:09:55,170
computationally expensive to solve it so

235
00:10:04,050 --> 00:09:58,600
it's possible that we may not get these

236
00:10:05,699 --> 00:10:04,060
filled in anytime soon and so once we

237
00:10:07,590 --> 00:10:05,709
were comfortable with the Titan we had

238
00:10:10,259 --> 00:10:07,600

created we essentially just took it and

239
00:10:12,569 --> 00:10:10,269
moved it over to barnyard stars location

240
00:10:14,759 --> 00:10:12,579
or choose her star and put it where

241
00:10:17,100 --> 00:10:14,769
Barnard star B is and that's what I'm

242
00:10:20,100 --> 00:10:17,110
going to go through now so these are

243
00:10:22,800 --> 00:10:20,110
first initial results using a Titan like

244
00:10:24,840 --> 00:10:22,810
a Titan radius of about 2,500 kilometers

245
00:10:27,059 --> 00:10:24,850
it's the same type of chart before where

246
00:10:29,819 --> 00:10:27,069
you've got reflectance on the y axis and

247
00:10:30,809 --> 00:10:29,829
wavelength on the right and you've got

248
00:10:32,670 --> 00:10:30,819
your methane Peaks

249
00:10:35,100 --> 00:10:32,680
and then the vertical bars are the noise

250
00:10:37,759 --> 00:10:35,110
that's created by the PSG and then I've

251
00:10:42,090 --> 00:10:37,769
added a little bit of randomness to it

252
00:10:43,980 --> 00:10:42,100
and this block here this essentially

253
00:10:47,519 --> 00:10:43,990
says we think this is what loon for

254
00:10:49,470 --> 00:10:47,529
would be able to see so you get a little

255
00:10:52,769 --> 00:10:49,480
bit into the visible and some into the

256
00:10:55,230 --> 00:10:52,779
IR now what if you want to play around

257
00:10:56,980 --> 00:10:55,240
with the radius when you do really with

258
00:10:58,660 --> 00:10:56,990
the radial velocity technique

259
00:11:00,760 --> 00:10:58,670
you actually get a minimum mass and

260
00:11:03,400 --> 00:11:00,770
there's mass raid relations that have

261
00:11:06,160 --> 00:11:03,410
been developed by Y Z and Marcy there's

262
00:11:08,500 --> 00:11:06,170
a paper from 2014 that you could use for

263
00:11:10,350 --> 00:11:08,510

rocky terrestrial planets and so we

264
00:11:14,110 --> 00:11:10,360
applied that using the minimum mass

265
00:11:15,639 --> 00:11:14,120
calculated for Bardot to start B and got

266
00:11:17,440 --> 00:11:15,649
a radius of about eighty three hundred

267
00:11:19,870 --> 00:11:17,450
kilometers so now the radius has

268
00:11:21,519 --> 00:11:19,880
increased close to four times and sure

269
00:11:26,110 --> 00:11:21,529
enough you can see that the Norris bars

270
00:11:29,860 --> 00:11:26,120
drop drastically expanding our region of

271
00:11:35,620 --> 00:11:29,870
detectability well into then for red all

272
00:11:36,790 --> 00:11:35,630
of them this one now part of the UV and

273
00:11:38,680 --> 00:11:36,800
I just did the same thing again I

274
00:11:41,710 --> 00:11:38,690
increase the mass a little bit more and

275
00:11:43,690 --> 00:11:41,720
got ninety five hundred kilometers so it

276
00:11:45,460 --> 00:11:43,700
says the raises have gone up a little

277
00:11:48,760 --> 00:11:45,470
bit and the noise bars have dropped a

278
00:11:53,560 --> 00:11:48,770
little bit more and you still have about

279
00:11:56,079 --> 00:11:53,570
the same range so now we can go back to

280
00:11:59,560 --> 00:11:56,089
that question that I posed earlier

281
00:12:01,180 --> 00:11:59,570
finally whether we can image a big and

282
00:12:02,829 --> 00:12:01,190
whether we can image this plant with a

283
00:12:05,280 --> 00:12:02,839
big Space Telescope the answer is a

284
00:12:07,840 --> 00:12:05,290
resounding yes

285
00:12:10,150 --> 00:12:07,850
and really what I'd like you to walk

286
00:12:12,360 --> 00:12:10,160
away from this with if there's anything

287
00:12:14,470 --> 00:12:12,370
is that Titan like exoplanets are

288
00:12:17,470 --> 00:12:14,480

characterized well with big space

289
00:12:20,170 --> 00:12:17,480
telescopes and the next plans that we

290
00:12:23,530 --> 00:12:20,180
have for this are adding on more of the

291
00:12:25,240 --> 00:12:23,540
complex hydrocarbons to our profile to

292
00:12:28,000 --> 00:12:25,250
then increase the complexity of our

293
00:12:30,940 --> 00:12:28,010
spectra that we're generating and that

294
00:12:35,440 --> 00:12:30,950
we can see what other possible gases we

295
00:12:37,030 --> 00:12:35,450
can detect with Lubar this is our group

296
00:12:38,769 --> 00:12:37,040
back how much this women shout out and

297
00:12:40,949 --> 00:12:38,779
some of us start here in the crowd we're

298
00:12:44,170 --> 00:12:40,959
a whole mix of photochemical or modelers

299
00:12:46,600 --> 00:12:44,180
chemists space policy quantum mechanics

300
00:12:50,590 --> 00:12:46,610
we have people that do clouds so very

301
00:12:57,829 --> 00:12:50,600
diverse group and do you have any

302
00:13:02,550 --> 00:12:59,730
he's camp a good talk

303
00:13:09,920 --> 00:13:02,560
I was worried I was wearing the same we

304
00:13:15,540 --> 00:13:13,800
hi ReadyTalk I hate this is gonna sound

305
00:13:18,000 --> 00:13:15,550
like a dumb quiet all these ask please

306
00:13:20,880 --> 00:13:18,010
so it says so the blue wire does that

307
00:13:24,240 --> 00:13:20,890
use like the like a shield so it like

308
00:13:24,660 --> 00:13:24,250
blocks out so great right I can get back

309
00:13:37,020 --> 00:13:24,670
to it

310
00:13:44,670 --> 00:13:41,240
this is a shield to help block and then

311
00:13:46,650 --> 00:13:44,680
for blocking out the light from the

312
00:13:48,210 --> 00:13:46,660
starters that it would be looking at

313
00:13:52,320 --> 00:13:48,220

that would be using a coronagraph that's

314
00:13:54,870 --> 00:13:52,330
actually part of that's on the telescope

315
00:13:56,910 --> 00:13:54,880
itself there's also a possible idea of

316
00:13:59,730 --> 00:13:56,920
including the star shade who's here

317
00:14:01,260 --> 00:13:59,740
who's heard of star shade okay so that's

318
00:14:02,490 --> 00:14:01,270
another ideas you would have the star

319
00:14:06,360 --> 00:14:02,500
shade which would be a completely

320
00:14:09,420 --> 00:14:06,370
independent object or shade out in front

321
00:14:10,820 --> 00:14:09,430
of flew far and you know you stay in

322
00:14:14,850 --> 00:14:10,830
line with it while it's looking around

323
00:14:25,010 --> 00:14:14,860
but this at houses does not include star

324
00:14:27,510 --> 00:14:25,020
shade hey did you look at the

325
00:14:30,750 --> 00:14:27,520
photochemical of stability of a type of

326
00:14:32,670 --> 00:14:30,760
hemisphere environment star so this is

327
00:14:36,180 --> 00:14:32,680
all during the radio transistor I

328
00:14:40,410 --> 00:14:36,190
separately so no I separately am working

329
00:14:42,750 --> 00:14:40,420
on Titan using photochemical models and

330
00:14:44,100 --> 00:14:42,760
so it's possible that we're probably at

331
00:14:46,680 --> 00:14:44,110
some point once we get that template

332
00:14:49,680 --> 00:14:46,690
working apply will probably do similar

333
00:14:53,400 --> 00:14:49,690
thing plug all of those / falls into PSG

334
00:14:57,890 --> 00:14:53,410
and run it again but now I haven't

335
00:15:01,620 --> 00:14:57,900
looked at any stability yeah thank you

336
00:15:03,060 --> 00:15:01,630
hi thanks for your talk um you alluded

337
00:15:04,829 --> 00:15:03,070
to this a little bit but I'm wondering

338
00:15:06,660 --> 00:15:04,839

what you think about the whole minimum

339
00:15:09,450 --> 00:15:06,670
NASA issue for this because it looks

340
00:15:11,130 --> 00:15:09,460
like the mass really like the spectrum

341
00:15:13,110 --> 00:15:11,140
that you get really sensitively depends

342
00:15:15,690 --> 00:15:13,120
on mass so how do you like get the

343
00:15:19,740 --> 00:15:15,700
inclination so we don't know that

344
00:15:22,140 --> 00:15:19,750
clinician that is something that maybe

345
00:15:27,870 --> 00:15:22,150
with future better observations do be it

346
00:15:29,610 --> 00:15:27,880
will get but that I mean so we stuck

347
00:15:31,170 --> 00:15:29,620
around us think the nation's depending

348
00:15:32,730 --> 00:15:31,180
on the geometry if you're looking at it

349
00:15:34,500 --> 00:15:32,740
like this and the stars orbiting this

350
00:15:36,690 --> 00:15:34,510
way you're not going to get any shift

351
00:15:38,579 --> 00:15:36,700
what it depending on how its tilted

352
00:15:40,650 --> 00:15:38,589
towards you you're gonna then start

353
00:15:42,439 --> 00:15:40,660
getting show and that's where the

354
00:15:44,730 --> 00:15:42,449
minimum mass comes in because then I

355
00:15:47,879 --> 00:15:44,740
believe it's just something like then

356
00:15:49,350 --> 00:15:47,889
you have the sine of the angle of the

357
00:15:52,559 --> 00:15:49,360
inclination equal to help you get the

358
00:15:53,790 --> 00:15:52,569
minimum mass so for this actually I was

359
00:15:56,430 --> 00:15:53,800
thinking about this sort of sitting down

360
00:15:57,990 --> 00:15:56,440
is what's stopping this from just being

361
00:16:00,179 --> 00:15:58,000
like something like a hot Jupiter or

362
00:16:02,429 --> 00:16:00,189
something or any kind of much larger non

363
00:16:03,809 --> 00:16:02,439

terrestrial planet and I believe in us

364
00:16:06,689 --> 00:16:03,819
to do with the fact that this that

365
00:16:08,670 --> 00:16:06,699
Barnard sir has been studied for years

366
00:16:10,710 --> 00:16:08,680
if actually I think decades they were

367
00:16:12,240 --> 00:16:10,720
looking for just this they were sifting

368
00:16:15,449 --> 00:16:12,250
through this data for a pretty long time

369
00:16:17,579 --> 00:16:15,459
and we thought we found a planet on a

370
00:16:20,160 --> 00:16:17,589
Barnard star system before and it ended

371
00:16:22,319 --> 00:16:20,170
up not being true I believe that what's

372
00:16:25,110 --> 00:16:22,329
constraining this to being a terrestrial

373
00:16:26,790 --> 00:16:25,120
planet is that it's not we would have to

374
00:16:29,670 --> 00:16:26,800
picked up some kind of transit or

375
00:16:31,170 --> 00:16:29,680
something else if it was larger then if

376
00:16:35,699 --> 00:16:31,180
it because right now we're not really

377
00:16:37,860 --> 00:16:35,709
able to identify exoplanets sort of that

378
00:16:39,449 --> 00:16:37,870
small but something like the transit

379
00:16:42,600 --> 00:16:39,459
mounted so the fact that it hasn't

380
00:16:44,100 --> 00:16:42,610
transit did I believe is why is one of

381
00:16:52,199 --> 00:16:44,110
the reasons that we can think it's still

382
00:16:55,530 --> 00:16:52,209
going to be reduced in size hi great

383
00:17:00,150 --> 00:16:55,540
talk would we be able to study these

384
00:17:02,189 --> 00:17:00,160
planets with leVoir be no Lavar be had

385
00:17:04,470 --> 00:17:02,199
the merest too small year of issues

386
00:17:06,449 --> 00:17:04,480
worth resolving power and enter working

387
00:17:10,289 --> 00:17:06,459
angle and it's no it wouldn't you

388
00:17:11,850 --> 00:17:10,299

wouldn't be able to do this alright and

389
00:17:13,409 --> 00:17:11,860
i think it's about time if you have any