
GIANTS, ROCKS, & GIANT ROCKS?
OBSERVING TERRESTRIAL
EXOPLANET TARGETS
HANNAH WAKEFORD

1
00:00:08,810 --> 00:00:06,580
[Music]

2
00:00:10,370 --> 00:00:08,820
thank you to the organizers for inviting

3
00:00:12,619 --> 00:00:10,380
me to give this incredibly difficult

4
00:00:13,970 --> 00:00:12,629
topic to talk about because observing

5
00:00:16,640 --> 00:00:13,980
things that we have very limited

6
00:00:19,220 --> 00:00:16,650
observations of made this very

7
00:00:22,370 --> 00:00:19,230
interesting to prepare so what I'm going

8
00:00:25,280 --> 00:00:22,380
to do is I'm going to take you from our

9
00:00:29,810 --> 00:00:25,290
giant to our rocks I have some I don't

10
00:00:31,910 --> 00:00:29,820
know giant rocks maybe so I'm gonna the

11
00:00:34,430 --> 00:00:31,920
exo climbers conference series really

12
00:00:36,890 --> 00:00:34,440
focuses around the two biggest questions

13
00:00:39,110 --> 00:00:36,900

that we have in astronomy related to

14
00:00:42,200 --> 00:00:39,120
planetary science now how do stars and

15
00:00:44,479 --> 00:00:42,210
planets form and in his life unique to

16
00:00:46,610 --> 00:00:44,489
our planet and we are discussing all of

17
00:00:48,140 --> 00:00:46,620
those things that we need to do that sit

18
00:00:50,690 --> 00:00:48,150
right between these two massive

19
00:00:52,580 --> 00:00:50,700
questions so we want to break it down a

20
00:00:55,250 --> 00:00:52,590
little bit more what are the

21
00:00:56,630 --> 00:00:55,260
demographics of hunnits how many

22
00:00:58,940 --> 00:00:56,640
different types of planets are out there

23
00:01:02,330 --> 00:00:58,950
order their radii what are their masses

24
00:01:04,759 --> 00:01:02,340
what kind of stars are their rounds what

25
00:01:08,300 --> 00:01:04,769
are the atmosphere is made of how many

26
00:01:10,850 --> 00:01:08,310
are there what are they made of and can

27
00:01:13,370 --> 00:01:10,860
we make any links whatsoever between

28
00:01:14,719 --> 00:01:13,380
those two these big questions can we

29
00:01:16,219 --> 00:01:14,729
take the links that we've got of the

30
00:01:18,530 --> 00:01:16,229
demographics the types of planets that

31
00:01:21,469 --> 00:01:18,540
are being formed how they might be being

32
00:01:22,940 --> 00:01:21,479
formed their atmospheric constituents

33
00:01:25,820 --> 00:01:22,950
that we can measure

34
00:01:27,710 --> 00:01:25,830
hopefully with telescopes can we take

35
00:01:29,810 --> 00:01:27,720
any of that information and pass it back

36
00:01:31,670 --> 00:01:29,820
between these two questions and that's

37
00:01:33,830 --> 00:01:31,680
really fundamentally what we're trying

38
00:01:35,300 --> 00:01:33,840

to do and I think you've seen many many

39
00:01:37,250 --> 00:01:35,310
talk this week which are trying to do

40
00:01:42,050 --> 00:01:37,260
parts of that and putting the pieces

41
00:01:44,810 --> 00:01:42,060
together so this is the famous prop from

42
00:01:46,700 --> 00:01:44,820
Fulton a tower this is the 2017 one

43
00:01:49,940 --> 00:01:46,710
because I added it and it wasn't much

44
00:01:52,190 --> 00:01:49,950
neater want to edit and we've got our

45
00:01:53,899 --> 00:01:52,200
rocks down in this end from our solar

46
00:01:56,359 --> 00:01:53,909
system we've got moons in there as well

47
00:01:58,640 --> 00:01:56,369
all things with atmospheres we saw also

48
00:02:00,410 --> 00:01:58,650
in Sarah Hurst talked that we've got to

49
00:02:02,690 --> 00:02:00,420
toast the atmosphere as well or consider

50
00:02:06,039 --> 00:02:02,700
even these smaller bodies we've got our

51
00:02:09,589 --> 00:02:06,049
Giants over here is hydrogen helium

52
00:02:12,020 --> 00:02:09,599
dominated atmospheres and we've got this

53
00:02:14,030 --> 00:02:12,030
big gap that we're seeing we don't have

54
00:02:16,760 --> 00:02:14,040
the majority of planets that are be

55
00:02:17,540 --> 00:02:16,770
found in our galaxy in our solar systems

56
00:02:19,910 --> 00:02:17,550
compared to

57
00:02:22,190 --> 00:02:19,920
some of those big middle ground that we

58
00:02:30,970 --> 00:02:22,200
need to try and understand and we can

59
00:02:38,390 --> 00:02:33,950
we can look at this in terms of the

60
00:02:41,180 --> 00:02:38,400
planetary composition as well and if we

61
00:02:43,040 --> 00:02:41,190
start looking at the atmospheres of

62
00:02:44,030 --> 00:02:43,050
those planets in our solar system and

63
00:02:46,040 --> 00:02:44,040

trying to understand what the

64
00:02:48,800 --> 00:02:46,050
atmospheres of those planets are made up

65
00:02:51,620 --> 00:02:48,810
of you can see that we've got those

66
00:02:54,470 --> 00:02:51,630
hydrogen helium dominated atmospheres

67
00:02:57,230 --> 00:02:54,480
we've got majority of elements are

68
00:02:59,570 --> 00:02:57,240
hydrogen helium carbon nitrogen oxygen

69
00:03:02,000 --> 00:02:59,580
in those giant planet atmospheres and

70
00:03:04,310 --> 00:03:02,010
then in the smaller planets where we've

71
00:03:07,100 --> 00:03:04,320
got detailed information so Venus and

72
00:03:09,530 --> 00:03:07,110
Earth for example we have that carbon

73
00:03:12,320 --> 00:03:09,540
nitrogen oxygen again and we've got

74
00:03:14,180 --> 00:03:12,330
other trace gases in there and I had to

75
00:03:16,430 --> 00:03:14,190
modify the earth one here so I'm sorry

76
00:03:18,560 --> 00:03:16,440
that it's a little bit disordered but I

77
00:03:21,260 --> 00:03:18,570
had to modify it because it was actually

78
00:03:23,090 --> 00:03:21,270
showing you what the composition of the

79
00:03:24,350 --> 00:03:23,100
crust was and I really was interested in

80
00:03:27,230 --> 00:03:24,360
the atmosphere because what's really

81
00:03:28,790 --> 00:03:27,240
important it was we're measuring the

82
00:03:30,620 --> 00:03:28,800
atmospheres of these planets with our

83
00:03:32,630 --> 00:03:30,630
observations right now with measuring

84
00:03:34,610 --> 00:03:32,640
the atmospheric temperature or edging

85
00:03:36,080 --> 00:03:34,620
the atmospheric composition so it's

86
00:03:38,980 --> 00:03:36,090
really important to try and understand

87
00:03:41,150 --> 00:03:38,990
the solar system context for that and

88
00:03:43,220 --> 00:03:41,160

try and think about what the difference

89
00:03:45,680 --> 00:03:43,230
is here we're losing our hydrogen and

90
00:03:47,390 --> 00:03:45,690
helium and we're increasing the amount

91
00:03:49,160 --> 00:03:47,400
we have of this carbon nitrogen oxygen

92
00:03:52,130 --> 00:03:49,170
they're not missing from the giant

93
00:03:54,230 --> 00:03:52,140
planets but they're dominated by this

94
00:03:56,210 --> 00:03:54,240
hydrogen helium so we've got to see

95
00:03:58,310 --> 00:03:56,220
about what this transition between the

96
00:03:59,449 --> 00:03:58,320
two is and this also comes down to a lot

97
00:04:01,010 --> 00:03:59,459
of stuff that we've been seeing about

98
00:04:03,170 --> 00:04:01,020
the internal composition of these

99
00:04:05,660 --> 00:04:03,180
planets where is that boundary what

100
00:04:07,670 --> 00:04:05,670
happens as we move from these neptune

101
00:04:09,620 --> 00:04:07,680
mathworld which have these large ice

102
00:04:11,780 --> 00:04:09,630
contents in our solar system what

103
00:04:14,150 --> 00:04:11,790
happens when we move to something more

104
00:04:15,770 --> 00:04:14,160
rock content and how does it change what

105
00:04:17,300 --> 00:04:15,780
we're going to be observing so we can

106
00:04:20,570 --> 00:04:17,310
use the solar system as a basis for

107
00:04:22,970 --> 00:04:20,580
trying to bridge these gaps but it's

108
00:04:25,370 --> 00:04:22,980
really ugly in exoplanets that we're

109
00:04:27,469 --> 00:04:25,380
going to be able to add all this

110
00:04:29,659 --> 00:04:27,479
together I'm sorry it's all keynote is

111
00:04:32,179 --> 00:04:29,669
the is the main issue

112
00:04:36,980 --> 00:04:32,189
don't get a new MacBook they don't like

113
00:04:38,719 --> 00:04:36,990

to connect to old projectors um so we've

114
00:04:40,219 --> 00:04:38,729
got these different things that we can

115
00:04:42,589 --> 00:04:40,229
see in our solar system and we have

116
00:04:44,570 --> 00:04:42,599
these different theories where how that

117
00:04:46,219 --> 00:04:44,580
is being affected by the formation

118
00:04:48,290 --> 00:04:46,229
processes visit of the cartoon that I

119
00:04:51,260 --> 00:04:48,300
made which brings together a lot of

120
00:04:53,570 --> 00:04:51,270
different work about the ice lines where

121
00:04:55,879 --> 00:04:53,580
a planet forms and how that informs what

122
00:04:59,119 --> 00:04:55,889
the atmosphere might be made of so the

123
00:05:01,730 --> 00:04:59,129
sitio ratio might inform us about where

124
00:05:03,740 --> 00:05:01,740
in the disk it formed beyond ice lines

125
00:05:05,929 --> 00:05:03,750
or interior to them so rocky planets we

126
00:05:08,600 --> 00:05:05,939
think from all interior to those ice

127
00:05:10,249 --> 00:05:08,610
lines how can we use the information

128
00:05:12,469 --> 00:05:10,259
we're measuring in the atmosphere to try

129
00:05:14,959 --> 00:05:12,479
and understand that and the two

130
00:05:16,640 --> 00:05:14,969
different formation processes which

131
00:05:18,409 --> 00:05:16,650
input themselves on the atmosphere

132
00:05:20,450 --> 00:05:18,419
differently so we can look at the

133
00:05:22,850 --> 00:05:20,460
atmospheres of these planets and try and

134
00:05:25,700 --> 00:05:22,860
understand and see if we can work out

135
00:05:28,670 --> 00:05:25,710
how they formed where they formed and

136
00:05:30,950 --> 00:05:28,680
that really helped inform us about what

137
00:05:32,869 --> 00:05:30,960
that demographic of planets really means

138
00:05:34,999 --> 00:05:32,879

when we compare it to our subsystem and

139
00:05:36,649 --> 00:05:35,009
with the big questions that come from

140
00:05:38,300 --> 00:05:36,659
this when with dirt towards these

141
00:05:40,899 --> 00:05:38,310
smaller planets because this has really

142
00:05:43,159 --> 00:05:40,909
been focused around these giant planets

143
00:05:44,749 --> 00:05:43,169
don't slip supply to those mini

144
00:05:47,389 --> 00:05:44,759
Neptune's does this apply to terrestrial

145
00:05:49,820 --> 00:05:47,399
planets at all and at what mass radius

146
00:05:51,829 --> 00:05:49,830
of a planet do these formation markets

147
00:05:54,170 --> 00:05:51,839
start to break down and we have to start

148
00:05:55,820 --> 00:05:54,180
asking different questions and I think

149
00:05:57,829 --> 00:05:55,830
we've seen a lot of those questions this

150
00:06:01,459 --> 00:05:57,839
week and we're going to be picking those

151
00:06:04,459 --> 00:06:01,469
apart so I want to go back and look at

152
00:06:07,159 --> 00:06:04,469
the kind of contingent of planets that

153
00:06:08,779 --> 00:06:07,169
we've got and this is a kind of old now

154
00:06:12,409 --> 00:06:08,789
it doesn't have a single test planet on

155
00:06:15,170 --> 00:06:12,419
it I'm afraid but it's a much easier way

156
00:06:17,510 --> 00:06:15,180
of showing it I like showing this

157
00:06:19,639 --> 00:06:17,520
because it really shows that we are

158
00:06:21,950 --> 00:06:19,649
observational II biased away from our

159
00:06:24,230 --> 00:06:21,960
solar system right now our solar system

160
00:06:25,339 --> 00:06:24,240
is really fitting quite far away in this

161
00:06:26,749 --> 00:06:25,349
program but I'm going to show other

162
00:06:28,279 --> 00:06:26,759
diagram paper where it's right in the

163
00:06:30,740 --> 00:06:28,289

mix of the types of planets that we're

164
00:06:33,379 --> 00:06:30,750
looking at and you can see that that

165
00:06:36,920 --> 00:06:33,389
region I've cut off for the the Neptune

166
00:06:39,110 --> 00:06:36,930
evaporation desert or core erosion or

167
00:06:40,610 --> 00:06:39,120
many different kinds of heating which

168
00:06:42,840 --> 00:06:40,620
might lose your atmosphere that we've

169
00:06:45,749 --> 00:06:42,850
seen and I've highlight

170
00:06:50,100 --> 00:06:45,759
the ones that we have well measured

171
00:06:52,170 --> 00:06:50,110
massive and radii and those are really

172
00:06:53,969 --> 00:06:52,180
important for any kind of

173
00:06:55,920 --> 00:06:53,979
characterization we're not just trying

174
00:06:57,420 --> 00:06:55,930
to observe these planets as a

175
00:06:58,620 --> 00:06:57,430
demographic we want to know more about

176
00:07:00,270 --> 00:06:58,630
them we need to know more about their

177
00:07:03,210 --> 00:07:00,280
atmosphere so we can start bridging the

178
00:07:05,550 --> 00:07:03,220
gap between these two big questions so

179
00:07:07,800 --> 00:07:05,560
we need the mass and the radii and that

180
00:07:10,770 --> 00:07:07,810
actually adds some complications because

181
00:07:13,439 --> 00:07:10,780
the masses are actually not easy to do

182
00:07:16,170 --> 00:07:13,449
for small planets and this is some work

183
00:07:19,379 --> 00:07:16,180
that Rafael Hayward shared with me so

184
00:07:23,279 --> 00:07:19,389
I'd like to share with you that looking

185
00:07:26,490 --> 00:07:23,289
at the different aspects of noise that

186
00:07:28,770 --> 00:07:26,500
you get from a star and this goes right

187
00:07:31,170 --> 00:07:28,780
down to the fundamental granulation the

188
00:07:34,589 --> 00:07:31,180

circulation patterns in the star that

189
00:07:36,540 --> 00:07:34,599
you can see here that adds noise to your

190
00:07:37,980 --> 00:07:36,550
radial velocity measurement so when

191
00:07:39,480 --> 00:07:37,990
you're trying to measure the mass of a

192
00:07:42,570 --> 00:07:39,490
planet through the radial velocity

193
00:07:44,370 --> 00:07:42,580
method you've got to consider all of the

194
00:07:47,550 --> 00:07:44,380
different noise parameters of the stars

195
00:07:49,920 --> 00:07:47,560
that you're looking at and we really

196
00:07:51,600 --> 00:07:49,930
don't understand the Stars enough and

197
00:07:52,830 --> 00:07:51,610
that's one of the really big take homes

198
00:07:55,260 --> 00:07:52,840
when we're looking at small planets is

199
00:07:58,080 --> 00:07:55,270
we've got to know the stars really well

200
00:08:00,540 --> 00:07:58,090
but what Raphael is doing is using

201
00:08:03,300 --> 00:08:00,550
observations of the Sun to try and

202
00:08:04,860 --> 00:08:03,310
understand and simulate how these might

203
00:08:06,689 --> 00:08:04,870
affect your rate of velocity data so

204
00:08:07,830 --> 00:08:06,699
that you can take that out and we can

205
00:08:10,409 --> 00:08:07,840
actually get way more accurate

206
00:08:11,459 --> 00:08:10,419
measurements and understand the size of

207
00:08:13,830 --> 00:08:11,469
these planets a little bit better

208
00:08:16,260 --> 00:08:13,840
because that's so important and we need

209
00:08:18,600 --> 00:08:16,270
that math it's essential to interpreting

210
00:08:20,909 --> 00:08:18,610
the atmosphere it is essential to know

211
00:08:22,589 --> 00:08:20,919
the math when we look at a transmission

212
00:08:25,439 --> 00:08:22,599
spectrum emission spectrum of a

213
00:08:27,450 --> 00:08:25,449

planetary atmosphere and we've got a

214
00:08:28,469 --> 00:08:27,460
nice roadmap for radial velocities

215
00:08:30,899 --> 00:08:28,479
moving into the future

216
00:08:33,750 --> 00:08:30,909
this isn't just old stuff we're

217
00:08:36,810 --> 00:08:33,760
constantly building and applying new

218
00:08:38,610 --> 00:08:36,820
radial velocity measurements and what

219
00:08:40,980 --> 00:08:38,620
you can see at the top there is some

220
00:08:44,100 --> 00:08:40,990
simulations of test yields and speculoos

221
00:08:45,960 --> 00:08:44,110
yields and those are just for the M

222
00:08:48,949 --> 00:08:45,970
stars so these you can see on the side

223
00:08:53,040 --> 00:08:48,959
very cold stars these red stars and

224
00:08:55,170 --> 00:08:53,050
we're going to be pushing in to the

225
00:08:56,190 --> 00:08:55,180
masses of these stars and that's really

226
00:08:58,170 --> 00:08:56,200
good news

227
00:09:01,500 --> 00:08:58,180
for trying to understand and

228
00:09:02,699 --> 00:09:01,510
characterize these small planets so in

229
00:09:04,800 --> 00:09:02,709
the future we've got a number of

230
00:09:08,310 --> 00:09:04,810
instruments coming onboard we got harps

231
00:09:11,490 --> 00:09:08,320
3 which is something that the UK is part

232
00:09:13,050 --> 00:09:11,500
of as well that's beyond the Palmer and

233
00:09:16,199 --> 00:09:13,060
we thought gee craft coming up which

234
00:09:21,090 --> 00:09:16,209
will really help push us as far as we

235
00:09:23,430 --> 00:09:21,100
can down to the small size world so it's

236
00:09:25,019 --> 00:09:23,440
really important that we keep pushing we

237
00:09:26,400 --> 00:09:25,029
keep pushing for radial velocity

238
00:09:27,960 --> 00:09:26,410

instruments and keep pushing for radial

239
00:09:30,449 --> 00:09:27,970
velocity measurements so we can get the

240
00:09:32,280 --> 00:09:30,459
masses of these systems where we might

241
00:09:35,790 --> 00:09:32,290
not be able to get transit climbing

242
00:09:38,250 --> 00:09:35,800
variations from multiple planets but

243
00:09:41,759 --> 00:09:38,260
it's not just the mass what we need we

244
00:09:46,680 --> 00:09:41,769
need the transit we need the size of the

245
00:09:48,449 --> 00:09:46,690
planet and if we don't have the radius

246
00:09:51,150 --> 00:09:48,459
of the planet we are still going to be

247
00:09:54,150 --> 00:09:51,160
reliant on those mass radius models to

248
00:09:55,829 --> 00:09:54,160
try and interpret a planet that we've

249
00:09:57,509 --> 00:09:55,839
discovered with other methods so we

250
00:09:59,519 --> 00:09:57,519
might if we if we've just got the mass

251
00:10:03,300 --> 00:09:59,529
that's still not enough we need both of

252
00:10:05,960 --> 00:10:03,310
these things and we need to in transit

253
00:10:08,519 --> 00:10:05,970
observations get the stellar radii right

254
00:10:10,800 --> 00:10:08,529
so that we can get the planetary radii

255
00:10:12,930 --> 00:10:10,810
right and this is a study done by Sam RL

256
00:10:15,090 --> 00:10:12,940
at the University of Exeter that's just

257
00:10:16,949 --> 00:10:15,100
gone up on the archive where they show

258
00:10:18,689 --> 00:10:16,959
that the Gaia measurement using the Gaia

259
00:10:22,439 --> 00:10:18,699
measurements the previous radius

260
00:10:25,290 --> 00:10:22,449
measurements for many of the transiting

261
00:10:26,699 --> 00:10:25,300
exoplanet host stars are off by 10% and

262
00:10:29,009 --> 00:10:26,709
they actually bring that measurement

263
00:10:30,630 --> 00:10:29,019

down to an uncertainty of plus or minus

264
00:10:32,430 --> 00:10:30,640
two point seven percent so I recommend

265
00:10:34,860 --> 00:10:32,440
you go check out that paper and have a

266
00:10:36,420 --> 00:10:34,870
look but the reason this is important is

267
00:10:38,009 --> 00:10:36,430
because we're trying to understand that

268
00:10:40,920 --> 00:10:38,019
big question is life unique to our

269
00:10:44,189 --> 00:10:40,930
planet we need to know about what the

270
00:10:46,769 --> 00:10:44,199
changes if we change the size how does

271
00:10:49,230 --> 00:10:46,779
that affect whether something is habit

272
00:10:52,530 --> 00:10:49,240
or not how does that change that we

273
00:10:56,100 --> 00:10:52,540
don't know if this is a linear trend I

274
00:10:58,530 --> 00:10:56,110
doubt it very much I think it's the

275
00:11:00,300 --> 00:10:58,540
really squiggly one and then each

276
00:11:02,699 --> 00:11:00,310
planets going to give us a bit of a

277
00:11:05,189 --> 00:11:02,709
headache so we've got to look at lots of

278
00:11:08,189 --> 00:11:05,199
them to try and understand this so we

279
00:11:10,050 --> 00:11:08,199
need the mass on the radius so I'm going

280
00:11:11,340 --> 00:11:10,060
to take you through some

281
00:11:14,340 --> 00:11:11,350
that we've done I'm gonna take you free

282
00:11:16,920 --> 00:11:14,350
nice and nice and slowly because I know

283
00:11:18,720 --> 00:11:16,930
this is quite a theory heavy crowd so

284
00:11:20,730 --> 00:11:18,730
let's start with putting all of those

285
00:11:25,380 --> 00:11:20,740
dark black dots on the mass radius

286
00:11:28,350 --> 00:11:25,390
diagram you can see I put some divisions

287
00:11:29,910 --> 00:11:28,360
up there as well if we stick our solar

288
00:11:32,130 --> 00:11:29,920

system in there you can see that we're

289
00:11:34,680 --> 00:11:32,140
actually capturing quite a nice range in

290
00:11:36,540 --> 00:11:34,690
there of our solar system but again

291
00:11:38,910 --> 00:11:36,550
remember that first bigger our solar

292
00:11:40,650 --> 00:11:38,920
system's way off to the side so the very

293
00:11:44,880 --> 00:11:40,660
different temperature regimes that we're

294
00:11:46,830 --> 00:11:44,890
talking about and if we pick pick your

295
00:11:48,900 --> 00:11:46,840
favorite models pick any models they all

296
00:11:51,060 --> 00:11:48,910
fill out this space somehow there's a

297
00:11:52,350 --> 00:11:51,070
nice big blur of models that go through

298
00:11:54,420 --> 00:11:52,360
their space I just picked these ones

299
00:11:56,640 --> 00:11:54,430
because they're very easy to to cross on

300
00:11:59,460 --> 00:11:56,650
up there we've got some of our solar

301
00:12:01,980 --> 00:11:59,470
system moves in there demonstrating how

302
00:12:04,700 --> 00:12:01,990
those lines go through the mass radius

303
00:12:07,080 --> 00:12:04,710
relations of different composition of

304
00:12:09,210 --> 00:12:07,090
planets so the mass radius gives you

305
00:12:11,400 --> 00:12:09,220
nice density and we can get a bulk

306
00:12:14,010 --> 00:12:11,410
composition from that and you can see

307
00:12:15,420 --> 00:12:14,020
that our Uranus and Neptune sit right in

308
00:12:18,780 --> 00:12:15,430
the middle of some of these models that

309
00:12:21,330 --> 00:12:18,790
are put up here and it's really the

310
00:12:24,330 --> 00:12:21,340
spread that I want you to focus on there

311
00:12:26,340 --> 00:12:24,340
in all of these regions we've split it

312
00:12:28,080 --> 00:12:26,350
in terms of mass down the bottom here

313
00:12:30,270 --> 00:12:28,090

we've got those nice lines which tell

314
00:12:32,400 --> 00:12:30,280
you what kind of mass box we want to put

315
00:12:34,080 --> 00:12:32,410
you in do you want our us super for mini

316
00:12:36,930 --> 00:12:34,090
Neptune and Neptune or Saturn

317
00:12:40,860 --> 00:12:36,940
that's your mass box but the spread in

318
00:12:43,470 --> 00:12:40,870
radii across that is quite vast and how

319
00:12:44,910 --> 00:12:43,480
does that affect how we're defining

320
00:12:48,060 --> 00:12:44,920
these planets and what that actually

321
00:12:52,620 --> 00:12:48,070
means what types of worlds these are

322
00:12:54,780 --> 00:12:52,630
that we're looking at so I'm going to

323
00:12:57,930 --> 00:12:54,790
take you through some of them I'm going

324
00:12:59,760 --> 00:12:57,940
to take you through planets from our

325
00:13:02,400 --> 00:12:59,770
Neptune regime where we've got some nice

326
00:13:05,520 --> 00:13:02,410
measurements of their atmospheres down

327
00:13:08,670 --> 00:13:05,530
to our terrestrial regime where things

328
00:13:10,110 --> 00:13:08,680
get a little bit more tricky and it

329
00:13:12,860 --> 00:13:10,120
gives observers a little bit of a

330
00:13:15,500 --> 00:13:12,870
headache when we get the data so

331
00:13:18,030 --> 00:13:15,510
starting with our nice beautiful

332
00:13:21,510 --> 00:13:18,040
hydrogen dominated atmosphere big

333
00:13:23,140 --> 00:13:21,520
signals lots of photons coming streaming

334
00:13:25,780 --> 00:13:23,150
through the atmosphere

335
00:13:30,220 --> 00:13:25,790
zeorge by the atmosphere and telling us

336
00:13:31,300 --> 00:13:30,230
what is in that atmosphere we've got the

337
00:13:34,660 --> 00:13:31,310
largest one that I'm going to talk about

338
00:13:38,200 --> 00:13:34,670

hat 26 up the top they're really nice

339
00:13:40,090 --> 00:13:38,210
clean clear water absorption feature we

340
00:13:42,130 --> 00:13:40,100
can get an understanding of the

341
00:13:45,760 --> 00:13:42,140
abundance of water in the atmosphere of

342
00:13:47,410 --> 00:13:45,770
that planet and as you go down as you go

343
00:13:50,800 --> 00:13:47,420
through and you can see it's labeled

344
00:13:53,050 --> 00:13:50,810
really nicely thanks to in cross Jordan

345
00:13:55,540 --> 00:13:53,060
lorac Ryberg in terms of temperature as

346
00:13:57,280 --> 00:13:55,550
we go down when we get colder we get

347
00:14:00,160 --> 00:13:57,290
flatter and flat the transmission

348
00:14:02,170 --> 00:14:00,170
spectra and what is happening there what

349
00:14:05,410 --> 00:14:02,180
is causing this is it that the planets

350
00:14:06,460 --> 00:14:05,420
don't have atmospheres even though we we

351
00:14:09,340 --> 00:14:06,470
know that they're going to be hard and

352
00:14:11,050 --> 00:14:09,350
helium devices not the case so there's

353
00:14:12,790 --> 00:14:11,060
got to be a pasty sources in there that

354
00:14:15,820 --> 00:14:12,800
are causing problems and we heard some

355
00:14:17,110 --> 00:14:15,830
things about the Haze's that will be

356
00:14:20,590 --> 00:14:17,120
causing problems there's a photo

357
00:14:23,560 --> 00:14:20,600
chemically generated materials and also

358
00:14:25,540 --> 00:14:23,570
about clouds and Jonathan Courtney told

359
00:14:26,980 --> 00:14:25,550
us that if we increase the internal

360
00:14:28,750 --> 00:14:26,990
temperature of these planets those

361
00:14:30,880 --> 00:14:28,760
clouds going to be a bit more pesky so

362
00:14:33,010 --> 00:14:30,890
we've got a really trying to understand

363
00:14:36,090 --> 00:14:33,020

the dynamics in town to these

364
00:14:38,230 --> 00:14:36,100
atmospheres to really pick them apart

365
00:14:40,960 --> 00:14:38,240
absolutely I'm gonna take you through

366
00:14:43,000 --> 00:14:40,970
two of them at the bottom here first I

367
00:14:45,490 --> 00:14:43,010
want to look at this Uranus mass planet

368
00:14:47,380 --> 00:14:45,500
and we got a nice talk from beyond

369
00:14:49,780 --> 00:14:47,390
earlier in the week looking at the new

370
00:14:52,630 --> 00:14:49,790
results that it shows at the top here

371
00:14:55,690 --> 00:14:52,640
we've got that water absorption feature

372
00:14:58,240 --> 00:14:55,700
there and then this is the the original

373
00:14:59,920 --> 00:14:58,250
data that was taken back in 2013 2014

374
00:15:03,460 --> 00:14:59,930
when this planet was first discovered

375
00:15:05,560 --> 00:15:03,470
and I'm gonna show this these are going

376
00:15:08,470 --> 00:15:05,570
to be on all of the slides for the next

377
00:15:09,970 --> 00:15:08,480
couple of minutes and I'm gonna move

378
00:15:12,250 --> 00:15:09,980
down this mass range and it's really

379
00:15:14,590 --> 00:15:12,260
important to note each of these radii

380
00:15:15,550 --> 00:15:14,600
and math because we're going to jump

381
00:15:17,380 --> 00:15:15,560
around a bit but it's going to

382
00:15:19,810 --> 00:15:17,390
completely change what kind of planet

383
00:15:21,820 --> 00:15:19,820
that we're looking at so I want you want

384
00:15:24,070 --> 00:15:21,830
keep note of that but what's really and

385
00:15:31,180 --> 00:15:24,080
beyond pointed this out important here

386
00:15:35,770 --> 00:15:31,190
is at 600 Kelvin we fully expect this to

387
00:15:38,830 --> 00:15:35,780
have methane in the atmosphere this is

388
00:15:41,530 --> 00:15:38,840

the chemical equilibrium diagram which

389
00:15:43,420 --> 00:15:41,540
says we should see methane in these

390
00:15:46,930 --> 00:15:43,430
cooler atmospheres and we're just not

391
00:15:48,430 --> 00:15:46,940
we're not seeing it and we haven't seen

392
00:15:50,410 --> 00:15:48,440
it in giant planet atmospheres where

393
00:15:52,150 --> 00:15:50,420
it's even easier to detect we haven't

394
00:15:54,340 --> 00:15:52,160
seen it in small planets we haven't seen

395
00:15:57,580 --> 00:15:54,350
in any of the planets that we've tried

396
00:16:01,120 --> 00:15:57,590
to look for so this where's the methane

397
00:16:02,800 --> 00:16:01,130
question is a massive one in trying to

398
00:16:04,330 --> 00:16:02,810
understand the composition of these

399
00:16:06,700 --> 00:16:04,340
planetary atmospheres and what's

400
00:16:08,800 --> 00:16:06,710
happening chemically and dynamically in

401
00:16:10,540 --> 00:16:08,810
those atmospheres which mean that we're

402
00:16:11,530 --> 00:16:10,550
not seeing it and that's a big important

403
00:16:13,270 --> 00:16:11,540
question we're going to have to be

404
00:16:14,770 --> 00:16:13,280
answering in the coming years and I'm

405
00:16:17,620 --> 00:16:14,780
hoping that James Webb's going to help

406
00:16:18,940 --> 00:16:17,630
us with that but another really

407
00:16:21,070 --> 00:16:18,950
interesting thing one of the things I

408
00:16:26,460 --> 00:16:21,080
really love about this planet is that in

409
00:16:28,930 --> 00:16:26,470
fact it is drastically losing its mass

410
00:16:31,600 --> 00:16:28,940
work that was published earlier this

411
00:16:33,760 --> 00:16:31,610
year by Vinson burrying from the panther

412
00:16:35,380 --> 00:16:33,770
program so the panchromatic hubble

413
00:16:38,920 --> 00:16:35,390

treasury program that's led by David

414
00:16:41,140 --> 00:16:38,930
Singh in Mercedes Lopez Morales observed

415
00:16:43,330 --> 00:16:41,150
the lyman-alpha of this planet we heard

416
00:16:44,920 --> 00:16:43,340
about lyman-alpha lines earlier this

417
00:16:45,250 --> 00:16:44,930
week so that was a nice introduction for

418
00:16:48,370 --> 00:16:45,260
you

419
00:16:51,850 --> 00:16:48,380
and what they saw was that this planet

420
00:16:56,020 --> 00:16:51,860
is losing a significant amount of its

421
00:16:58,570 --> 00:16:56,030
atmosphere and very quickly it is not a

422
00:17:01,990 --> 00:16:58,580
particularly old system and it seems

423
00:17:04,300 --> 00:17:02,000
like we're seeing it in the first stages

424
00:17:05,740 --> 00:17:04,310
of it losing that dominant hydrogen

425
00:17:08,350 --> 00:17:05,750
helium atmosphere we heard from James

426
00:17:11,920 --> 00:17:08,360
Aaron's talk that there is two kind of

427
00:17:13,900 --> 00:17:11,930
links if you got extreme x-ray UV

428
00:17:16,300 --> 00:17:13,910
radiation we expect that will be the

429
00:17:19,090 --> 00:17:16,310
main driver of mass loss in the early

430
00:17:21,579 --> 00:17:19,100
years of a planet as it forms and then

431
00:17:23,980 --> 00:17:21,589
the softer radiation will be causing

432
00:17:26,500 --> 00:17:23,990
mass loss after that we're seeing

433
00:17:28,900 --> 00:17:26,510
extreme UV radiation mass loss from this

434
00:17:32,050 --> 00:17:28,910
planet it's going to be getting smaller

435
00:17:34,720 --> 00:17:32,060
and smaller and smaller and it's then

436
00:17:36,970 --> 00:17:34,730
the question of how that changes the

437
00:17:39,370 --> 00:17:36,980
atmospheric composition and if that's

438
00:17:42,790 --> 00:17:39,380

something that means that we can no

439
00:17:44,340 --> 00:17:42,800
longer trace it back to what size it

440
00:17:47,490 --> 00:17:44,350
started up

441
00:17:50,100 --> 00:17:47,500
can we ever know how big this planet

442
00:17:53,639 --> 00:17:50,110
started out as that's a really important

443
00:17:55,950 --> 00:17:53,649
question and how long can a planet live

444
00:17:59,399 --> 00:17:55,960
like this and at what end State will we

445
00:18:03,210 --> 00:17:59,409
see it in I don't know how many million

446
00:18:05,310 --> 00:18:03,220
years we're gonna be alive for but if we

447
00:18:07,470 --> 00:18:05,320
could what would it end up as and it's

448
00:18:09,450 --> 00:18:07,480
really down to simulations matching with

449
00:18:11,460 --> 00:18:09,460
what we're seeing observational II that

450
00:18:13,769 --> 00:18:11,470
is required to try and really fully

451
00:18:17,519 --> 00:18:13,779
understand these worlds so it's a link

452
00:18:20,669 --> 00:18:17,529
between both theory and observations as

453
00:18:23,279 --> 00:18:20,679
we move down to the most famous of the

454
00:18:25,740 --> 00:18:23,289
planets this is a very cloudy atmosphere

455
00:18:28,289 --> 00:18:25,750
that was measured by a number of people

456
00:18:31,730 --> 00:18:28,299
and then you know finally then the nail

457
00:18:34,019 --> 00:18:31,740
in the coffin from Laura Craig 60

458
00:18:36,539 --> 00:18:34,029
observations were huddled to get the

459
00:18:38,480 --> 00:18:36,549
most precise flat line that's ever been

460
00:18:41,519 --> 00:18:38,490
measured with the Hubble Space Telescope

461
00:18:43,740 --> 00:18:41,529
it's very beautiful and one that really

462
00:18:46,320 --> 00:18:43,750
really showed was that this atmosphere

463
00:18:48,720 --> 00:18:46,330

has an opacity source that is really

464
00:18:51,269 --> 00:18:48,730
obscuring any molecular features that

465
00:18:52,740 --> 00:18:51,279
we're seeing that and that's something

466
00:18:54,720 --> 00:18:52,750
that we're going to have to deal with

467
00:18:56,249 --> 00:18:54,730
but it also tells us as we saw earlier

468
00:18:58,499 --> 00:18:56,259
this week very nicely pointed out

469
00:19:01,889 --> 00:18:58,509
something about the dynamics of this

470
00:19:04,289 --> 00:19:01,899
atmosphere if you have opacity particles

471
00:19:06,619 --> 00:19:04,299
in the atmosphere that are causing this

472
00:19:09,240 --> 00:19:06,629
they have to be held at that altitude

473
00:19:10,860 --> 00:19:09,250
there has to be dynamical movement to

474
00:19:13,740 --> 00:19:10,870
maintain them they're not being

475
00:19:15,810 --> 00:19:13,750
destroyed by the stellar radiation so

476
00:19:17,700 --> 00:19:15,820
they're either being recreated and

477
00:19:19,169 --> 00:19:17,710
there's a recycling mechanism or they're

478
00:19:21,119 --> 00:19:19,179
forming there and they're staying there

479
00:19:23,549 --> 00:19:21,129
so we're learning a little bit about the

480
00:19:27,779 --> 00:19:23,559
dynamics there but one thing that I want

481
00:19:30,629 --> 00:19:27,789
to to really point out please stop

482
00:19:33,690 --> 00:19:30,639
calling in a super-earth pretty please

483
00:19:35,730 --> 00:19:33,700
if we look at some of the models from

484
00:19:37,200 --> 00:19:35,740
Lopez and Fort Lee and they've got a lot

485
00:19:38,820 --> 00:19:37,210
of really nice bigger than this paper I

486
00:19:43,320 --> 00:19:38,830
really encourage you to go check it out

487
00:19:47,460 --> 00:19:43,330
and we look at the radius and the mass

488
00:19:49,649 --> 00:19:47,470

of this planet there is no way you

489
00:19:53,039 --> 00:19:49,659
cannot have a hydrogen helium and bloap

490
00:19:56,170 --> 00:19:53,049
around it and mass dominated by that

491
00:19:58,330 --> 00:19:56,180
envelope and if a man

492
00:20:01,810 --> 00:19:58,340
let's talk about definitions definitions

493
00:20:03,430 --> 00:20:01,820
are like humans want to define things

494
00:20:05,470 --> 00:20:03,440
we're horrible creatures like that we

495
00:20:07,420 --> 00:20:05,480
want a very specific definition there

496
00:20:10,720 --> 00:20:07,430
isn't one in science and none of these

497
00:20:13,570 --> 00:20:10,730
planets are going to agree with us but

498
00:20:16,030 --> 00:20:13,580
if something is dominated in math by its

499
00:20:22,720 --> 00:20:16,040
atmosphere as we see with our giant

500
00:20:26,260 --> 00:20:22,730
planets mini Neptune if it's dominated

501
00:20:29,700 --> 00:20:26,270
in mass by its core by rock by anything

502
00:20:32,530 --> 00:20:29,710
else then sure call it a super F but I

503
00:20:35,230 --> 00:20:32,540
really think it's important that we we

504
00:20:37,360 --> 00:20:35,240
don't add labels to things that are a

505
00:20:39,550 --> 00:20:37,370
little bit misleading and this has got a

506
00:20:41,860 --> 00:20:39,560
fantastically large atmosphere that we

507
00:20:44,080 --> 00:20:41,870
can look at so there's lots of different

508
00:20:46,330 --> 00:20:44,090
ways that we can do that and I think

509
00:20:48,580 --> 00:20:46,340
that it really sits within that hydrogen

510
00:20:50,860 --> 00:20:48,590
helium dominated regime but we just

511
00:20:55,510 --> 00:20:50,870
don't know we need to we need to look at

512
00:20:57,640 --> 00:20:55,520
these worlds that leads me on to

513
00:20:59,620 --> 00:20:57,650

something else that we've covered so I'm

514
00:21:01,060 --> 00:20:59,630
really glad that I'm actually at the end

515
00:21:02,590 --> 00:21:01,070
I was very nervous about that at first

516
00:21:04,060 --> 00:21:02,600
but everyone else is giving really great

517
00:21:06,430 --> 00:21:04,070
introduction to all of these things I

518
00:21:09,220 --> 00:21:06,440
don't have to go into too much detail we

519
00:21:11,710 --> 00:21:09,230
have our lava world and we've got quite

520
00:21:13,840 --> 00:21:11,720
a few of them in this regime where we've

521
00:21:15,790 --> 00:21:13,850
measured their radii and their mass one

522
00:21:19,030 --> 00:21:15,800
of the most famous ones is 55 Cancri E

523
00:21:21,640 --> 00:21:19,040
and there's a lot of questions that we

524
00:21:23,350 --> 00:21:21,650
need to ask about this if we look again

525
00:21:26,080 --> 00:21:23,360
at that Lopez important diagram it

526
00:21:28,000 --> 00:21:26,090
should have an atmosphere of roughly 30%

527
00:21:31,690 --> 00:21:28,010
hydrogen and helium but we know it can't

528
00:21:34,560 --> 00:21:31,700
because it's so hot it's so hot it

529
00:21:37,120 --> 00:21:34,570
cannot have that kind of atmosphere so

530
00:21:39,070 --> 00:21:37,130
this is just me pointing out that we

531
00:21:40,840 --> 00:21:39,080
can't just rely on those two parameters

532
00:21:43,570 --> 00:21:40,850
I started out by going through we need

533
00:21:45,190 --> 00:21:43,580
the mass we need the radius we also need

534
00:21:46,750 --> 00:21:45,200
to know the temperature we need to know

535
00:21:48,760 --> 00:21:46,760
the star a radiance we need to know what

536
00:21:50,830 --> 00:21:48,770
kind of star it's around there's a huge

537
00:21:52,720 --> 00:21:50,840
amount of information that we need about

538
00:21:54,610 --> 00:21:52,730

each of these individual worlds that we

539
00:21:57,400 --> 00:21:54,620
can look at them collectively and this

540
00:21:59,260 --> 00:21:57,410
is a really prime example of that some

541
00:22:01,240 --> 00:21:59,270
of the first observations that were done

542
00:22:03,340 --> 00:22:01,250
are 55 Cancri you were looking for this

543
00:22:06,400 --> 00:22:03,350
large dominant atmosphere around this

544
00:22:08,080 --> 00:22:06,410
world and actually one of the most

545
00:22:09,740 --> 00:22:08,090
important things that's been seen as

546
00:22:12,750 --> 00:22:09,750
variations in this planet

547
00:22:15,480 --> 00:22:12,760
so I had a couple of questions when

548
00:22:18,330 --> 00:22:15,490
Laura was giving her talk you know if

549
00:22:20,310 --> 00:22:18,340
we're looking at variations in this

550
00:22:22,490 --> 00:22:20,320
poetry answers were seeing differences

551
00:22:24,480 --> 00:22:22,500
changes are we talking about

552
00:22:27,180 --> 00:22:24,490
catastrophic outgassing where it's

553
00:22:29,220 --> 00:22:27,190
bursting and is random or are we talking

554
00:22:32,280 --> 00:22:29,230
about continuous outgassing from this

555
00:22:35,490 --> 00:22:32,290
lava lake this possibly eyeball of a

556
00:22:37,320 --> 00:22:35,500
magma ocean where it's just changing the

557
00:22:40,170 --> 00:22:37,330
types of material that are being

558
00:22:41,730 --> 00:22:40,180
released from that magma and these are

559
00:22:44,220 --> 00:22:41,740
questions that we don't know the answer

560
00:22:46,290 --> 00:22:44,230
to and we need to be observing what the

561
00:22:48,330 --> 00:22:46,300
specific materials of those are and

562
00:22:51,750 --> 00:22:48,340
there's two fantastic posters which show

563
00:22:54,780 --> 00:22:51,760

that it's not any of these so sorry

564
00:22:56,820 --> 00:22:54,790
spoiler it's not paint the end being

565
00:22:59,280 --> 00:22:56,830
observed there and there's not evidence

566
00:23:01,380 --> 00:22:59,290
of the sodium and the calcium as well so

567
00:23:03,330 --> 00:23:01,390
what is being released from this large

568
00:23:05,790 --> 00:23:03,340
magma ocean and how is that being

569
00:23:08,280 --> 00:23:05,800
recirculated around the planet we're

570
00:23:11,190 --> 00:23:08,290
seeing strong fades curve so therefore

571
00:23:12,750 --> 00:23:11,200
there's recirculation of heat what what

572
00:23:15,090 --> 00:23:12,760
does that mean how is that doing it and

573
00:23:17,610 --> 00:23:15,100
when we saw really nice examples in

574
00:23:21,360 --> 00:23:17,620
Laura's talk about how you might expect

575
00:23:22,860 --> 00:23:21,370
the timescales of some rain out being

576
00:23:24,810 --> 00:23:22,870
closer to the edge of the magma ocean

577
00:23:28,230 --> 00:23:24,820
and therefore going under and being

578
00:23:29,730 --> 00:23:28,240
recirculated sub subsurface on the night

579
00:23:31,290 --> 00:23:29,740
side so these are really big questions

580
00:23:33,690 --> 00:23:31,300
that we don't have the answers to and

581
00:23:35,490 --> 00:23:33,700
that's what we need to do is to

582
00:23:39,240 --> 00:23:35,500
understand them by looking both in

583
00:23:40,950 --> 00:23:39,250
emission phase curves and in seeing if

584
00:23:44,580 --> 00:23:40,960
we can get any kind of absorption

585
00:23:47,460 --> 00:23:44,590
features there's another lava world

586
00:23:49,950 --> 00:23:47,470
which again does not fit at all with

587
00:23:53,100 --> 00:23:49,960
this program because it's also too hot

588
00:23:56,400 --> 00:23:53,110

but it's actually a lot cooler than 55

589
00:23:59,460 --> 00:23:56,410
Cancri it's about 500 to 700 Kelvin

590
00:24:01,680 --> 00:23:59,470
cooler than 55 Cancri E but it's still

591
00:24:03,390 --> 00:24:01,690
too hot to maintain any atmosphere even

592
00:24:06,240 --> 00:24:03,400
if it was big enough for it and we know

593
00:24:11,100 --> 00:24:06,250
that it's not the question we have here

594
00:24:13,080 --> 00:24:11,110
for core o 7 is it a stripped core if it

595
00:24:15,510 --> 00:24:13,090
is a stripped core how big was it to

596
00:24:17,880 --> 00:24:15,520
start with when did it lose its

597
00:24:19,980 --> 00:24:17,890
atmosphere and how quickly did it lose

598
00:24:22,950 --> 00:24:19,990
its atmosphere it's very similar

599
00:24:23,520 --> 00:24:22,960
questions that we have to Venus's

600
00:24:25,800 --> 00:24:23,530
atmosphere

601
00:24:28,500 --> 00:24:25,810
when did it lose its water how quickly

602
00:24:30,120 --> 00:24:28,510
did it lose its water these questions

603
00:24:31,740 --> 00:24:30,130
aren't new none of the questions we're

604
00:24:33,750 --> 00:24:31,750
asking an exoplanet science are

605
00:24:36,030 --> 00:24:33,760
particularly new our solar system has

606
00:24:37,410 --> 00:24:36,040
given us a plethora of ridiculous

607
00:24:40,620 --> 00:24:37,420
questions over the years that we've had

608
00:24:43,140 --> 00:24:40,630
to go and answer and the beauty of

609
00:24:45,660 --> 00:24:43,150
exoplanets is we have thousands of them

610
00:24:47,370 --> 00:24:45,670
to answer those question with so we need

611
00:24:50,010 --> 00:24:47,380
to be looking at across a wide diversity

612
00:24:52,170 --> 00:24:50,020
of planets and trying to observational e

613
00:24:55,170 --> 00:24:52,180

differentiate between these two

614
00:24:57,600 --> 00:24:55,180
different kinds of worlds is really

615
00:24:58,590 --> 00:24:57,610
important so my questions to you these

616
00:25:00,750 --> 00:24:58,600
aren't questions I'm going to answer

617
00:25:03,270 --> 00:25:00,760
that would be completely ridiculous I'm

618
00:25:05,460 --> 00:25:03,280
an observant on a theorist my questions

619
00:25:08,580 --> 00:25:05,470
to you are how do we answer them how can

620
00:25:11,100 --> 00:25:08,590
you provide observers with different

621
00:25:13,770 --> 00:25:11,110
things that we can look for to prove or

622
00:25:16,080 --> 00:25:13,780
disprove different models that's so

623
00:25:19,800 --> 00:25:16,090
important as we move into a far more

624
00:25:22,530 --> 00:25:19,810
data rich era is having things that we

625
00:25:23,970 --> 00:25:22,540
can prove and disprove places we can

626
00:25:26,040 --> 00:25:23,980
look and actually make those

627
00:25:29,460 --> 00:25:26,050
measurements for you so please think

628
00:25:31,410 --> 00:25:29,470
about all of these things can end our

629
00:25:33,960 --> 00:25:31,420
journey across the mass radius diagram

630
00:25:35,310 --> 00:25:33,970
at the most famous of the planets the

631
00:25:38,970 --> 00:25:35,320
traffix one system we've got a bit of an

632
00:25:40,650 --> 00:25:38,980
introduction to them earlier these are

633
00:25:42,090 --> 00:25:40,660
two of my favorite figures of the

634
00:25:44,580 --> 00:25:42,100
trapars one system there's so many

635
00:25:46,410 --> 00:25:44,590
papers on them but the the Dellacroce

636
00:25:48,690 --> 00:25:46,420
paper has these two beautiful figures

637
00:25:52,230 --> 00:25:48,700
which show all of the seven planets on

638
00:25:54,690 --> 00:25:52,240

the angle they september star which is

639
00:25:57,330 --> 00:25:54,700
just really really useful information

640
00:25:59,580 --> 00:25:57,340
for an observer this is the angle all of

641
00:26:01,860 --> 00:25:59,590
the planets attend on the star and that

642
00:26:04,890 --> 00:26:01,870
is something that is invaluable and I'll

643
00:26:07,650 --> 00:26:04,900
explain why in a second we've also got

644
00:26:10,890 --> 00:26:07,660
the nice comparison to Earth and Venus

645
00:26:14,580 --> 00:26:10,900
here we're looking at seven planets that

646
00:26:16,500 --> 00:26:14,590
all sit within the terrestrial realm and

647
00:26:18,870 --> 00:26:16,510
I use the word terrestrial not to mean

648
00:26:22,860 --> 00:26:18,880
earth-like because that's a silly word I

649
00:26:25,740 --> 00:26:22,870
mean they are dominated by rock of some

650
00:26:27,330 --> 00:26:25,750
kind and we want to find out what we

651
00:26:31,680 --> 00:26:27,340
also want to find out if they've got an

652
00:26:33,590 --> 00:26:31,690
atmosphere we've ruled out of Hubble

653
00:26:36,659 --> 00:26:33,600
Space Telescope observations a

654
00:26:40,440 --> 00:26:36,669
primordial hydrogen and helium

655
00:26:42,779 --> 00:26:40,450
my sphere around B through G our

656
00:26:46,529 --> 00:26:42,789
observations of each haven't come in but

657
00:26:49,470 --> 00:26:46,539
when they do I will let you know but the

658
00:26:52,759 --> 00:26:49,480
real question is the real answers we

659
00:26:55,169 --> 00:26:52,769
don't have we were no clue we ruled out

660
00:26:56,340 --> 00:26:55,179
primordial and probe of hydrogen helium

661
00:26:59,099 --> 00:26:56,350
we've won no idea if there's anything

662
00:27:02,070 --> 00:26:59,109
underneath that we've got no current

663
00:27:04,229 --> 00:27:02,080

idea of if it's got an outlet so

664
00:27:07,560 --> 00:27:04,239
dominated by co2 and - we're not gonna

665
00:27:11,700 --> 00:27:07,570
find out her then - if it's just the

666
00:27:15,739 --> 00:27:11,710
bowling ball but we're going to look are

667
00:27:19,349 --> 00:27:15,749
any of these habitable we don't know and

668
00:27:21,869 --> 00:27:19,359
can we use these wells to disentangle

669
00:27:23,810 --> 00:27:21,879
the impact of stellar radiation this is

670
00:27:26,129 --> 00:27:23,820
my favorite thing about this gold mine

671
00:27:28,440 --> 00:27:26,139
we have seven planets different

672
00:27:31,409 --> 00:27:28,450
distances from the same star all roughly

673
00:27:33,690 --> 00:27:31,419
the same mass density that we can use to

674
00:27:36,899 --> 00:27:33,700
try and understand how a star affects

675
00:27:38,759 --> 00:27:36,909
the planet's atmosphere and that's what

676
00:27:40,799 --> 00:27:38,769
we intend to do with the system more

677
00:27:42,090 --> 00:27:40,809
than anything else don't talk the

678
00:27:43,970 --> 00:27:42,100
astrobiologists they want to look for

679
00:27:46,769 --> 00:27:43,980
life I want to know how a star is

680
00:27:48,720 --> 00:27:46,779
affecting a planetary atmosphere at

681
00:27:52,440 --> 00:27:48,730
various distances and this is a great

682
00:27:53,879 --> 00:27:52,450
place to start looking for that and in

683
00:27:56,340 --> 00:27:53,889
the future we're getting a lot more

684
00:27:58,409 --> 00:27:56,350
planets this is just the calculation or

685
00:28:03,019 --> 00:27:58,419
the test yield it's based on Barkat all

686
00:28:05,999 --> 00:28:03,029
I just made it into more me colors and

687
00:28:08,039 --> 00:28:06,009
you can see we're getting lots of mm

688
00:28:09,960 --> 00:28:08,049

star planets down here as well and we've

689
00:28:11,460 --> 00:28:09,970
got speculoos coming online as well and

690
00:28:13,259 --> 00:28:11,470
that radial velocity diagram I showed

691
00:28:15,090 --> 00:28:13,269
you showed you all of the types of

692
00:28:16,859 --> 00:28:15,100
planets that we expect to find around

693
00:28:20,759 --> 00:28:16,869
those so we really need to understand

694
00:28:24,539 --> 00:28:20,769
this type of system and honestly Travis

695
00:28:25,889 --> 00:28:24,549
has given us the ability to do that so

696
00:28:27,749 --> 00:28:25,899
I'm gonna take you through some work

697
00:28:30,479 --> 00:28:27,759
that I've just recently done looking at

698
00:28:33,539 --> 00:28:30,489
the Trappist one system and trying to

699
00:28:36,479 --> 00:28:33,549
learn how we can disentangle the

700
00:28:40,409 --> 00:28:36,489
planetary atmosphere from that of a

701
00:28:41,759 --> 00:28:40,419
annoying little cold star I don't know

702
00:28:44,360 --> 00:28:41,769
how many stellar physicists have got in

703
00:28:46,950 --> 00:28:44,370
the room that I can annoy with

704
00:28:49,080 --> 00:28:46,960
so the trapars one system again and I

705
00:28:51,090 --> 00:28:49,090
feel introduction here is the the

706
00:28:54,210 --> 00:28:51,100
analysis that we've done to rule out

707
00:28:56,220 --> 00:28:54,220
those hydrogen helium envelopes around

708
00:28:59,340 --> 00:28:56,230
these planets and we had some very

709
00:29:02,430 --> 00:28:59,350
tentative evidence here for Trappist 1g

710
00:29:04,320 --> 00:29:02,440
so what we did is we went back and we

711
00:29:05,970 --> 00:29:04,330
got more observations of Travis 1g so

712
00:29:08,730 --> 00:29:05,980
I'm gonna take you through a case study

713
00:29:11,820 --> 00:29:08,740

on that but first the reason why we need

714
00:29:17,610 --> 00:29:11,830
to care about this strap is one is a

715
00:29:21,690 --> 00:29:17,620
very cool M star at 2500 Kelvin that

716
00:29:24,299 --> 00:29:21,700
means that it itself has water vapor in

717
00:29:26,789 --> 00:29:24,309
its atmosphere so the star itself has

718
00:29:29,249 --> 00:29:26,799
absorption and emission features due to

719
00:29:31,049 --> 00:29:29,259
water vapor in the atmosphere and that

720
00:29:32,850 --> 00:29:31,059
is exactly what we're looking for in the

721
00:29:35,279 --> 00:29:32,860
planet's atmosphere so we have to

722
00:29:37,740 --> 00:29:35,289
understand that water absorption in the

723
00:29:39,899 --> 00:29:37,750
star to really understand what we're

724
00:29:42,869 --> 00:29:39,909
seeing in that planetary atmosphere and

725
00:29:44,759 --> 00:29:42,879
it's really important where in the

726
00:29:47,039 --> 00:29:44,769
atmosphere of the star there are

727
00:29:49,860 --> 00:29:47,049
different features so if you've got a

728
00:29:51,149 --> 00:29:49,870
spot either cool or hot on That star

729
00:29:53,009 --> 00:29:51,159
it's gonna be a different temperature

730
00:29:56,340 --> 00:29:53,019
it's gonna have different spectral

731
00:29:58,740 --> 00:29:56,350
features how can we try and understand

732
00:30:00,360 --> 00:29:58,750
what different structures there are on

733
00:30:05,580 --> 00:30:00,370
the star itself and how they're changing

734
00:30:09,029 --> 00:30:05,590
the spectral features of the star been

735
00:30:11,850 --> 00:30:09,039
rockin in 2018 started a study looking

736
00:30:14,730 --> 00:30:11,860
at boy well he dubbed the transit light

737
00:30:16,980 --> 00:30:14,740
source effect I like to think of it more

738
00:30:17,999 --> 00:30:16,990

of a flux contrast but that's because

739
00:30:20,879 --> 00:30:18,009
I've been hanging out with solar

740
00:30:23,369 --> 00:30:20,889
physicists too long but the the light

741
00:30:25,350 --> 00:30:23,379
source effect is really looking at how

742
00:30:28,860 --> 00:30:25,360
these different features based on hot

743
00:30:31,110 --> 00:30:28,870
spots cold spots on a cold star which

744
00:30:34,529 --> 00:30:31,120
already has a base absorption of water

745
00:30:37,860 --> 00:30:34,539
change what we're measuring in the

746
00:30:41,100 --> 00:30:37,870
transit depth and the transit depth have

747
00:30:43,799 --> 00:30:41,110
a function of wave them is what's giving

748
00:30:46,649 --> 00:30:43,809
us the planetary spectrum and if that's

749
00:30:48,090 --> 00:30:46,659
changing with the star as well we need

750
00:30:50,610 --> 00:30:48,100
to understand that we need to remove

751
00:30:53,759 --> 00:30:50,620
that stellar effect so I'm gonna take

752
00:30:55,529 --> 00:30:53,769
you through what I've done to try and

753
00:30:57,600 --> 00:30:55,539
remove that star effect and this is a

754
00:30:57,990 --> 00:30:57,610
lot based on the rack and papers and the

755
00:31:00,540 --> 00:30:58,000
equation

756
00:31:03,600 --> 00:31:00,550
that they had in there so first just

757
00:31:06,120 --> 00:31:03,610
look at what that might might do you can

758
00:31:08,850 --> 00:31:06,130
see your observed spectrum in green here

759
00:31:10,920 --> 00:31:08,860
and then the true planetary spectrum

760
00:31:12,600 --> 00:31:10,930
without the imprints of the star on it

761
00:31:14,940 --> 00:31:12,610
in blue there so that's what we're

762
00:31:17,310 --> 00:31:14,950
trying to get to and the way that we do

763
00:31:20,670 --> 00:31:17,320

that is we take simply the measured

764
00:31:24,090 --> 00:31:20,680
transit depth and that is equal to a

765
00:31:27,900 --> 00:31:24,100
contrast factor of the star so how

766
00:31:30,840 --> 00:31:27,910
different is the star to a real

767
00:31:34,770 --> 00:31:30,850
planetary spectrum so we can calculate

768
00:31:38,610 --> 00:31:34,780
what this contrast factor is by modeling

769
00:31:41,430 --> 00:31:38,620
what the flux of the star is and taking

770
00:31:42,660 --> 00:31:41,440
it as different components and what

771
00:31:44,880 --> 00:31:42,670
we're doing here is we're taking three

772
00:31:45,600 --> 00:31:44,890
temperature components of the star so

773
00:31:48,060 --> 00:31:45,610
we're saying you've got a base

774
00:31:50,040 --> 00:31:48,070
photosphere that is one temperature and

775
00:31:52,170 --> 00:31:50,050
you might have cool spots or hot spots

776
00:31:54,030 --> 00:31:52,180
so two different types of temperatures

777
00:31:57,030 --> 00:31:54,040
on that base photosphere ik temperature

778
00:31:59,370 --> 00:31:57,040
and we're trying to calculate how much

779
00:32:03,930 --> 00:31:59,380
area on the star each of those

780
00:32:06,360 --> 00:32:03,940
temperatures are represented by so you

781
00:32:10,050 --> 00:32:06,370
can then calculate what this factor is

782
00:32:12,240 --> 00:32:10,060
you need to multiply by your well divide

783
00:32:15,420 --> 00:32:12,250
your measured spectrum by to get your

784
00:32:17,580 --> 00:32:15,430
real spectrum and the way that we did

785
00:32:19,320 --> 00:32:17,590
that with Travis one is we've got a huge

786
00:32:22,890 --> 00:32:19,330
number of observations of this planet

787
00:32:24,450 --> 00:32:22,900
out of transit so out of transit no

788
00:32:26,400 --> 00:32:24,460

planets in front of the star this is

789
00:32:28,560 --> 00:32:26,410
just the star and what it looks like and

790
00:32:32,010 --> 00:32:28,570
we took all of those observations that

791
00:32:33,570 --> 00:32:32,020
we had we created a a ver egde template

792
00:32:36,540 --> 00:32:33,580
of that star for this particular

793
00:32:37,860 --> 00:32:36,550
observation and we fit different models

794
00:32:40,050 --> 00:32:37,870
to and we fit three different

795
00:32:43,290 --> 00:32:40,060
temperature component models to that

796
00:32:45,030 --> 00:32:43,300
star and we found we allowed them to

797
00:32:46,890 --> 00:32:45,040
vary in terms of the temperature that

798
00:32:49,470 --> 00:32:46,900
they wanted the fraction that they

799
00:32:51,270 --> 00:32:49,480
covered we created an entire grid of

800
00:32:53,700 --> 00:32:51,280
different temperatures and combination

801
00:32:57,390 --> 00:32:53,710
factors that we could do to find out

802
00:33:00,240 --> 00:32:57,400
what this star might look like and what

803
00:33:02,730 --> 00:33:00,250
we what we found was that with these

804
00:33:04,770 --> 00:33:02,740
three different temperatures sorry this

805
00:33:07,680 --> 00:33:04,780
is a bit dense but for the three

806
00:33:09,780 --> 00:33:07,690
different temperatures you end up with a

807
00:33:11,670 --> 00:33:09,790
single temperature model where your

808
00:33:14,010 --> 00:33:11,680
planets passing in front just of boring

809
00:33:15,810 --> 00:33:14,020
quiet star of the same temperature to

810
00:33:19,560 --> 00:33:15,820
temperatures where your planet passes in

811
00:33:21,150 --> 00:33:19,570
front a mixture of hot cool regions it

812
00:33:23,490 --> 00:33:21,160
passes just in front of the cool

813
00:33:25,920 --> 00:33:23,500

photosphere and it passes just in front

814
00:33:27,510 --> 00:33:25,930
of the hot bit and then again that same

815
00:33:29,370 --> 00:33:27,520
kind of combinations for the three

816
00:33:30,990 --> 00:33:29,380
temperature model and then you have it

817
00:33:32,490 --> 00:33:31,000
could pass in front of a cold and medium

818
00:33:35,790 --> 00:33:32,500
mix it could pass in front of a cold hot

819
00:33:37,590 --> 00:33:35,800
mix hot medium mix all of that and what

820
00:33:39,570 --> 00:33:37,600
you can do by looking at these fractions

821
00:33:41,070 --> 00:33:39,580
and painting you know logical steps

822
00:33:43,920 --> 00:33:41,080
through this is you can start ruling

823
00:33:46,800 --> 00:33:43,930
things out based on the stellar models

824
00:33:48,210 --> 00:33:46,810
and based on the fit to the observations

825
00:33:50,970 --> 00:33:48,220
that we got we were able to rule out the

826
00:33:53,490 --> 00:33:50,980
one temperature model this did not fit

827
00:33:56,220 --> 00:33:53,500
the what we are measuring from the start

828
00:33:57,720 --> 00:33:56,230
all we're then able to look at the

829
00:34:00,210 --> 00:33:57,730
different things that we've got here we

830
00:34:02,310 --> 00:34:00,220
can use the geometry of this to rule

831
00:34:05,550 --> 00:34:02,320
things out and it's really nice when you

832
00:34:07,290 --> 00:34:05,560
think about it logically you have a hot

833
00:34:10,580 --> 00:34:07,300
region in your to temperature model

834
00:34:15,330 --> 00:34:10,590
which covers 3.5% of the star surface

835
00:34:19,560 --> 00:34:15,340
and our planet transits that star it's

836
00:34:22,890 --> 00:34:19,570
not it would need to only cover a stripe

837
00:34:25,710 --> 00:34:22,900
of hot atmosphere around that star on

838
00:34:27,270 --> 00:34:25,720

its transit not go anywhere near any

839
00:34:29,970 --> 00:34:27,280
cool bits so that would mean that the

840
00:34:33,240 --> 00:34:29,980
star would have a stripe of hot around

841
00:34:35,580 --> 00:34:33,250
it and that is according to all of the

842
00:34:37,550 --> 00:34:35,590
seller physicists I talked to completely

843
00:34:40,950 --> 00:34:37,560
unrealistic so we can rule that one out

844
00:34:43,020 --> 00:34:40,960
we can also rule out this hot model here

845
00:34:45,840 --> 00:34:43,030
as well and we can rule out the medium

846
00:34:49,740 --> 00:34:45,850
model for a very similar reason so we've

847
00:34:52,770 --> 00:34:49,750
already been able to rule out a huge

848
00:34:54,270 --> 00:34:52,780
number of this parameter space so we can

849
00:34:56,730 --> 00:34:54,280
start digging down and trying to

850
00:34:58,530 --> 00:34:56,740
understand ok what's left what are the

851
00:35:00,240 --> 00:34:58,540
possibilities that are left this planet

852
00:35:01,560 --> 00:35:00,250
is passing in front of the mixture of

853
00:35:04,110 --> 00:35:01,570
different temperature regions it's

854
00:35:06,270 --> 00:35:04,120
evenly distributed across the stellar

855
00:35:07,710 --> 00:35:06,280
surface or there's kind of some spots in

856
00:35:09,540 --> 00:35:07,720
there that are nice and small that we

857
00:35:12,090 --> 00:35:09,550
don't see in the transit like curves

858
00:35:15,840 --> 00:35:12,100
we're not seeing any evidence whatsoever

859
00:35:17,310 --> 00:35:15,850
of spot occupation and we can start

860
00:35:19,680 --> 00:35:17,320
ruling these out and we do that by

861
00:35:21,750 --> 00:35:19,690
taking that equation we take our

862
00:35:24,390 --> 00:35:21,760
measured transmission spectrum we

863
00:35:25,140 --> 00:35:24,400

calculate the contrast factors for each

864
00:35:27,630 --> 00:35:25,150
of those calm

865
00:35:30,769 --> 00:35:27,640
Nations these are what the correction

866
00:35:33,930 --> 00:35:30,779
factors should be and you end up with a

867
00:35:35,250 --> 00:35:33,940
series of five potential transmission

868
00:35:37,980 --> 00:35:35,260
spectra for what this planetary

869
00:35:40,500 --> 00:35:37,990
atmosphere should look like so we've got

870
00:35:42,660 --> 00:35:40,510
five different potential poetry

871
00:35:45,029 --> 00:35:42,670
transmission spectra so now let's take

872
00:35:47,370 --> 00:35:45,039
some more logical steps which we're

873
00:35:49,740 --> 00:35:47,380
going to take the first logical step of

874
00:35:51,660 --> 00:35:49,750
saying that this plant could not have an

875
00:35:53,579 --> 00:35:51,670
atmosphere greater than scale height

876
00:35:54,930 --> 00:35:53,589
five scale Heights here and we know that

877
00:35:57,660 --> 00:35:54,940
because then we would measure it to be a

878
00:36:00,809 --> 00:35:57,670
mini Neptune and it's very much got a

879
00:36:04,470 --> 00:36:00,819
mass and density of an earth as well so

880
00:36:07,260 --> 00:36:04,480
we're actually only left with two we're

881
00:36:10,920 --> 00:36:07,270
left with the green one which is

882
00:36:12,960 --> 00:36:10,930
actually our original measurement so the

883
00:36:15,630 --> 00:36:12,970
measured transmission spectrum is equal

884
00:36:18,089 --> 00:36:15,640
to the real transmission structure of

885
00:36:20,640 --> 00:36:18,099
the planet and the purple one which

886
00:36:21,750 --> 00:36:20,650
suggests that the planet is the star is

887
00:36:24,870 --> 00:36:21,760
represented by three different

888
00:36:26,549 --> 00:36:24,880

temperatures and that the planet is

889
00:36:28,170 --> 00:36:26,559
passing in front of a mixture of the

890
00:36:31,200 --> 00:36:28,180
cool and medium temperatures in that

891
00:36:35,279 --> 00:36:31,210
model and we can look at each of those

892
00:36:37,260 --> 00:36:35,289
in turn and we can start now by being

893
00:36:40,980 --> 00:36:37,270
planetary scientists so we've gone from

894
00:36:43,620 --> 00:36:40,990
stellar physicists to mathematicians and

895
00:36:46,470 --> 00:36:43,630
geographers essentially to planetary

896
00:36:48,539 --> 00:36:46,480
scientists finally um we were using

897
00:36:51,029 --> 00:36:48,549
models which were created by Sarah Moran

898
00:36:53,010 --> 00:36:51,039
and you can go find and talk to her she

899
00:36:54,870 --> 00:36:53,020
presented a poster earlier this week but

900
00:36:57,120 --> 00:36:54,880
please go and chat about the models that

901
00:37:00,470 --> 00:36:57,130
she made for us these are based on the

902
00:37:03,299 --> 00:37:00,480
data that comes from the horse lab and

903
00:37:05,370 --> 00:37:03,309
using the information from that she

904
00:37:06,930 --> 00:37:05,380
created a series of models for all of

905
00:37:09,960 --> 00:37:06,940
the Travis planets you can see that in

906
00:37:11,579 --> 00:37:09,970
in her paper in 2018 all of the

907
00:37:13,680 --> 00:37:11,589
different rapid fire ants for both both

908
00:37:15,809 --> 00:37:13,690
chemically generated species Solis hates

909
00:37:18,029 --> 00:37:15,819
particles and these different cloud

910
00:37:20,279 --> 00:37:18,039
particles how might they affect what

911
00:37:22,019 --> 00:37:20,289
transmission Spectre you're getting how

912
00:37:23,430 --> 00:37:22,029
might they change what you'll get to be

913
00:37:25,410 --> 00:37:23,440

measuring so using those different

914
00:37:27,720 --> 00:37:25,420
models that she created for us we looked

915
00:37:30,210 --> 00:37:27,730
at each of these transmission spectra

916
00:37:33,269 --> 00:37:30,220
and what we were able to find was that

917
00:37:35,309 --> 00:37:33,279
there is only one possibility that is

918
00:37:37,710 --> 00:37:35,319
reasonable for this planetary

919
00:37:39,089 --> 00:37:37,720
configuration that the measured

920
00:37:42,089 --> 00:37:39,099
transmission spectrum of trap

921
00:37:44,309 --> 00:37:42,099
1g is the real transmission spectrum of

922
00:37:46,620 --> 00:37:44,319
traffice 1g and that means that we're

923
00:37:49,049 --> 00:37:46,630
not getting this contrast effect we're

924
00:37:51,749 --> 00:37:49,059
not measuring differences on the star

925
00:37:53,609 --> 00:37:51,759
and that's really great here that would

926
00:37:55,140 --> 00:37:53,619
be really nice it makes our life simpler

927
00:37:56,940 --> 00:37:55,150
to make that assumption but what I'm

928
00:37:59,729 --> 00:37:56,950
saying is we can't make that assumption

929
00:38:02,549 --> 00:37:59,739
we do have to go through this grueling

930
00:38:04,170 --> 00:38:02,559
process of analyzing each of these types

931
00:38:06,989 --> 00:38:04,180
of planets around these M stars these

932
00:38:10,109 --> 00:38:06,999
cool stars through a step-by-step

933
00:38:12,150 --> 00:38:10,119
process to rule out the presence of

934
00:38:14,430 --> 00:38:12,160
stellar features on the measured

935
00:38:15,930 --> 00:38:14,440
transmission spectrum so it's going to

936
00:38:17,489 --> 00:38:15,940
be a little bit grueling for everybody

937
00:38:20,099 --> 00:38:17,499
when we're doing this but it's so

938
00:38:22,920 --> 00:38:20,109

important so that web they're using our

939
00:38:25,229 --> 00:38:22,930
models we can know that we're looking at

940
00:38:28,499 --> 00:38:25,239
what the planet is giving us and not

941
00:38:30,210 --> 00:38:28,509
what the star is giving us so I'm just

942
00:38:32,160 --> 00:38:30,220
going to show you what those logical

943
00:38:34,440 --> 00:38:32,170
steps are just so that you've got them

944
00:38:36,960 --> 00:38:34,450
written down please take a picture or go

945
00:38:38,910 --> 00:38:36,970
look at the paper you need to measure

946
00:38:41,370 --> 00:38:38,920
the stellar spectrum out of transit you

947
00:38:43,950 --> 00:38:41,380
need to have an understanding of over a

948
00:38:46,890 --> 00:38:43,960
fairly decent amount of time what this

949
00:38:48,569 --> 00:38:46,900
star looks like if you're going to fit

950
00:38:52,799 --> 00:38:48,579
the models to it the models aren't

951
00:38:55,620 --> 00:38:52,809
perfect the models are actually quite

952
00:38:57,630 --> 00:38:55,630
wrong in some cases you need to make

953
00:38:59,160 --> 00:38:57,640
sure that you're fitting multiple

954
00:39:01,950 --> 00:38:59,170
different models and you are scaling

955
00:39:04,109 --> 00:39:01,960
them to the correct unit the units are

956
00:39:06,180 --> 00:39:04,119
hugely important here please go read the

957
00:39:08,969 --> 00:39:06,190
paper to why the units are hugely

958
00:39:12,660 --> 00:39:08,979
important here do not inflate the

959
00:39:14,940 --> 00:39:12,670
uncertainties on your data so units are

960
00:39:17,670 --> 00:39:14,950
hugely important use the geometries are

961
00:39:19,319 --> 00:39:17,680
the logic where is this planet passing

962
00:39:22,950 --> 00:39:19,329
in front of its star could you have just

963
00:39:24,900 --> 00:39:22,960

a stripe of hot spot is the spots that

964
00:39:26,670 --> 00:39:24,910
you would expect the fractional coverage

965
00:39:28,890 --> 00:39:26,680
big enough that you might expect an

966
00:39:31,709 --> 00:39:28,900
occultation event if you don't see one

967
00:39:34,140 --> 00:39:31,719
you can actually put a limit on the

968
00:39:35,609 --> 00:39:34,150
sizes of the spots on the atmosphere and

969
00:39:39,209 --> 00:39:35,619
we actually do that for this traffice

970
00:39:41,880 --> 00:39:39,219
one planet as well and then use those

971
00:39:45,989 --> 00:39:41,890
corrective models to your different

972
00:39:47,729 --> 00:39:45,999
measured and potentially real planetary

973
00:39:49,229 --> 00:39:47,739
transmission spectra with theoretical

974
00:39:52,140 --> 00:39:49,239
models to try and understand which ones

975
00:39:55,020 --> 00:39:52,150
might be might be real and in fact I

976
00:39:56,550 --> 00:39:55,030
let you know that we didn't know the

977
00:39:58,350 --> 00:39:56,560
difference between the two of them until

978
00:39:59,790 --> 00:39:58,360
we looked out to the Spitzer data points

979
00:40:02,100 --> 00:39:59,800
as well so you can't just correct the

980
00:40:04,200 --> 00:40:02,110
date you've got use all the data on that

981
00:40:07,410 --> 00:40:04,210
planet and use the correction factor

982
00:40:09,660 --> 00:40:07,420
over the right wavelength ranges to

983
00:40:13,650 --> 00:40:09,670
correct it and try and understand those

984
00:40:15,900 --> 00:40:13,660
planetary atmospheres so that's kind of

985
00:40:17,400 --> 00:40:15,910
a whirlwind tour through the problems

986
00:40:21,240 --> 00:40:17,410
that we have with terrestrial planets

987
00:40:24,540 --> 00:40:21,250
but also the amazing array of different

988
00:40:28,950 --> 00:40:24,550

types of worlds that we've got and the

989
00:40:30,720 --> 00:40:28,960
question is where do we go from here I'm

990
00:40:35,760 --> 00:40:30,730
not going to just focus on web but I do

991
00:40:39,780 --> 00:40:35,770
like the awful pun we have in the future

992
00:40:43,080 --> 00:40:39,790
a huge number of missions at our

993
00:40:47,340 --> 00:40:43,090
disposal and that it's going to really

994
00:40:51,600 --> 00:40:47,350
really Drive exoplanets forward this is

995
00:40:54,780 --> 00:40:51,610
a new field maybe not anymore but it's

996
00:40:56,160 --> 00:40:54,790
going to get Wilder it's going to get

997
00:40:58,740 --> 00:40:56,170
more difficult and there's going to be

998
00:41:02,540 --> 00:40:58,750
way more data than we've ever known how

999
00:41:05,900 --> 00:41:02,550
to handle before so we're gonna scare

1000
00:41:12,540 --> 00:41:05,910
the crap out of the theorists for a bit

1001
00:41:14,730 --> 00:41:12,550
so get ready cuz we're excited for it so

1002
00:41:16,350 --> 00:41:14,740
we've currently got lots of really nice

1003
00:41:18,000 --> 00:41:16,360
missions going on I didn't list them all

1004
00:41:19,560 --> 00:41:18,010
here we've got tests which is really

1005
00:41:21,890 --> 00:41:19,570
churning out planets I haven't talked

1006
00:41:23,760 --> 00:41:21,900
about any of them here but there are

1007
00:41:25,350 --> 00:41:23,770
tons of them and if you're following

1008
00:41:28,350 --> 00:41:25,360
along with the test science conference

1009
00:41:30,270 --> 00:41:28,360
week or so ago then you had seen loads

1010
00:41:31,980 --> 00:41:30,280
of stuff and if your extreme Sol systems

1011
00:41:33,750 --> 00:41:31,990
next week you will see even more stuff

1012
00:41:36,090 --> 00:41:33,760
coming out from those to have fun it's

1013
00:41:38,970 --> 00:41:36,100

some characterization stuff as well so

1014
00:41:41,940 --> 00:41:38,980
keep an eye out for that we've got James

1015
00:41:43,500 --> 00:41:41,950
Webb launching we've got G cleff coming

1016
00:41:45,300 --> 00:41:43,510
online which would be great and we've

1017
00:41:47,340 --> 00:41:45,310
got all of these different types of

1018
00:41:49,560 --> 00:41:47,350
instruments which are going to help us

1019
00:41:51,240 --> 00:41:49,570
characterize these very small ones

1020
00:41:53,960 --> 00:41:51,250
really pushing down to these small

1021
00:41:57,930 --> 00:41:53,970
worlds and I wouldn't be doing my job

1022
00:42:00,930 --> 00:41:57,940
from Space Telescope if I didn't remind

1023
00:42:05,150 --> 00:42:00,940
you that in the next year you have a lot

1024
00:42:07,819 --> 00:42:05,160
of work to do we have two proposal

1025
00:42:10,220 --> 00:42:07,829
like that we really focus on here and

1026
00:42:13,849 --> 00:42:10,230
exoplanets coming up we've got the HSC

1027
00:42:16,069 --> 00:42:13,859
28 so that cool will go out in November

1028
00:42:19,609 --> 00:42:16,079
you will then need your proposals in by

1029
00:42:21,499 --> 00:42:19,619
March 1st it's earlier than normal the

1030
00:42:23,900 --> 00:42:21,509
call for proposals for James Webb will

1031
00:42:25,640 --> 00:42:23,910
be going out in January sometime and

1032
00:42:27,499 --> 00:42:25,650
then your proposals will be due in May

1033
00:42:32,259 --> 00:42:27,509
just two months after your Hubble

1034
00:42:34,190 --> 00:42:32,269
proposals so get writing now please

1035
00:42:39,200 --> 00:42:34,200
seriously don't leave it to the last

1036
00:42:41,599 --> 00:42:39,210
minute it really stresses me out but

1037
00:42:43,640 --> 00:42:41,609
it's not just that's like one proposals

1038
00:42:45,589 --> 00:42:43,650

we already know that James Webb is going

1039
00:42:49,220 --> 00:42:45,599
to be looking at loads of small planets

1040
00:42:52,190 --> 00:42:49,230
in fact almost half of the gto time that

1041
00:42:54,680 --> 00:42:52,200
is dedicated to exoplanets which is 27%

1042
00:42:57,410 --> 00:42:54,690
of all of the gto time we're really

1043
00:43:00,859 --> 00:42:57,420
crushing it as a field and making the

1044
00:43:03,440 --> 00:43:00,869
cosmologists very angry at us which I

1045
00:43:05,359 --> 00:43:03,450
hear far too often that we've got

1046
00:43:09,200 --> 00:43:05,369
roughly half of these are actually

1047
00:43:11,870 --> 00:43:09,210
smaller planets and I'm defining smaller

1048
00:43:13,970 --> 00:43:11,880
here coming from the water 1:07 which is

1049
00:43:15,620 --> 00:43:13,980
actually a fairly large world very

1050
00:43:16,910 --> 00:43:15,630
nicely inflated we're gonna have lots of

1051
00:43:20,660 --> 00:43:16,920
photons from that one that one's gonna

1052
00:43:23,240 --> 00:43:20,670
be nice observation down through to that

1053
00:43:25,249 --> 00:43:23,250
Trappist one system that I showed you so

1054
00:43:28,819 --> 00:43:25,259
we're getting GTO

1055
00:43:30,710 --> 00:43:28,829
guaranteed observations of all of these

1056
00:43:32,720 --> 00:43:30,720
different worlds and the black dots up

1057
00:43:34,609 --> 00:43:32,730
here represents the the larger planets

1058
00:43:36,259 --> 00:43:34,619
that we'll be looking at and put in

1059
00:43:38,450 --> 00:43:36,269
brackets over here whether it's a

1060
00:43:40,880 --> 00:43:38,460
transit or eclipse so we're getting a

1061
00:43:42,140 --> 00:43:40,890
mixture of transit observations which

1062
00:43:44,089 --> 00:43:42,150
are the ones I've been showing you today

1063
00:43:45,650 --> 00:43:44,099

I've really been only showing you the

1064
00:43:47,839 --> 00:43:45,660
transmission spectrum the absorption

1065
00:43:49,880 --> 00:43:47,849
spectrum of these planetary atmospheres

1066
00:43:51,410 --> 00:43:49,890
if they have one but emission is so

1067
00:43:53,480 --> 00:43:51,420
important for trying to understand the

1068
00:43:54,740 --> 00:43:53,490
temperature structure if they have an

1069
00:43:56,660 --> 00:43:54,750
atmosphere what's the temperature

1070
00:43:58,460 --> 00:43:56,670
structure if they don't can we get any

1071
00:44:00,650 --> 00:43:58,470
kind of measurement from the surface at

1072
00:44:02,299 --> 00:44:00,660
all and we got lots of eclipse

1073
00:44:04,009 --> 00:44:02,309
measurements and a phase curve up here

1074
00:44:06,259 --> 00:44:04,019
as well for some of these smaller ones

1075
00:44:08,329 --> 00:44:06,269
this is because I couldn't find the mass

1076
00:44:10,039 --> 00:44:08,339
of this planet or this planet so I'm not

1077
00:44:11,900 --> 00:44:10,049
really sure where they lie but I will

1078
00:44:14,940 --> 00:44:11,910
definitely update it once I have better

1079
00:44:17,160 --> 00:44:14,950
numbers on those and

1080
00:44:19,319 --> 00:44:17,170
to give you an idea of what those James

1081
00:44:23,040 --> 00:44:19,329
Webb observations might look like here's

1082
00:44:25,849 --> 00:44:23,050
a very complicated slide so on the top

1083
00:44:28,290 --> 00:44:25,859
we're seeing some transmission spectra

1084
00:44:30,120 --> 00:44:28,300
simulations these are partial battaglia

1085
00:44:32,280 --> 00:44:30,130
you can see various different

1086
00:44:34,859 --> 00:44:32,290
combinations of gases and what we might

1087
00:44:40,829 --> 00:44:34,869
see for this poetry atmosphere this is

1088
00:44:42,329 --> 00:44:40,839

the most kind of optimistic version of

1089
00:44:43,920 --> 00:44:42,339
the transmission spectra we will be

1090
00:44:47,630 --> 00:44:43,930
measuring with the GG program which is

1091
00:44:50,819 --> 00:44:47,640
led by Nicole Lewis we will be getting 4

1092
00:44:53,310 --> 00:44:50,829
full transit observations of Travis 1e

1093
00:44:55,950 --> 00:44:53,320
with the prism which will allow us to

1094
00:44:57,930 --> 00:44:55,960
get the full spectrum from point six out

1095
00:44:59,880 --> 00:44:57,940
to five microns in one shot while we

1096
00:45:02,130 --> 00:44:59,890
gain four of those to get this

1097
00:45:04,140 --> 00:45:02,140
uncertainty compared to what we measured

1098
00:45:06,569 --> 00:45:04,150
with Hubble with two so you can see

1099
00:45:08,220 --> 00:45:06,579
we're going to learn something even if

1100
00:45:12,210 --> 00:45:08,230
it's a bowling ball we'll learn that

1101
00:45:14,310 --> 00:45:12,220
it's a very precise bowling ball so this

1102
00:45:16,020 --> 00:45:14,320
is really really exciting and then we

1103
00:45:18,420 --> 00:45:16,030
heard a little bit earlier but Caroline

1104
00:45:20,730 --> 00:45:18,430
Molly's got an excellent paper in 2017

1105
00:45:21,870 --> 00:45:20,740
looking through at the difference in

1106
00:45:23,520 --> 00:45:21,880
motions that you can get and really

1107
00:45:25,890 --> 00:45:23,530
importantly looking at the thermal

1108
00:45:27,870 --> 00:45:25,900
component looking at the emission of

1109
00:45:29,700 --> 00:45:27,880
these planets and in fact out of the gto

1110
00:45:32,640 --> 00:45:29,710
program the trapper swamp eyes are only

1111
00:45:34,740 --> 00:45:32,650
looked at in emissions for Travis 1b so

1112
00:45:36,030 --> 00:45:34,750
if you want to put in any proposals to

1113
00:45:38,099 --> 00:45:36,040

look at any of the other planets in a

1114
00:45:40,500 --> 00:45:38,109
mission please do please put those

1115
00:45:43,200 --> 00:45:40,510
proposals in lead that charge trying to

1116
00:45:45,180 --> 00:45:43,210
get the information there and then some

1117
00:45:47,790 --> 00:45:45,190
recent work which we've got on some very

1118
00:45:50,670 --> 00:45:47,800
nice posters please go out and talk to

1119
00:45:53,760 --> 00:45:50,680
them which just came out on archive like

1120
00:45:55,650 --> 00:45:53,770
they said where we're looking at how the

1121
00:45:57,720 --> 00:45:55,660
emission can be measured for these

1122
00:45:59,309 --> 00:45:57,730
planets and what that tells us that's

1123
00:46:01,859 --> 00:45:59,319
the most important thing what does that

1124
00:46:03,300 --> 00:46:01,869
tell us we've got the models which come

1125
00:46:05,069 --> 00:46:03,310
from Eric and we've got the

1126
00:46:06,960 --> 00:46:05,079
observational constraints that we might

1127
00:46:08,819 --> 00:46:06,970
be able to get from Mansfield so please

1128
00:46:10,710 --> 00:46:08,829
go and see those posters in any time

1129
00:46:13,620 --> 00:46:10,720
that you have and have a chat for them

1130
00:46:16,620 --> 00:46:13,630
because this is so important we need to

1131
00:46:18,569 --> 00:46:16,630
predict and we need to simulate these

1132
00:46:21,059 --> 00:46:18,579
observations so that we can try and

1133
00:46:23,250 --> 00:46:21,069
understand these worlds and just to put

1134
00:46:26,370 --> 00:46:23,260
this in context I normally work giant

1135
00:46:28,500 --> 00:46:26,380
planets because I'm lazy this is much

1136
00:46:30,450 --> 00:46:28,510
much easier to measure this is

1137
00:46:32,160 --> 00:46:30,460
much easier to measure it's very nice to

1138
00:46:34,110 --> 00:46:32,170

see when you do a data analysis and this

1139
00:46:37,770 --> 00:46:34,120
big massive water bump comes out it's

1140
00:46:41,430 --> 00:46:37,780
beautiful this is the scale of that very

1141
00:46:44,640 --> 00:46:41,440
very optimistic travis 1e transmission

1142
00:46:46,320 --> 00:46:44,650
the spectrum I just showed you but to

1143
00:46:49,140 --> 00:46:46,330
still put that in context the

1144
00:46:52,020 --> 00:46:49,150
uncertainty on that with tiny we can

1145
00:46:53,580 --> 00:46:52,030
measure this with James Webb you can

1146
00:46:56,370 --> 00:46:53,590
measure the relative difference between

1147
00:46:58,050 --> 00:46:56,380
this massive feature which to be honest

1148
00:47:03,090 --> 00:46:58,060
we're going to get in such good detail

1149
00:47:07,440 --> 00:47:03,100
I'm very excited about that yeah I don't

1150
00:47:11,640 --> 00:47:07,450
know anything but we can do this we can

1151
00:47:12,990 --> 00:47:11,650
measure these with James Webb so we've

1152
00:47:14,640 --> 00:47:13,000
got really big questions

1153
00:47:17,400 --> 00:47:14,650
compared to hot Jupiters it's not

1154
00:47:21,300 --> 00:47:17,410
impossible I hope I've convinced you of

1155
00:47:23,730 --> 00:47:21,310
that we need multi cycle programs to

1156
00:47:25,800 --> 00:47:23,740
really push this field to smaller

1157
00:47:28,200 --> 00:47:25,810
planets we need multi cycle programs

1158
00:47:29,640 --> 00:47:28,210
which go back and look at these planets

1159
00:47:31,710 --> 00:47:29,650
and that's got to be a coordinated

1160
00:47:36,090 --> 00:47:31,720
effort this has got to be a coordinated

1161
00:47:37,530 --> 00:47:36,100
effort across the community can think

1162
00:47:38,730 --> 00:47:37,540
about when you're writing your proposals

1163
00:47:40,470 --> 00:47:38,740

or thinking about the models that you're

1164
00:47:42,630 --> 00:47:40,480
gonna be running can any of the current

1165
00:47:44,220 --> 00:47:42,640
GTO programs can any of the current

1166
00:47:46,470 --> 00:47:44,230
observations that will be getting

1167
00:47:48,720 --> 00:47:46,480
Darren's help with that can they help

1168
00:47:51,080 --> 00:47:48,730
with your proposal can may help really

1169
00:47:53,450 --> 00:47:51,090
push forward what you want to be doing

1170
00:47:55,560 --> 00:47:53,460
we need to understand what the noise is

1171
00:47:57,270 --> 00:47:55,570
associated with this we saw some some

1172
00:47:59,100 --> 00:47:57,280
talks where we can learn about the noise

1173
00:48:01,620 --> 00:47:59,110
the noise is important it really

1174
00:48:02,970 --> 00:48:01,630
restricts what we can do where is the

1175
00:48:04,200 --> 00:48:02,980
noise for on this and how does that

1176
00:48:06,660 --> 00:48:04,210
limit us and that's something we're

1177
00:48:08,190 --> 00:48:06,670
going to learn when we're on Sky so make

1178
00:48:14,460 --> 00:48:08,200
sure you're keeping that in mind when

1179
00:48:16,590 --> 00:48:14,470
you upgrade your models later on and can

1180
00:48:19,140 --> 00:48:16,600
we get phrase curves of non transiting

1181
00:48:20,520 --> 00:48:19,150
planets really think about that that's a

1182
00:48:21,990 --> 00:48:20,530
really important one we're talking about

1183
00:48:24,090 --> 00:48:22,000
the temperature structure it's not just

1184
00:48:26,490 --> 00:48:24,100
the transiting planets here in terms of

1185
00:48:27,630 --> 00:48:26,500
that characterization if we want to try

1186
00:48:28,560 --> 00:48:27,640
and understand these larval words a

1187
00:48:30,540 --> 00:48:28,570
little bit more is there a non

1188
00:48:32,340 --> 00:48:30,550

transferring one that we can use so I

1189
00:48:33,810 --> 00:48:32,350
think that there's a lot of combinations

1190
00:48:36,720 --> 00:48:33,820
of things across the community that can

1191
00:48:38,280 --> 00:48:36,730
do and it's really moving further

1192
00:48:40,770 --> 00:48:38,290
forward um for that timeline that I

1193
00:48:42,279 --> 00:48:40,780
showed you into that era of the giant

1194
00:48:45,159 --> 00:48:42,289
telescopes the extreme

1195
00:48:48,339 --> 00:48:45,169
large telescopes and looking at both

1196
00:48:49,659 --> 00:48:48,349
their reflected and the thermal from

1197
00:48:52,749 --> 00:48:49,669
these planets we need to be looking in

1198
00:48:57,099 --> 00:48:52,759
the optical Hubble is not dead Hubble is

1199
00:48:59,169 --> 00:48:57,109
still kicking around please use it to

1200
00:49:01,839 --> 00:48:59,179
look in the optical he needs the optical

1201
00:49:03,579 --> 00:49:01,849
measurement and the ELT is on the ground

1202
00:49:06,609 --> 00:49:03,589
are going to do a fantastic job of

1203
00:49:09,069 --> 00:49:06,619
looking at reflected light from both you

1204
00:49:12,309 --> 00:49:09,079
know directly image planets as well

1205
00:49:13,779 --> 00:49:12,319
which is going to teach us a lot try and

1206
00:49:15,429 --> 00:49:13,789
understand how they fit into those

1207
00:49:16,989 --> 00:49:15,439
matter atheist relations and if we can

1208
00:49:21,479 --> 00:49:16,999
really refine those measurements we can

1209
00:49:24,489 --> 00:49:21,489
possibly estimate a good radius on them

1210
00:49:27,339 --> 00:49:24,499
own eat the EOPS can realistically get

1211
00:49:29,259 --> 00:49:27,349
both of these and we need to make sure

1212
00:49:31,059 --> 00:49:29,269
that we're not just focusing on the

1213
00:49:32,949 --> 00:49:31,069

space based kind of transmission studies

1214
00:49:34,779 --> 00:49:32,959
we need to be looking towards what we

1215
00:49:36,429 --> 00:49:34,789
can do to combine the phase space

1216
00:49:37,870 --> 00:49:36,439
where's the overlap between transiting

1217
00:49:39,579 --> 00:49:37,880
planets and directly which planets can

1218
00:49:40,959 --> 00:49:39,589
we use that one of the things that I

1219
00:49:45,489 --> 00:49:40,969
think's really interesting to consider

1220
00:49:48,249 --> 00:49:45,499
is the friends of hot Jupiters or the

1221
00:49:49,779 --> 00:49:48,259
the small transiting planets that we

1222
00:49:52,059 --> 00:49:49,789
have and there's an a radial velocity

1223
00:49:53,679 --> 00:49:52,069
planet further out can we use the Yale

1224
00:49:55,559 --> 00:49:53,689
piece look at planets where we've got an

1225
00:49:58,419 --> 00:49:55,569
inner transiting planet and an outer

1226
00:50:00,640 --> 00:49:58,429
radius rotc planet can we use that to

1227
00:50:03,959 --> 00:50:00,650
understand each of them in turn and how

1228
00:50:06,039 --> 00:50:03,969
they might have evolved over time and

1229
00:50:07,599 --> 00:50:06,049
obviously looking even further into the

1230
00:50:09,399 --> 00:50:07,609
future it doesn't even fit a or near

1231
00:50:12,309 --> 00:50:09,409
that time line we're talking about

1232
00:50:14,499 --> 00:50:12,319
currently at NASA is asking for

1233
00:50:17,109 --> 00:50:14,509
information on these three really

1234
00:50:20,049 --> 00:50:17,119
benchmark missions the origins which

1235
00:50:22,749 --> 00:50:20,059
will be a trancing kind of based

1236
00:50:24,699 --> 00:50:22,759
exoplanet mission we've got habits which

1237
00:50:26,319 --> 00:50:24,709
we'll be looking at mostly directly

1238
00:50:29,739 --> 00:50:26,329

image by and Louvois

1239
00:50:31,809 --> 00:50:29,749
which will do whatever it can do with

1240
00:50:33,789 --> 00:50:31,819
the biggest mirror it can possibly build

1241
00:50:36,640 --> 00:50:33,799
in space without breaking the budget of

1242
00:50:38,409 --> 00:50:36,650
the entire world so there's a number of

1243
00:50:40,329 --> 00:50:38,419
people here that can talk to you about

1244
00:50:42,489 --> 00:50:40,339
that please go find them and chat about

1245
00:50:48,489 --> 00:50:42,499
those missions I'm afraid I'm not not an

1246
00:50:50,259 --> 00:50:48,499
expert on that we do have a poster by by

1247
00:50:53,019 --> 00:50:50,269
ty and he can tell you a lot about

1248
00:50:54,819 --> 00:50:53,029
habits and I definitely cannot so direct

1249
00:50:56,110 --> 00:50:54,829
your questions to him but I want to

1250
00:50:58,870 --> 00:50:56,120
leave you with

1251
00:51:01,270 --> 00:50:58,880
this horribleness these are outstanding

1252
00:51:02,470 --> 00:51:01,280
questions please if some of the

1253
00:51:06,310 --> 00:51:02,480
outstanding question I think this week

1254
00:51:07,840 --> 00:51:06,320
we see and applause about standing

1255
00:51:10,180 --> 00:51:07,850
questions that we need to answer as a

1256
00:51:12,100 --> 00:51:10,190
community and it really stopped talking

1257
00:51:13,780 --> 00:51:12,110
more of the giant planets where which

1258
00:51:15,250 --> 00:51:13,790
thing to look at those formation markers

1259
00:51:16,690 --> 00:51:15,260
can we use the c2 officio the

1260
00:51:18,250 --> 00:51:16,700
metallicity of these hydrogen helium

1261
00:51:19,750 --> 00:51:18,260
dominates that says where does that

1262
00:51:23,260 --> 00:51:19,760
break down whether the hydrogen helium

1263
00:51:25,090 --> 00:51:23,270

lift of these planets break down what

1264
00:51:27,910 --> 00:51:25,100
makes up the atmospheres where is that

1265
00:51:29,410 --> 00:51:27,920
methane can we use web in the 3.3 micron

1266
00:51:31,120 --> 00:51:29,420
region where it's more dominant and we

1267
00:51:33,130 --> 00:51:31,130
should be able to see it to really

1268
00:51:34,870 --> 00:51:33,140
search for those signatures that's going

1269
00:51:36,190 --> 00:51:34,880
to be really interesting for us to try

1270
00:51:39,400 --> 00:51:36,200
and understand the dynamical and

1271
00:51:41,410 --> 00:51:39,410
critical nature of this planet do the

1272
00:51:44,140 --> 00:51:41,420
traffic I don't even have an atmosphere

1273
00:51:47,590 --> 00:51:44,150
for a number of the move we will be able

1274
00:51:49,180 --> 00:51:47,600
to answer that and I'm not sure what

1275
00:51:54,250 --> 00:51:49,190
happens when we do forget your models

1276
00:51:56,890 --> 00:51:54,260
ready how can we classify them and is it

1277
00:51:58,840 --> 00:51:56,900
important then we classify them how

1278
00:52:01,990 --> 00:51:58,850
important are those classifications in

1279
00:52:04,630 --> 00:52:02,000
terms of understanding the demographic

1280
00:52:06,790 --> 00:52:04,640
of planets out there we want to

1281
00:52:08,650 --> 00:52:06,800
understand how likely it is for a solar

1282
00:52:11,530 --> 00:52:08,660
system to form how likely is it to have

1283
00:52:14,170 --> 00:52:11,540
a system without a super elf or mini

1284
00:52:16,870 --> 00:52:14,180
Neptune we've got this gap everyone else

1285
00:52:19,300 --> 00:52:16,880
seems to have one why don't we how can

1286
00:52:21,190 --> 00:52:19,310
we try and understand what these planets

1287
00:52:23,140 --> 00:52:21,200
are made of to really fill in the

1288
00:52:26,410 --> 00:52:23,150

information we're missing from our solar

1289
00:52:27,460 --> 00:52:26,420
system and then another thing I really

1290
00:52:29,440 --> 00:52:27,470
want you to think about so I want to

1291
00:52:31,570 --> 00:52:29,450
break these I don't want them to be

1292
00:52:33,340 --> 00:52:31,580
fundamental limits but these are the

1293
00:52:36,190 --> 00:52:33,350
ones that I came up with as fundamental

1294
00:52:37,630 --> 00:52:36,200
limits and I hope that they're not so we

1295
00:52:40,540 --> 00:52:37,640
need to work out how we can break these

1296
00:52:42,160 --> 00:52:40,550
as with much as we possibly can stellar

1297
00:52:44,050 --> 00:52:42,170
granulation is going to be a problem we

1298
00:52:47,230 --> 00:52:44,060
don't know that stars as well as we

1299
00:52:50,530 --> 00:52:47,240
think we know them we need to know what

1300
00:52:52,180 --> 00:52:50,540
these stars are doing is there a perfect

1301
00:52:53,470 --> 00:52:52,190
target people keep saying if we find the

1302
00:52:55,090 --> 00:52:53,480
perfect target we'll be able to do this

1303
00:52:55,510 --> 00:52:55,100
that and the other what's the perfect

1304
00:52:56,770 --> 00:52:55,520
target

1305
00:52:58,390 --> 00:52:56,780
where am i looking for this perfect

1306
00:52:59,530 --> 00:52:58,400
target what does it consist of how do

1307
00:53:02,110 --> 00:52:59,540
you know it's a perfect target until

1308
00:53:03,970 --> 00:53:02,120
you've looked at it it's an absolute

1309
00:53:05,500 --> 00:53:03,980
nightmare of a phrase and it's real

1310
00:53:06,880 --> 00:53:05,510
fundamental limit for a lot of the

1311
00:53:09,790 --> 00:53:06,890
models that I'm saying and I'm just like

1312
00:53:11,440 --> 00:53:09,800
what's the perfect time what do you want

1313
00:53:14,020 --> 00:53:11,450

what do you need to see and how can we

1314
00:53:20,290 --> 00:53:14,030
most efficiently find that perfect

1315
00:53:38,470 --> 00:53:20,300
target and time time is a fundamental

1316
00:53:41,680 --> 00:53:38,480
limit brittle and Omega Oh a lot of

1317
00:53:43,210 --> 00:53:41,690
question all no it's okay we have some

1318
00:53:44,770 --> 00:53:43,220
time there's a couple in the front this

1319
00:53:49,090 --> 00:53:44,780
one over here's one in the middle of

1320
00:53:52,420 --> 00:53:49,100
thing they all went up at once so ever

1321
00:53:55,690 --> 00:53:52,430
you can get to this frame just quickly

1322
00:53:58,360 --> 00:53:55,700
yeah you just mind you guys okay

1323
00:53:59,890 --> 00:53:58,370
you mentioned GPO and it sounded like

1324
00:54:03,040 --> 00:53:59,900
that means something about guaranteed

1325
00:54:07,650 --> 00:54:03,050
could you say what the acronym is what

1326
00:54:10,210 --> 00:54:07,660
it what it means and what fraction of

1327
00:54:12,700 --> 00:54:10,220
whatever is guaranteed what non

1328
00:54:16,960 --> 00:54:12,710
guarantee it is and on previous missions

1329
00:54:19,060 --> 00:54:16,970
like Kepler and and Hubble what

1330
00:54:20,770 --> 00:54:19,070
observations came from guaranteed and

1331
00:54:22,300 --> 00:54:20,780
what came from non Gary that's a great

1332
00:54:24,430 --> 00:54:22,310
question sorry I didn't explain that a

1333
00:54:27,190 --> 00:54:24,440
little bit more so guaranteed time for

1334
00:54:29,230 --> 00:54:27,200
the James Webb Space Telescope is given

1335
00:54:33,880 --> 00:54:29,240
a long time ago to instrument teams

1336
00:54:36,630 --> 00:54:33,890
engineers and support institutions which

1337
00:54:40,690 --> 00:54:36,640
have supported the development and

1338
00:54:42,300 --> 00:54:40,700

implementation of telescope from I think

1339
00:54:45,520 --> 00:54:42,310
the James Webb ones date back to about

1340
00:54:48,940 --> 00:54:45,530
30-40 years so guaranteed time is

1341
00:54:51,220 --> 00:54:48,950
assigned in the first year of the

1342
00:54:52,570 --> 00:54:51,230
telescope's operation to various teams

1343
00:54:55,000 --> 00:54:52,580
who have worked on that telescope or

1344
00:54:56,740 --> 00:54:55,010
supported that telescope now this

1345
00:55:00,640 --> 00:54:56,750
happened with the Hubble Space Telescope

1346
00:55:03,760 --> 00:55:00,650
as well when Hubble launched in 1990

1347
00:55:05,310 --> 00:55:03,770
there weren't xx to look at that was no

1348
00:55:06,820 --> 00:55:05,320
exit planet studies that were done

1349
00:55:08,830 --> 00:55:06,830
specifically on the Hubble Space

1350
00:55:10,450 --> 00:55:08,840
Telescope as part of guaranteed time

1351
00:55:11,850 --> 00:55:10,460
assigned to those people that worked on

1352
00:55:14,470 --> 00:55:11,860
it the Hubble Space Telescope

1353
00:55:18,160 --> 00:55:14,480
observations really started kicking in

1354
00:55:19,930 --> 00:55:18,170
in the 90s the mid 90s and actually we

1355
00:55:21,520 --> 00:55:19,940
didn't know that they had made the

1356
00:55:23,500 --> 00:55:21,530
planet observations until the early

1357
00:55:26,050 --> 00:55:23,510
2000s when someone reanalyzed

1358
00:55:27,940 --> 00:55:26,060
data so there's a lot of things that we

1359
00:55:29,800 --> 00:55:27,950
can do now with the James Webb Space a

1360
00:55:31,300 --> 00:55:29,810
script that we were never ever able to

1361
00:55:33,640 --> 00:55:31,310
do with the James Webb with the Hubble

1362
00:55:35,710 --> 00:55:33,650
Space Telescope also a number of the

1363
00:55:37,330 --> 00:55:35,720

instruments and many of the modes that

1364
00:55:40,570 --> 00:55:37,340
we'll be using on designed specifically

1365
00:55:43,630 --> 00:55:40,580
for us now we can really use that

1366
00:55:47,560 --> 00:55:43,640
information to push forward the data

1367
00:55:50,440 --> 00:55:47,570
analysis era of exoplanet there is still

1368
00:55:52,270 --> 00:55:50,450
after the GTO time that ers early

1369
00:55:54,240 --> 00:55:52,280
released science time and the transiting

1370
00:55:57,550 --> 00:55:54,250
exoplanet community has the biggest

1371
00:55:59,349 --> 00:55:57,560
beautifulest chunk of that time and they

1372
00:56:01,510 --> 00:55:59,359
will be looking at the full transmission

1373
00:56:03,580 --> 00:56:01,520
spectrum of a hot Jupiter they will be

1374
00:56:06,370 --> 00:56:03,590
doing the phase curve of I believe

1375
00:56:08,410 --> 00:56:06,380
what's 43 B in the infrared with Mary's

1376
00:56:10,480 --> 00:56:08,420
instrument and they will be doing trying

1377
00:56:12,520 --> 00:56:10,490
to test that fundamental limit of the

1378
00:56:14,500 --> 00:56:12,530
noise floor of James Webb with a really

1379
00:56:15,910 --> 00:56:14,510
bright target really pushing the limits

1380
00:56:18,160 --> 00:56:15,920
to try and understand the noise floor of

1381
00:56:20,680 --> 00:56:18,170
the instrument itself so those programs

1382
00:56:22,270 --> 00:56:20,690
the GTO programs are programs and they

1383
00:56:25,320 --> 00:56:22,280
will have proprietary time for a year

1384
00:56:28,120 --> 00:56:25,330
the ers program is open to everybody and

1385
00:56:31,390 --> 00:56:28,130
we encourage every single one of you to

1386
00:56:34,180 --> 00:56:31,400
join the ers team join us we need your

1387
00:56:36,310 --> 00:56:34,190
help we want your help and we want to

1388
00:56:38,470 --> 00:56:36,320

get as many people as possible involved

1389
00:56:40,000 --> 00:56:38,480
in the community in the James Webb time

1390
00:56:42,310 --> 00:56:40,010
that we'll get so that we can understand

1391
00:56:44,859 --> 00:56:42,320
the instrument now the other time is

1392
00:56:46,720 --> 00:56:44,869
guest observer time so guest observer

1393
00:56:48,640 --> 00:56:46,730
time is he think that you want to

1394
00:56:50,170 --> 00:56:48,650
propose for and the way that it's going

1395
00:56:52,630 --> 00:56:50,180
to work is it's going to respond to

1396
00:56:55,450 --> 00:56:52,640
proposal pressure so the more you ask

1397
00:56:57,670 --> 00:56:55,460
the more proposals you put in the more

1398
00:56:59,530 --> 00:56:57,680
the community is going to get out now I

1399
00:57:01,390 --> 00:56:59,540
can't guarantee for a single person if

1400
00:57:03,910 --> 00:57:01,400
you put 50 in you're gonna get a

1401
00:57:05,500 --> 00:57:03,920
proportional amount out from that they

1402
00:57:08,620 --> 00:57:05,510
can't guarantee that but the community

1403
00:57:12,340 --> 00:57:08,630
as a whole will be getting as much out

1404
00:57:15,820 --> 00:57:12,350
as it pushes pushes pressure on the

1405
00:57:18,190 --> 00:57:15,830
proposals to get that time and as I as I

1406
00:57:21,430 --> 00:57:18,200
said with the GT eight I'm actually out

1407
00:57:24,700 --> 00:57:21,440
of a hundred percent of GTO time 27

1408
00:57:26,650 --> 00:57:24,710
percent is going to exoplanet and that

1409
00:57:29,170 --> 00:57:26,660
would never ever have been fought off

1410
00:57:31,420 --> 00:57:29,180
before it wasn't thought of at all when

1411
00:57:35,820 --> 00:57:31,430
the GTA to come was first assigned so

1412
00:57:40,110 --> 00:57:38,130
no no no no not to talk nozzle there's

1413
00:57:41,700 --> 00:57:40,120

tons of guests observer time in in the

1414
00:57:43,890 --> 00:57:41,710
first year this is a very small fraction

1415
00:57:46,200 --> 00:57:43,900
of that very small fraction of that

1416
00:57:48,150 --> 00:57:46,210
first year there is going to be a huge

1417
00:57:49,740 --> 00:57:48,160
amount of time for community and in

1418
00:57:51,420 --> 00:57:49,750
January where you hear the call you will

1419
00:57:52,890 --> 00:57:51,430
hear exactly how many hours they are

1420
00:57:59,390 --> 00:57:52,900
signing in that first year to the

1421
00:58:06,360 --> 00:58:03,270
oh you already have it John I'm sorry

1422
00:58:07,800 --> 00:58:06,370
jonathan fourney UC santa cruz i was in

1423
00:58:09,870 --> 00:58:07,810
terms of knowing nice star i was really

1424
00:58:12,140 --> 00:58:09,880
taken by the this for this for the

1425
00:58:15,090 --> 00:58:12,150
Trappist parent star that you found a

1426
00:58:16,560 --> 00:58:15,100
tiny filling fraction of extremely hot

1427
00:58:18,720 --> 00:58:16,570
material like fifty eight hundred

1428
00:58:21,210 --> 00:58:18,730
degrees but like one percent of the star

1429
00:58:22,800 --> 00:58:21,220
is that fairly robust and because if

1430
00:58:24,150 --> 00:58:22,810
that has that being true for the M

1431
00:58:25,620 --> 00:58:24,160
dwarfs typically I think that's a really

1432
00:58:27,450 --> 00:58:25,630
interesting finding about the stars

1433
00:58:29,670 --> 00:58:27,460
themselves but the vacuole a or

1434
00:58:31,560 --> 00:58:29,680
something would be so hot yeah I had

1435
00:58:32,820 --> 00:58:31,570
exactly the same question when we did

1436
00:58:34,350 --> 00:58:32,830
the analysis for the analysis was

1437
00:58:36,720 --> 00:58:34,360
actually I should say thank you to my

1438
00:58:38,520 --> 00:58:36,730

team it was a huge team of people we had

1439
00:58:39,660 --> 00:58:38,530
stellar physicists who were working a

1440
00:58:41,580 --> 00:58:39,670
lot on that side of things

1441
00:58:43,560 --> 00:58:41,590
we had planetary scientists and we had

1442
00:58:45,450 --> 00:58:43,570
observers and theorists working on all

1443
00:58:47,130 --> 00:58:45,460
aspects of this there was a massive team

1444
00:58:50,280 --> 00:58:47,140
effort in terms of that really hot

1445
00:58:52,770 --> 00:58:50,290
portion of the star it seems like yes

1446
00:58:56,070 --> 00:58:52,780
according to the surfaces it is it is

1447
00:58:59,070 --> 00:58:56,080
possible to have that the mechanism for

1448
00:59:00,990 --> 00:58:59,080
that and why you would see it on a photo

1449
00:59:03,540 --> 00:59:01,000
steric level is very interesting and

1450
00:59:06,390 --> 00:59:03,550
that I do not know but I know exactly

1451
00:59:08,280 --> 00:59:06,400
who to point you to please have a

1452
00:59:10,230 --> 00:59:08,290
discussion with Jeff Valenti it's always

1453
00:59:14,370 --> 00:59:10,240
very entertaining to explain why

1454
00:59:16,200 --> 00:59:14,380
Travis's is so interesting but there's

1455
00:59:19,230 --> 00:59:16,210
another there's another paper and

1456
00:59:22,260 --> 00:59:19,240
another project done by Brett Morris who

1457
00:59:25,410 --> 00:59:22,270
also looked at the Trappist one star and

1458
00:59:28,140 --> 00:59:25,420
found that it's plausible that there is

1459
00:59:32,310 --> 00:59:28,150
this incredibly hot and they suggest

1460
00:59:34,860 --> 00:59:32,320
it's magnetically active so this is not

1461
00:59:40,350 --> 00:59:34,870
a search that's found that that best fit

1462
00:59:41,490 --> 00:59:40,360
to the star as well okay women um I have

1463
00:59:44,010 --> 00:59:41,500

a comment and a question

1464
00:59:46,920 --> 00:59:44,020
further comment just to come back on

1465
00:59:48,540 --> 00:59:46,930
Trappist and and what we saw in the in

1466
00:59:51,900 --> 00:59:48,550
the transit

1467
00:59:53,790 --> 00:59:51,910
to be exact it's not hydrogen atmosphere

1468
00:59:55,590 --> 00:59:53,800
that is rolled out it's a cloud free

1469
00:59:59,490 --> 00:59:55,600
hydrogen element yeah I think we we

1470
01:00:04,620 --> 00:59:59,500
still have to you know have the GG 2014

1471
01:00:06,330 --> 01:00:04,630
Milan I rec France for some of the

1472
01:00:07,650 --> 01:00:06,340
planets we can rule out a lot more and

1473
01:00:10,680 --> 01:00:07,660
some of them yeah we can't rule out a

1474
01:00:12,710 --> 01:00:10,690
fair amount at all be in observations

1475
01:00:14,640 --> 01:00:12,720
we've got just aren't precise enough

1476
01:00:15,870 --> 01:00:14,650
some of them I really recommend reading

1477
01:00:17,760 --> 01:00:15,880
that paper that's already go triggers

1478
01:00:20,010 --> 01:00:17,770
and now that will show you exactly what

1479
01:00:22,140 --> 01:00:20,020
kinds of combinations of cloud haze and

1480
01:00:24,840 --> 01:00:22,150
hydrogen helium percentage we can all

1481
01:00:28,740 --> 01:00:24,850
out for those okay and for the question

1482
01:00:31,830 --> 01:00:28,750
is I've seen going around a letter to

1483
01:00:36,330 --> 01:00:31,840
stsci about maybe a servicing mission to

1484
01:00:39,180 --> 01:00:36,340
Hubble or Oh white paper yes that's a

1485
01:00:43,080 --> 01:00:39,190
why do you think there is any chain that

1486
01:00:47,670 --> 01:00:43,090
this can fly I do not speak officially

1487
01:00:50,550 --> 01:00:47,680
for Space Telescope in a capacity and

1488
01:00:54,859 --> 01:00:50,560

unofficially unofficially yeah god

1489
01:00:58,590 --> 01:00:56,910
alright well with that we're out of time

1490
01:00:59,470 --> 01:00:58,600
so let's give Hannah another round of