AbGradCon 2018

1
00:00:00,260 --> 00:00:10,720
[Music]

2
00:00:16,450 --> 00:00:13,160
so thanks for introduction this is

3
00:00:18,440 --> 00:00:16,460
probably the longest title of the

4
00:00:20,750 --> 00:00:18,450
mouthful so I explain a characterization

5
00:00:23,600 --> 00:00:20,760
with James Webb ticularly focused about

6
00:00:24,890 --> 00:00:23,610
the Chaplin system and I'm gonna give us

7
00:00:26,270 --> 00:00:24,900
a little bit about introduction to that

8
00:00:27,530 --> 00:00:26,280
which is great because I'm gonna zip

9
00:00:28,880 --> 00:00:27,540
through the introduction really fast

10
00:00:31,580 --> 00:00:28,890
because I have a lot of stuff to show

11
00:00:33,830 --> 00:00:31,590
so the key big picture here is that M

12
00:00:35,180 --> 00:00:33,840
dwarfs are about three-quarters of the

13
00:00:36,740 --> 00:00:35,190

stars in our local group so if you're

14
00:00:39,260 --> 00:00:36,750
thinking about the distribution of life

15
00:00:40,430 --> 00:00:39,270
and astrobiologist both in the solar

16
00:00:42,050 --> 00:00:40,440
system and beyond

17
00:00:44,180 --> 00:00:42,060
you kind of want an idea about where

18
00:00:46,790 --> 00:00:44,190
life might exist in the local universe

19
00:00:49,160 --> 00:00:46,800
and chances are good that you're gonna

20
00:00:52,370 --> 00:00:49,170
be looking at an EM door around four

21
00:00:54,639 --> 00:00:52,380
planets around other stars so the other

22
00:00:57,770 --> 00:00:54,649
good piece of information here is that

23
00:01:01,340 --> 00:00:57,780
the Kepler statistics show us that M

24
00:01:02,690 --> 00:01:01,350
dwarf stars are more likely to are very

25
00:01:05,299 --> 00:01:02,700
likely to have planets around all of

26
00:01:06,469 --> 00:01:05,309
them and the stars that do have planets

27
00:01:08,749 --> 00:01:06,479
are likely to have multiple planets

28
00:01:11,210 --> 00:01:08,759
that's really great and because these M

29
00:01:13,340 --> 00:01:11,220
dwarf stars are small and red and cooler

30
00:01:14,630 --> 00:01:13,350
they're a lot easier to observe planets

31
00:01:15,710 --> 00:01:14,640
around them because that transit method

32
00:01:17,060 --> 00:01:15,720
right you're looking for earth-size

33
00:01:18,950 --> 00:01:17,070
planet and if you're around a smaller

34
00:01:21,170 --> 00:01:18,960
dimmer star so much easier to see that

35
00:01:23,060 --> 00:01:21,180
signal so that's really the only way

36
00:01:25,340 --> 00:01:23,070
that will observe terrestrial AXA

37
00:01:29,149 --> 00:01:25,350
planets around other stars in the next

38
00:01:31,520 --> 00:01:29,159

20 years is with James Webb but M dwarf

39
00:01:33,050 --> 00:01:31,530
stars have their own problems that other

40
00:01:35,359 --> 00:01:33,060
stars may not have and that's a very

41
00:01:37,310 --> 00:01:35,369
long super luminous premium sequence

42
00:01:39,740 --> 00:01:37,320
phase so for up to a billion years while

43
00:01:41,240 --> 00:01:39,750
the star and planets are forming the

44
00:01:43,250 --> 00:01:41,250
star is much brighter than it will

45
00:01:45,260 --> 00:01:43,260
eventually be and so planets that are in

46
00:01:47,359 --> 00:01:45,270
the habitable zone for the main-sequence

47
00:01:49,969 --> 00:01:47,369
phase during the pre main-sequence phase

48
00:01:51,710 --> 00:01:49,979
they can boil off you know tens or

49
00:01:53,749 --> 00:01:51,720
hundreds of oceans and build up to

50
00:01:56,090 --> 00:01:53,759
thousands of bars of or atmospheres of

51
00:01:57,859 --> 00:01:56,100
oxygen and this is a serious issue for

52
00:02:00,980 --> 00:01:57,869
these planets actually having life

53
00:02:02,960 --> 00:02:00,990
eventually in addition to this pre

54
00:02:05,450 --> 00:02:02,970
main-sequence phase the last so long you

55
00:02:06,920 --> 00:02:05,460
have life long stellar activity that can

56
00:02:08,869 --> 00:02:06,930
continue to sterilize the surface and

57
00:02:12,530 --> 00:02:08,879
strip off the atmosphere so that's

58
00:02:14,900 --> 00:02:12,540
that's maybe a bad sign so if you're so

59
00:02:17,150 --> 00:02:14,910
with that information then you ask how

60
00:02:18,800 --> 00:02:17,160
could M dwarf planets even have life how

61
00:02:19,850 --> 00:02:18,810
could they even have an atmosphere so we

62
00:02:21,470 --> 00:02:19,860
need to start asking some of these

63
00:02:22,820 --> 00:02:21,480

questions to be able to see if these are

64
00:02:25,339 --> 00:02:22,830
even great things to look at for

65
00:02:27,740 --> 00:02:25,349
astrobiology so our first question might

66
00:02:29,150 --> 00:02:27,750
be do these planets even have an

67
00:02:30,830 --> 00:02:29,160
atmosphere that's kind of the first bit

68
00:02:33,410 --> 00:02:30,840
of information you want when you observe

69
00:02:34,790 --> 00:02:33,420
them next might be are these massive

70
00:02:36,380 --> 00:02:34,800
oxygen atmospheres I'm talking about

71
00:02:38,030 --> 00:02:36,390
which are just theorized at this point

72
00:02:39,770 --> 00:02:38,040
right we don't have an oxygen a mass of

73
00:02:41,420 --> 00:02:39,780
oxygen planet in our solar system we

74
00:02:44,320 --> 00:02:41,430
just have a life based oxygen around

75
00:02:47,330 --> 00:02:44,330
Earth that's also a problem for a false

76
00:02:48,949 --> 00:02:47,340
false bio signature right so are those

77
00:02:52,100 --> 00:02:48,959
types of planets even possible or a

78
00:02:53,600 --> 00:02:52,110
common even or do you get a more venous

79
00:02:55,309 --> 00:02:53,610
like planet looking at our solar system

80
00:02:56,990 --> 00:02:55,319
we know a Venus like planet can exist

81
00:02:59,479 --> 00:02:57,000
and this is a post runaway greenhouse

82
00:03:02,780 --> 00:02:59,489
planet are these perhaps the most common

83
00:03:04,670 --> 00:03:02,790
types of planets around or star or and

84
00:03:07,520 --> 00:03:04,680
perhaps the only way you can really get

85
00:03:09,740 --> 00:03:07,530
a habitable planet in the habitable zone

86
00:03:11,660 --> 00:03:09,750
of an M dwarf star is can you have some

87
00:03:13,550 --> 00:03:11,670
kind of mini Neptune a more hydrogen

88
00:03:15,410 --> 00:03:13,560

rich volatile rich planet can this

89
00:03:17,059 --> 00:03:15,420
migrate in during formation strip off

90
00:03:18,740 --> 00:03:17,069
its hydrogen envelope and leave you with

91
00:03:20,089 --> 00:03:18,750
a habitable evaporated core which is

92
00:03:22,309 --> 00:03:20,099
positive if you used to go by Richard

93
00:03:25,040 --> 00:03:22,319
Lugar at all so spectral observations by

94
00:03:27,229 --> 00:03:25,050
James Webb will help us distinguish or

95
00:03:28,790 --> 00:03:27,239
show whether these types of planets can

96
00:03:29,589 --> 00:03:28,800
occur and distinguish among them

97
00:03:31,399 --> 00:03:29,599
hopefully

98
00:03:32,630 --> 00:03:31,409
so we've already heard a little bit

99
00:03:34,100 --> 00:03:32,640
about Trappist one this is a great

100
00:03:36,170 --> 00:03:34,110
system I'll just hit it briefly again

101
00:03:37,790 --> 00:03:36,180
three planets inside the inner edge of

102
00:03:39,530 --> 00:03:37,800
the habitable zone three planets within

103
00:03:41,330 --> 00:03:39,540
the conservative habitable zone at least

104
00:03:43,850 --> 00:03:41,340
one planet beyond the outer edge so this

105
00:03:46,550 --> 00:03:43,860
gives you a great single system to look

106
00:03:48,640 --> 00:03:46,560
at planetary evolution among seven

107
00:03:51,020 --> 00:03:48,650
different targets which is really great

108
00:03:52,399 --> 00:03:51,030
so just the first of my talk I'm going

109
00:03:54,380 --> 00:03:52,409
to talk about the climate model and the

110
00:03:55,850 --> 00:03:54,390
chemistry model I use show some of the

111
00:03:57,740 --> 00:03:55,860
modeling results in terms of the

112
00:03:59,690 --> 00:03:57,750
atmospheres and their structures and

113
00:04:01,070 --> 00:03:59,700

their chemistry and then go into some of

114
00:04:04,460 --> 00:04:01,080
the spectral signatures which is really

115
00:04:06,170 --> 00:04:04,470
the point of the work I'm doing so the

116
00:04:08,440 --> 00:04:06,180
model I use is a 1d climate model this

117
00:04:10,520 --> 00:04:08,450
is a very rigorous line-by-line

118
00:04:11,809 --> 00:04:10,530
radiative convective model and whose

119
00:04:14,780 --> 00:04:11,819
multi scattering off so it's a great

120
00:04:16,789 --> 00:04:14,790
stuff that you use to you can model

121
00:04:19,159 --> 00:04:16,799
earth and all the solar system plans

122
00:04:21,170 --> 00:04:19,169
with these this is coupled to a photo

123
00:04:23,269 --> 00:04:21,180
chemical kinetics model because as I

124
00:04:25,040 --> 00:04:23,279
said M dwarfs have really crazy UV and

125
00:04:26,359 --> 00:04:25,050
so in order to really understand what

126
00:04:27,799 --> 00:04:26,369
might happen to an atmosphere around

127
00:04:29,340 --> 00:04:27,809
them core if you have to understand what

128
00:04:32,130 --> 00:04:29,350
the UV is doing to the chemical

129
00:04:35,310 --> 00:04:32,140
species in the atmosphere once I've

130
00:04:37,920 --> 00:04:35,320
converged on a photochemical and climate

131
00:04:39,270 --> 00:04:37,930
equilibrium state then this uses the

132
00:04:41,040 --> 00:04:39,280
exact same radio transfer models

133
00:04:43,620 --> 00:04:41,050
prettiest very high-resolution spectra

134
00:04:45,120 --> 00:04:43,630
that can then be get degraded and so you

135
00:04:48,030 --> 00:04:45,130
can see what they might look like for

136
00:04:49,710 --> 00:04:48,040
James Webb so when we're considering

137
00:04:53,010 --> 00:04:49,720
what kind of atmosphere is I'm modeling

138
00:04:54,600 --> 00:04:53,020

I'm mostly modeling thick evolved

139
00:04:56,490 --> 00:04:54,610
atmospheres right atmospheres that have

140
00:04:59,220 --> 00:04:56,500
evolved from the primordial composition

141
00:05:01,410 --> 00:04:59,230
this spans from a recent ocean loss type

142
00:05:03,510 --> 00:05:01,420
system where we said okay it just lost

143
00:05:05,280 --> 00:05:03,520
its water from the pre main sequence

144
00:05:08,820 --> 00:05:05,290
phase and perhaps you're just left with

145
00:05:11,040 --> 00:05:08,830
mostly oxygen and then perhaps if that

146
00:05:12,360 --> 00:05:11,050
planet was not totally desiccated from

147
00:05:14,400 --> 00:05:12,370
its interior that it might have

148
00:05:17,790 --> 00:05:14,410
outgassing like earth right greenness

149
00:05:19,620 --> 00:05:17,800
like IO then you have other constituents

150
00:05:20,940 --> 00:05:19,630
that are volcanic that can be emitted so

151
00:05:22,290 --> 00:05:20,950
you can look at that and then all the

152
00:05:24,570 --> 00:05:22,300
way to the Venus like end of the

153
00:05:25,860 --> 00:05:24,580
spectrum where you just have a runaway

154
00:05:27,590 --> 00:05:25,870
greenhouse planet and this is what are

155
00:05:29,850 --> 00:05:27,600
you left with but since this is a

156
00:05:32,820 --> 00:05:29,860
astrobiology conference let's also

157
00:05:34,260 --> 00:05:32,830
consider what an earth-like planet might

158
00:05:36,300 --> 00:05:34,270
look like right all the other previous

159
00:05:38,430 --> 00:05:36,310
ones I showed are not really anything

160
00:05:40,530 --> 00:05:38,440
that we would expect life that we know

161
00:05:42,270 --> 00:05:40,540
it took to live on but I'm comparing

162
00:05:44,280 --> 00:05:42,280
this with an ocean bearing planet that

163
00:05:48,000 --> 00:05:44,290

perhaps could develop life so we can see

164
00:05:49,710 --> 00:05:48,010
if we can distinguish these now when I

165
00:05:51,570 --> 00:05:49,720
model these atmospheres and come up with

166
00:05:53,910 --> 00:05:51,580
the surface temperatures the story

167
00:05:55,710 --> 00:05:53,920
becomes more complicated the habitable

168
00:05:57,480 --> 00:05:55,720
zone is only a first-order indicator of

169
00:05:58,800 --> 00:05:57,490
habitability but if you stick different

170
00:06:01,800 --> 00:05:58,810
types of atmospheres on the same planet

171
00:06:03,810 --> 00:06:01,810
you end up finding that the habitable

172
00:06:07,110 --> 00:06:03,820
zone is not a guarantee of habitability

173
00:06:08,550 --> 00:06:07,120
you can have planets span from 600 PS

174
00:06:11,640 --> 00:06:08,560
600 Kelvin if you have a Venus like

175
00:06:13,860 --> 00:06:11,650
atmosphere all the way down to very low

176
00:06:16,260 --> 00:06:13,870
cold 180 Kelvin for just an oxygen

177
00:06:18,060 --> 00:06:16,270
atmosphere on a colder planet so this is

178
00:06:19,710 --> 00:06:18,070
kind of a problem but the habitable zone

179
00:06:21,960 --> 00:06:19,720
is still a place that is more likely

180
00:06:23,670 --> 00:06:21,970
alright knock with planet gives us some

181
00:06:24,600 --> 00:06:23,680
more cases so we have more good

182
00:06:27,060 --> 00:06:24,610
green-colored

183
00:06:28,590 --> 00:06:27,070
maybe habitable temperatures in the

184
00:06:30,680 --> 00:06:28,600
habitable zone than we have outside of

185
00:06:33,240 --> 00:06:30,690
it so it's still a good indicator

186
00:06:34,860 --> 00:06:33,250
now with the modeling results here's

187
00:06:36,120 --> 00:06:34,870
pressure and temperature structures and

188
00:06:37,980 --> 00:06:36,130

chemistry I'm just going to breeze

189
00:06:40,009 --> 00:06:37,990
through these really fast but just a

190
00:06:41,269 --> 00:06:40,019
couple important points

191
00:06:42,859 --> 00:06:41,279
the previous speaker talked about phase

192
00:06:44,749 --> 00:06:42,869
curves and that can tell you something

193
00:06:46,579 --> 00:06:44,759
about the temperature structure of the

194
00:06:48,619 --> 00:06:46,589
planet that's one way you can observe an

195
00:06:51,769 --> 00:06:48,629
oxygen planet is because there's no

196
00:06:53,479 --> 00:06:51,779
water the oxygen absorption actually

197
00:06:55,249 --> 00:06:53,489
creates a temperature inversion near the

198
00:06:57,139 --> 00:06:55,259
surface and this may be observable by a

199
00:06:58,969 --> 00:06:57,149
thermal phase curve but I'm not going to

200
00:07:00,289 --> 00:06:58,979
show any of those in this talk this

201
00:07:02,119 --> 00:07:00,299
these planets are otherwise

202
00:07:03,679 --> 00:07:02,129
distinguished by high ozone levels

203
00:07:05,179 --> 00:07:03,689
because there's no water to scrub out

204
00:07:07,189 --> 00:07:05,189
the ozone which happens in Earth's

205
00:07:08,449 --> 00:07:07,199
troposphere and the same thing you get

206
00:07:08,989 --> 00:07:08,459
carbon monoxide build up in the

207
00:07:11,719 --> 00:07:08,999
atmosphere

208
00:07:13,519 --> 00:07:11,729
you might be observable now if you have

209
00:07:14,959 --> 00:07:13,529
a little more outgassing with an oxygen

210
00:07:16,790 --> 00:07:14,969
planet you end up losing this

211
00:07:20,329 --> 00:07:16,800
temperature inversion at the surface you

212
00:07:22,609 --> 00:07:20,339
create a more typical terrestrial a tbat

213
00:07:26,119 --> 00:07:22,619

of a temperature but this is a lot

214
00:07:27,889 --> 00:07:26,129
warmer you get some some water in the

215
00:07:29,299 --> 00:07:27,899
atmosphere and this ends up going

216
00:07:33,049 --> 00:07:29,309
basically into it runaway greenhouse

217
00:07:34,790 --> 00:07:33,059
state as you can see where you have even

218
00:07:36,469 --> 00:07:34,800
more than you know point one percent

219
00:07:38,769 --> 00:07:36,479
water in the in the upper atmosphere

220
00:07:41,350 --> 00:07:38,779
indicating that the planets losing water

221
00:07:44,149 --> 00:07:41,360
but you get a lot less carbon monoxide

222
00:07:45,259 --> 00:07:44,159
and you get a little bit less buildup of

223
00:07:48,040 --> 00:07:45,269
ozone but this is still fairly

224
00:07:50,479 --> 00:07:48,050
substantial so that's pretty interesting

225
00:07:53,079 --> 00:07:50,489
then if we go to Venus like planet and

226
00:07:55,879 --> 00:07:53,089
as far as I know this is the first real

227
00:07:59,299 --> 00:07:55,889
EXO Venus modelling I've ever seen so

228
00:08:00,739 --> 00:07:59,309
yeah but you end up seeing that even a

229
00:08:02,479 --> 00:08:00,749
Venus around m-dwarf still looks kind of

230
00:08:04,040 --> 00:08:02,489
Venus like these white lines are the

231
00:08:05,869 --> 00:08:04,050
Venus ones in each color is the each

232
00:08:08,149 --> 00:08:05,879
planet you'll notice there's no Trappist

233
00:08:10,189 --> 00:08:08,159
1b here because the planet is too hot to

234
00:08:11,989 --> 00:08:10,199
actually form sulfuric acid clouds so

235
00:08:14,419 --> 00:08:11,999
that really is not going to be quite as

236
00:08:16,369 --> 00:08:14,429
Venus like and that's maybe good news or

237
00:08:17,600 --> 00:08:16,379
bad news for a couple of reasons but you

238
00:08:18,949 --> 00:08:17,610

see these planets can still form

239
00:08:20,059 --> 00:08:18,959
sulfuric acid clouds and here's the

240
00:08:22,909 --> 00:08:20,069
optical depth that I form in this

241
00:08:24,499 --> 00:08:22,919
photochemical model and so you still

242
00:08:26,059 --> 00:08:24,509
make it clouds which is if you've

243
00:08:28,129 --> 00:08:26,069
followed any of the exoplanet work with

244
00:08:29,779 --> 00:08:28,139
hubble space telescope that's might be a

245
00:08:32,389 --> 00:08:29,789
serious problem for anthing spectroscopy

246
00:08:34,670 --> 00:08:32,399
that I've burned through some of the

247
00:08:36,679 --> 00:08:34,680
climates let's look maybe more at what

248
00:08:39,129 --> 00:08:36,689
we act might actually observe so here's

249
00:08:42,079 --> 00:08:39,139
a very confusing spectra of

250
00:08:43,879 --> 00:08:42,089
Trappist one see the second planet with

251
00:08:45,980 --> 00:08:43,889
all of its cases I modeled so you have

252
00:08:47,569 --> 00:08:45,990
the oxygen cases down here and green and

253
00:08:49,610 --> 00:08:47,579
purple and then Venus light cases up

254
00:08:52,309 --> 00:08:49,620
here and yellow and red

255
00:08:53,689 --> 00:08:52,319
and what you see here is that first of

256
00:08:55,879 --> 00:08:53,699
all where is your signal coming from

257
00:08:58,489 --> 00:08:55,889
since like so the previous speakers have

258
00:09:01,850 --> 00:08:58,499
said your transit spectrum is light from

259
00:09:03,220 --> 00:09:01,860
within from the star not from the planet

260
00:09:05,239 --> 00:09:03,230
so it's passing through the atmosphere

261
00:09:06,199 --> 00:09:05,249
so that's where your stronger signal is

262
00:09:07,429 --> 00:09:06,209
so keep that in mind when you're looking

263
00:09:09,619 --> 00:09:07,439

at how big some of these features are

264
00:09:10,999 --> 00:09:09,629
and where the signal is but you get co2

265
00:09:12,559 --> 00:09:11,009
features right that goes back to our

266
00:09:14,449 --> 00:09:12,569
first question is how do we know these

267
00:09:15,860 --> 00:09:14,459
planets even have an atmosphere the most

268
00:09:17,569 --> 00:09:15,870
universal sign for a terrestrial planet

269
00:09:19,549 --> 00:09:17,579
is probably going to be carbon dioxide

270
00:09:21,199 --> 00:09:19,559
every planet I modeled had some carbon

271
00:09:22,819 --> 00:09:21,209
dioxide and carbon dioxide produces very

272
00:09:24,650 --> 00:09:22,829
strong signals and multiple wavelength

273
00:09:26,449 --> 00:09:24,660
bands so that's probably the first place

274
00:09:29,059 --> 00:09:26,459
to look for whether a planet has an

275
00:09:31,009 --> 00:09:29,069
atmosphere the next thing we might be

276
00:09:33,829 --> 00:09:31,019
interested in is a water signal for a

277
00:09:35,059 --> 00:09:33,839
planet like this in the inside in inside

278
00:09:37,280 --> 00:09:35,069
of inner edge of the habitable zone

279
00:09:39,259 --> 00:09:37,290
water is not necessarily a good sign

280
00:09:40,670 --> 00:09:39,269
these have very strong water features

281
00:09:42,619 --> 00:09:40,680
and this is actually sign that there's

282
00:09:43,879 --> 00:09:42,629
water in the stratosphere and so your

283
00:09:46,329 --> 00:09:43,889
planet is actually losing water so

284
00:09:48,860 --> 00:09:46,339
that's maybe not a good thing to see I

285
00:09:50,360 --> 00:09:48,870
mentioned the oxygen planets so you can

286
00:09:53,210 --> 00:09:50,370
actually distinguish these from their

287
00:09:54,530 --> 00:09:53,220
heavy oxygen so you get oxygen collision

288
00:09:55,850 --> 00:09:54,540

because the atmospheres are so dense and

289
00:09:57,019 --> 00:09:55,860
have sufficient oxygen for that so

290
00:09:58,420 --> 00:09:57,029
that's a signal we can actually look for

291
00:10:00,920 --> 00:09:58,430
as well

292
00:10:04,369 --> 00:10:00,930
ozone again is another thing that maybe

293
00:10:07,340 --> 00:10:04,379
might be an issue or false bio

294
00:10:08,749 --> 00:10:07,350
signatures and then you have other gases

295
00:10:10,939 --> 00:10:08,759
like sulfur dioxide which indicate

296
00:10:12,980 --> 00:10:10,949
volcanism and that is maybe a good or

297
00:10:15,230 --> 00:10:12,990
bad thing for what the planet is active

298
00:10:18,499 --> 00:10:15,240
geologically active or is this thing

299
00:10:19,970 --> 00:10:18,509
more venus like CEO also indicates

300
00:10:21,769 --> 00:10:19,980
desiccation so that's not good

301
00:10:23,509 --> 00:10:21,779
but so Trapattoni this is probably I

302
00:10:24,920 --> 00:10:23,519
think the literature is mostly an

303
00:10:27,579 --> 00:10:24,930
agreement that Trapattoni is probably

304
00:10:30,470 --> 00:10:27,589
the best target for trafficed one for

305
00:10:32,629 --> 00:10:30,480
potentially habitable planet and so I've

306
00:10:33,829 --> 00:10:32,639
plotted the Aqua planet as well and

307
00:10:36,230 --> 00:10:33,839
that's these two spectra down here and

308
00:10:37,309 --> 00:10:36,240
since their one bar their transmission

309
00:10:39,290 --> 00:10:37,319
Spectre get deeper into the atmosphere

310
00:10:41,689 --> 00:10:39,300
in fact deep enough to start seeing

311
00:10:43,579 --> 00:10:41,699
water features from the troposphere and

312
00:10:44,990 --> 00:10:43,589
in this case you can see that the water

313
00:10:46,610 --> 00:10:45,000

features are actually kind of similar if

314
00:10:48,410 --> 00:10:46,620
you look at the relative transit depth

315
00:10:49,780 --> 00:10:48,420
from the top of the Cygnus to the bottom

316
00:10:51,980 --> 00:10:49,790
of the signal they're roughly the same

317
00:10:53,449 --> 00:10:51,990
and that's because these even the

318
00:10:55,400 --> 00:10:53,459
runaway greenhouse planets have a little

319
00:10:56,749 --> 00:10:55,410
bit less water in their atmosphere so

320
00:10:58,460 --> 00:10:56,759
it's really hard to distinguish whether

321
00:11:00,819 --> 00:10:58,470
this planet has an ocean just from

322
00:11:03,079 --> 00:11:00,829
seeing a water feature in the atmosphere

323
00:11:05,299 --> 00:11:03,089
those own features a little bit smaller

324
00:11:06,649 --> 00:11:05,309
for an earth-like planet so that might

325
00:11:08,749 --> 00:11:06,659
be good but that really might be hard to

326
00:11:10,159 --> 00:11:08,759
distinguish but the other thing you get

327
00:11:12,499 --> 00:11:10,169
for an earth-like planet right is

328
00:11:13,429 --> 00:11:12,509
methane that's simply something Leavitt

329
00:11:15,229 --> 00:11:13,439
biologists study and though there's a

330
00:11:17,479 --> 00:11:15,239
methane talk later in the session

331
00:11:18,919 --> 00:11:17,489
and this is only a biotic levels of

332
00:11:21,169 --> 00:11:18,929
methane and it's still showing up as a

333
00:11:22,519 --> 00:11:21,179
signal in my spectra one thing if you're

334
00:11:24,199 --> 00:11:22,529
familiar with some of the other M dwarf

335
00:11:25,969 --> 00:11:24,209
Tresckow exoplanet literature is M

336
00:11:29,359 --> 00:11:25,979
dwarfs and dwarf planets have a lot

337
00:11:31,699 --> 00:11:29,369
higher capability of seeing more methane

338
00:11:32,809 --> 00:11:31,709

much more methane than earth gifts so

339
00:11:34,579 --> 00:11:32,819
this is actually earth bubbles of

340
00:11:36,529 --> 00:11:34,589
methane from only geological levels

341
00:11:38,179 --> 00:11:36,539
reflexes so you can imagine that these

342
00:11:42,019 --> 00:11:38,189
methane bands could be much stronger

343
00:11:44,359 --> 00:11:42,029
from an actual biosphere so those were

344
00:11:45,379 --> 00:11:44,369
beautiful perfect christine spectra even

345
00:11:47,959 --> 00:11:45,389
though they're really scary-looking

346
00:11:49,249 --> 00:11:47,969
there was no air bars on them so what

347
00:11:51,049 --> 00:11:49,259
happens when a telescope is actually

348
00:11:52,759 --> 00:11:51,059
trying to observe this planet this is

349
00:11:55,009 --> 00:11:52,769
gonna be a lot more difficult case and

350
00:11:56,989 --> 00:11:55,019
this is this one right here is trapezoid

351
00:11:58,549 --> 00:11:56,999
B the innermost planet probably the

352
00:12:01,099 --> 00:11:58,559
easiest to observe because the hottest

353
00:12:03,229 --> 00:12:01,109
it's fairly large compared to the other

354
00:12:06,889 --> 00:12:03,239
ones so this one produces very strong

355
00:12:10,099 --> 00:12:06,899
signals up to 200 parts per million from

356
00:12:12,499 --> 00:12:10,109
an instrument that has a noise floor of

357
00:12:13,879 --> 00:12:12,509
probably 30 parts per million so this

358
00:12:15,319 --> 00:12:13,889
you can actually see you can see the co2

359
00:12:17,239 --> 00:12:15,329
features you're looking at the dots you

360
00:12:19,249 --> 00:12:17,249
can see actually a water feature co2

361
00:12:21,469 --> 00:12:19,259
feature water so this is actually great

362
00:12:24,049 --> 00:12:21,479
and this is only ten occultation sort n

363
00:12:25,849 --> 00:12:24,059

transits to observe in this planet so

364
00:12:28,189 --> 00:12:25,859
that's actually doable with James Webb

365
00:12:30,289 --> 00:12:28,199
hopefully is that we have capability

366
00:12:31,869 --> 00:12:30,299
here perhaps observing this planet and

367
00:12:34,729 --> 00:12:31,879
actually seeing spectral features

368
00:12:35,749 --> 00:12:34,739
now I mentioned clouds before our clouds

369
00:12:37,219 --> 00:12:35,759
are a serious problem

370
00:12:39,949 --> 00:12:37,229
so let's look a Trappist one see which

371
00:12:41,479 --> 00:12:39,959
could form sulfuric acid clouds the

372
00:12:43,309 --> 00:12:41,489
cloud deck is right here right it

373
00:12:45,619 --> 00:12:43,319
truncates the transmission spectrum at

374
00:12:47,359 --> 00:12:45,629
the top of the cloud deck and so this is

375
00:12:49,849 --> 00:12:47,369
a serious problem because now our signal

376
00:12:52,459 --> 00:12:49,859
went from maybe 200 parts per million to

377
00:12:53,539 --> 00:12:52,469
now it's half that and so that's a lot

378
00:12:55,159 --> 00:12:53,549
more difficult and here's the number of

379
00:12:57,949 --> 00:12:55,169
occupations you'd have to get to several

380
00:12:59,989 --> 00:12:57,959
noise of five or ten fifteen for Travis

381
00:13:01,129 --> 00:12:59,999
Muncey for a Venus like atmosphere or if

382
00:13:03,829 --> 00:13:01,139
you have a Venus like atmosphere that

383
00:13:06,619 --> 00:13:03,839
actually has clouds now you're up to

384
00:13:08,209 --> 00:13:06,629
eighty and I don't think the James Webb

385
00:13:10,459 --> 00:13:08,219
committees have determined how much time

386
00:13:11,750 --> 00:13:10,469
is going we're ever going to approve

387
00:13:14,870 --> 00:13:11,760
eighty transit system

388
00:13:16,610 --> 00:13:14,880

like 100 200 hours of time on a very

389
00:13:20,720 --> 00:13:16,620
expensive telescope that has to compete

390
00:13:23,150 --> 00:13:20,730
with other science so now that was

391
00:13:27,230 --> 00:13:23,160
already really bad the habitable planet

392
00:13:28,580 --> 00:13:27,240
potentially trap us 1e this this looks

393
00:13:30,440 --> 00:13:28,590
pretty scary right you can see a co2

394
00:13:32,660 --> 00:13:30,450
band but this is fifty or a hundred

395
00:13:34,220 --> 00:13:32,670
transits of this planet to be able to

396
00:13:35,630 --> 00:13:34,230
see these features so this maybe is

397
00:13:37,010 --> 00:13:35,640
something that once we really understand

398
00:13:39,230 --> 00:13:37,020
the noise characteristics of James Webb

399
00:13:41,780 --> 00:13:39,240
and if it's favorable maybe this is

400
00:13:44,480 --> 00:13:41,790
something we can convince the observers

401
00:13:46,040 --> 00:13:44,490
in charge of the telescope to look at

402
00:13:48,350 --> 00:13:46,050
something like trap is running long

403
00:13:49,880 --> 00:13:48,360
enough to actually be able to

404
00:13:51,050 --> 00:13:49,890
distinguish an atmosphere in this plant

405
00:13:52,610 --> 00:13:51,060
otherwise if you just look at five

406
00:13:54,380 --> 00:13:52,620
transits and traffice or any you're not

407
00:13:57,800 --> 00:13:54,390
going to see anything and not gonna

408
00:13:58,310 --> 00:13:57,810
learn anything so what data do we have

409
00:13:59,900 --> 00:13:58,320
now

410
00:14:01,700 --> 00:13:59,910
Korea's speaker Arthur mentioned

411
00:14:04,280 --> 00:14:01,710
photometry so we did look at the

412
00:14:07,190 --> 00:14:04,290
photometric bands from Spitzer and

413
00:14:09,290 --> 00:14:07,200

Kepler that are available and we find

414
00:14:12,080 --> 00:14:09,300
that our models kind of fit the data

415
00:14:14,180 --> 00:14:12,090
here but the Spitzer bands Spitzer

416
00:14:16,310 --> 00:14:14,190
really struggles with seeing at rest

417
00:14:19,070 --> 00:14:16,320
reply that they tried this really

418
00:14:21,800 --> 00:14:19,080
doesn't rule out anything straight-line

419
00:14:23,000 --> 00:14:21,810
my spectra hey but at least they're kind

420
00:14:25,390 --> 00:14:23,010
of going the right way

421
00:14:28,130 --> 00:14:25,400
but that's probably confirmation bias

422
00:14:30,920 --> 00:14:28,140
but everything's still consistent so

423
00:14:32,690 --> 00:14:30,930
everything's still available I think it

424
00:14:35,840 --> 00:14:32,700
out of time now so I'll just leave up my

425
00:14:37,430 --> 00:14:35,850
conclusions primarily that extent

426
00:14:38,780 --> 00:14:37,440
activity drives the composition of the

427
00:14:39,890 --> 00:14:38,790
atmosphere to drive the photochemistry

428
00:14:41,750 --> 00:14:39,900
and I charged with climbin what you

429
00:14:43,550 --> 00:14:41,760
might observe and that these planets

430
00:14:45,050 --> 00:14:43,560
while they may be observable by James

431
00:14:47,600 --> 00:14:45,060
Webb with features up to 200 parts per

432
00:14:48,950 --> 00:14:47,610
million for the most favorable cases we

433
00:14:50,600 --> 00:14:48,960
really have to consider hard our

434
00:14:52,280 --> 00:14:50,610
observing strategy for the smaller

435
00:14:57,300 --> 00:14:52,290
planets and whether we'll be able to

436
00:14:57,310 --> 00:15:06,900
[Applause]

437
00:15:06,910 --> 00:15:12,360
any questions do your left

438
00:15:16,300 --> 00:15:14,740

so pretty much hmm pretty much all of

439
00:15:18,550 --> 00:15:16,310
these planets are in some sort of mean

440
00:15:19,090 --> 00:15:18,560
motion resonance and probably all tied

441
00:15:21,880 --> 00:15:19,100
and they live

442
00:15:24,640 --> 00:15:21,890
yep how do you does the model account

443
00:15:26,860 --> 00:15:24,650
for a lack or a possible some amount of

444
00:15:28,840 --> 00:15:26,870
circulation between them and do you see

445
00:15:30,700 --> 00:15:28,850
big variations in the day and night side

446
00:15:32,470 --> 00:15:30,710
spectra so I don't model the day or

447
00:15:34,420 --> 00:15:32,480
night side this is a 1d model I am

448
00:15:36,880 --> 00:15:34,430
working on a kind of day and night side

449
00:15:39,000 --> 00:15:36,890
type model to be able to do more

450
00:15:42,490 --> 00:15:39,010
difficult planets that way I've done

451
00:15:46,000 --> 00:15:42,500
some comparison from work on Proximus NB

452
00:15:50,110 --> 00:15:46,010
on comparing 1d to 3d models and so

453
00:15:53,560 --> 00:15:50,120
forth ich say atmosphere is like Venus

454
00:15:57,240 --> 00:15:53,570
that have very good thermal capabilities

455
00:15:59,890 --> 00:15:57,250
there you can actually find that see

456
00:16:01,060 --> 00:15:59,900
that yeah so like one of the sums that

457
00:16:04,870 --> 00:16:01,070
were shown is that okay if you have a

458
00:16:06,430 --> 00:16:04,880
resonance your atmosphere is can be

459
00:16:08,500 --> 00:16:06,440
smeared out so the day/night side is

460
00:16:10,840 --> 00:16:08,510
quite similar and that's one reason why

461
00:16:12,400 --> 00:16:10,850
we can use a 1d model here I found that

462
00:16:13,720 --> 00:16:12,410
the temperatures and when you're looking

463
00:16:15,579 --> 00:16:13,730

at the surface temperatures which is

464
00:16:17,650 --> 00:16:15,589
primarily what I'm looking at in terms

465
00:16:19,180 --> 00:16:17,660
of habitability that the surface

466
00:16:21,460 --> 00:16:19,190
temperatures that the 3d modelers got

467
00:16:24,310 --> 00:16:21,470
from the LM D model from próxima son

468
00:16:26,140 --> 00:16:24,320
were quite repetitive all in 2016 under

469
00:16:28,420 --> 00:16:26,150
the exact same assumptions for the 1d

470
00:16:31,329 --> 00:16:28,430
model they get very similar answers

471
00:16:33,190 --> 00:16:31,339
within 5 or 10 Kelvin in most cases the

472
00:16:35,260 --> 00:16:33,200
other thing to think about is when we

473
00:16:37,240 --> 00:16:35,270
look at that but for an ocean baring

474
00:16:39,220 --> 00:16:37,250
planet like the Aqua planet if you

475
00:16:41,079 --> 00:16:39,230
actually do include ocean heat transport

476
00:16:43,000 --> 00:16:41,089
which is very very computationally

477
00:16:45,340 --> 00:16:43,010
expensive in 3d models that typically

478
00:16:48,220 --> 00:16:45,350
they don't do that but some work by Yang

479
00:16:50,199 --> 00:16:48,230
Hyun Jung or yang at all in 2014

480
00:16:52,449 --> 00:16:50,209
actually showed that you get a lot more

481
00:16:54,220 --> 00:16:52,459
ocean heat transport to the backside of

482
00:16:56,890 --> 00:16:54,230
the planet even in a synchronously

483
00:16:58,930 --> 00:16:56,900
rotating rotating case yeah so the

484
00:17:01,120 --> 00:16:58,940
caveats are with 1d is we can do the

485
00:17:03,100 --> 00:17:01,130
radiation much much better but you lose

486
00:17:05,559 --> 00:17:03,110
any information about the dynamics so

487
00:17:07,240 --> 00:17:05,569
really kind of need to understand both

488
00:17:08,980 --> 00:17:07,250

cases to know what's going on with the

489
00:17:15,460 --> 00:17:08,990
planet yeah but we are working towards

490
00:17:20,990 --> 00:17:19,700
hi so I just wanted to go back to when

491
00:17:24,080 --> 00:17:21,000
you were talking about

492
00:17:26,810 --> 00:17:24,090
I'm dwarf planets / French or well I'm

493
00:17:28,820 --> 00:17:26,820
dwarf planets that preferentially have

494
00:17:32,090 --> 00:17:28,830
high methane concentrations that are

495
00:17:35,210 --> 00:17:32,100
abiotic and that like levels am I right

496
00:17:37,940 --> 00:17:35,220
in interpreting that as atmospheric loss

497
00:17:39,620 --> 00:17:37,950
processes sort of blow off other species

498
00:17:42,410 --> 00:17:39,630
and then the methane is preferentially

499
00:17:45,470 --> 00:17:42,420
left behind or that not right no that's

500
00:17:48,830 --> 00:17:45,480
a great question so but that's not

501
00:17:50,030 --> 00:17:48,840
really right methane so the the methane

502
00:17:52,850 --> 00:17:50,040
is a little bit more confusing because

503
00:17:54,890 --> 00:17:52,860
methane survives easier around an EM

504
00:17:57,350 --> 00:17:54,900
door even though it has a lot more far

505
00:17:59,900 --> 00:17:57,360
UV flux and a lot more lyman-alpha it

506
00:18:02,210 --> 00:17:59,910
still survives stronger because of the

507
00:18:05,150 --> 00:18:02,220
other processes such as ozone that

508
00:18:07,340 --> 00:18:05,160
destroy methane so it's so it's not that

509
00:18:10,100 --> 00:18:07,350
the destruction of methane directly by

510
00:18:11,270 --> 00:18:10,110
the star is much different it's that the

511
00:18:13,580 --> 00:18:11,280
destruction of methane by other

512
00:18:16,850 --> 00:18:13,590
molecules such as water and such as

513
00:18:18,470 --> 00:18:16,860

ozone is much reduced because the n UV

514
00:18:21,800 --> 00:18:18,480
absorption the near UV that's more like

515
00:18:24,500 --> 00:18:21,810
what ozone absorbs and earth Earth's

516
00:18:27,680 --> 00:18:24,510
atmosphere that UV level is actually

517
00:18:30,110 --> 00:18:27,690
much less compared to gee doors so you

518
00:18:31,790 --> 00:18:30,120
actually get longer methane lifespans

519
00:18:33,680 --> 00:18:31,800
and so even the same flux of methane

520
00:18:34,970 --> 00:18:33,690
results in just more methane building up

521
00:18:39,470 --> 00:18:34,980
in the atmosphere gotcha