AbGradCon 2018

1
00:00:00,260 --> 00:00:12,340
[Music]

2
00:00:18,200 --> 00:00:15,200
welcome to the first science session of

3
00:00:21,050 --> 00:00:18,210
AFRICOM I am here to put the Astro in

4
00:00:23,720 --> 00:00:21,060
astrobiology by talking about the first

5
00:00:26,030 --> 00:00:23,730
two sessions which also happened to be

6
00:00:30,760 --> 00:00:26,040
the entirety of the morning session and

7
00:00:36,260 --> 00:00:34,639
okay so as the first time attended of

8
00:00:38,780 --> 00:00:36,270
this meeting I was pretty amused to see

9
00:00:42,229 --> 00:00:38,790
the diversity of topics just within one

10
00:00:43,759 --> 00:00:42,239
common theme and this was apparently

11
00:00:46,069 --> 00:00:43,769
true in previous years as well so I

12
00:00:47,900 --> 00:00:46,079
think it really emphasizes the identity

13
00:00:50,959 --> 00:00:47,910

of astrobiology as a truly

14
00:00:53,119 --> 00:00:50,969
interdisciplinary science field but you

15
00:00:56,450 --> 00:00:53,129
know that being said we do have a story

16
00:00:59,180 --> 00:00:56,460
right here so my own research is on the

17
00:01:00,979 --> 00:00:59,190
atmospheric composition modeling of a

18
00:01:03,380 --> 00:01:00,989
variety of exoplanet types from

19
00:01:05,119 --> 00:01:03,390
earth-like planets to hot Jupiters which

20
00:01:07,610 --> 00:01:05,129
are essentially Jupiter's that are at

21
00:01:12,530 --> 00:01:07,620
1/10 of the mercury sun distance from

22
00:01:14,360 --> 00:01:12,540
their host star so basically what I'm

23
00:01:16,219 --> 00:01:14,370
trying to say here is as somebody who's

24
00:01:20,270 --> 00:01:16,229
actually interested in this kind of

25
00:01:25,039 --> 00:01:20,280
stuff I found that you know I'm somebody

26
00:01:27,859 --> 00:01:25,049
who wants to look at how we like how we

27
00:01:30,859 --> 00:01:27,869
got these spectroscopic signals that we

28
00:01:33,889 --> 00:01:30,869
see when we look at planets so when we

29
00:01:37,999 --> 00:01:33,899
look at the planets with Spitzer or the

30
00:01:39,740 --> 00:01:38,009
James Webb Space Telescope or you know

31
00:01:41,840 --> 00:01:39,750
Spitzer and James Webb has launched yet

32
00:01:43,609 --> 00:01:41,850
so we are able to look at their spectra

33
00:01:46,100 --> 00:01:43,619
in the infrared and we can detect all

34
00:01:49,880 --> 00:01:46,110
these molecules and of course for the

35
00:01:53,480 --> 00:01:49,890
molecules to have gotten there they need

36
00:01:56,330 --> 00:01:53,490
to have had you know things delivered on

37
00:01:59,179 --> 00:01:56,340
their surfaces so obviously the delivery

38
00:02:01,249 --> 00:01:59,189

part which is the topics in the middle

39
00:02:02,899 --> 00:02:01,259
of these two sessions are important

40
00:02:05,359 --> 00:02:02,909
because that's how we get the molecules

41
00:02:10,520 --> 00:02:05,369
that we can see with Space Telescope so

42
00:02:13,670 --> 00:02:10,530
in that sense what we look at for

43
00:02:17,390 --> 00:02:13,680
exoplanets and what we know about solar

44
00:02:20,990 --> 00:02:17,400
systems essentially just inform each

45
00:02:22,850 --> 00:02:21,000
other and the idea is that we will be

46
00:02:23,740 --> 00:02:22,860
combining the knowledge and eventually

47
00:02:26,830 --> 00:02:23,750
end up with the

48
00:02:29,740 --> 00:02:26,840
search for life being our ultimate goal

49
00:02:31,720 --> 00:02:29,750
which is the goal of astrobiology and in

50
00:02:34,900 --> 00:02:31,730
order for us to do that to even get to

51
00:02:36,460 --> 00:02:34,910
that stage so you know we talk about the

52
00:02:39,190 --> 00:02:36,470
delivery process and we look at

53
00:02:41,860 --> 00:02:39,200
exoplanets and ultimately we want to

54
00:02:44,110 --> 00:02:41,870
look at analog sites on earth for say

55
00:02:45,940 --> 00:02:44,120
ocean worlds like deep sea regions and

56
00:02:48,160 --> 00:02:45,950
we want to explore them with robotic

57
00:02:50,500 --> 00:02:48,170
missions and we also want to look at you

58
00:02:52,810 --> 00:02:50,510
know other extreme planets where there

59
00:02:53,350 --> 00:02:52,820
might have been life in the past like

60
00:02:56,440 --> 00:02:53,360
Mars

61
00:02:59,050 --> 00:02:56,450
so talks about them will basically be

62
00:03:01,660 --> 00:02:59,060
the end of the session so we're gonna go

63
00:03:04,090 --> 00:03:01,670

how did everything get there how do we

64
00:03:05,710 --> 00:03:04,100
look at exoplanets and basically looking

65
00:03:08,050 --> 00:03:05,720
at your own solar neighborhood to

66
00:03:09,910 --> 00:03:08,060
characterize the extreme of Bayeux

67
00:03:15,630 --> 00:03:09,920
habitable zones so I think that's how

68
00:03:17,800 --> 00:03:15,640
the session here comes together okay so

69
00:03:19,600 --> 00:03:17,810
as I mentioned we've had all these

70
00:03:22,660 --> 00:03:19,610
missions and I'm sure you know all about

71
00:03:26,530 --> 00:03:22,670
them and we've had specially we have had

72
00:03:29,080 --> 00:03:26,540
Kepler which was phenomenally crucial

73
00:03:30,520 --> 00:03:29,090
for identifying all these planets around

74
00:03:33,580 --> 00:03:30,530
other solar system that are like

75
00:03:35,860 --> 00:03:33,590
earth-like and what that has meant for

76
00:03:38,530 --> 00:03:35,870
us is we have been able to draw some

77
00:03:41,410 --> 00:03:38,540
constraints all the Goldilocks zone /

78
00:03:43,300 --> 00:03:41,420
habitable zone around different types of

79
00:03:45,039 --> 00:03:43,310
stars now there's relationship for them

80
00:03:48,070 --> 00:03:45,049
what one of my code visors actually

81
00:03:49,840 --> 00:03:48,080
defined that Ravi Kokura and so now we

82
00:03:51,250 --> 00:03:49,850
can actually know the properties of the

83
00:03:53,350 --> 00:03:51,260
star and we can actually calculate

84
00:03:55,840 --> 00:03:53,360
what's the conservative habitable zone

85
00:03:57,670 --> 00:03:55,850
around them and we can even identify the

86
00:04:00,940 --> 00:03:57,680
inner habitable zone which is basically

87
00:04:03,190 --> 00:04:00,950
the limit you know beyond or rather

88
00:04:05,830 --> 00:04:03,200

before which there's going to be too

89
00:04:08,050 --> 00:04:05,840
much heat and things are just gonna like

90
00:04:09,670 --> 00:04:08,060
boil over and not remain and the other

91
00:04:12,340 --> 00:04:09,680
outer edge of the habitable zone which

92
00:04:15,039 --> 00:04:12,350
is the green house glaciation zone where

93
00:04:17,680 --> 00:04:15,049
you know it's too cold gases freeze out

94
00:04:19,810 --> 00:04:17,690
and I reflectivity albedo and you're

95
00:04:22,409 --> 00:04:19,820
done basically the inner and outer edges

96
00:04:28,060 --> 00:04:22,419
are just point of no return

97
00:04:30,990 --> 00:04:28,070
okay so right so now I'm gonna actually

98
00:04:35,650 --> 00:04:31,000
proceed to the actual warm-up talk

99
00:04:37,430 --> 00:04:35,660
having introduced all this part okay so

100
00:04:39,050 --> 00:04:37,440
let's start with some Astro

101
00:04:41,360 --> 00:04:39,060
chemistry since we're talking about

102
00:04:43,880 --> 00:04:41,370
you're gonna start with before you know

103
00:04:46,280 --> 00:04:43,890
things even formed so once there was a

104
00:04:48,290 --> 00:04:46,290
star it exploded it reset all the

105
00:04:50,780 --> 00:04:48,300
chemistry everything blew up everything

106
00:04:53,540 --> 00:04:50,790
atomized everything started from scratch

107
00:04:54,920 --> 00:04:53,550
and then things condensed back to clouds

108
00:04:57,290 --> 00:04:54,930
of gas and dust

109
00:04:59,900 --> 00:04:57,300
roughly hundreds of light years across

110
00:05:02,540 --> 00:04:59,910
and then they condense into smaller and

111
00:05:04,610 --> 00:05:02,550
smaller core and then we get protostars

112
00:05:06,200 --> 00:05:04,620
and from protostars we get disks and

113
00:05:09,260 --> 00:05:06,210

then they condense further into

114
00:05:11,660 --> 00:05:09,270
planetesimals so astrochemistry is the

115
00:05:13,040 --> 00:05:11,670
process that happens during this whole

116
00:05:16,630 --> 00:05:13,050
ordeal

117
00:05:19,460 --> 00:05:16,640
you know once things blow up and and

118
00:05:22,280 --> 00:05:19,470
begin to compress you know things get

119
00:05:23,570 --> 00:05:22,290
hotter more complex molecules are formed

120
00:05:26,420 --> 00:05:23,580
there's all sorts of weird chemistry

121
00:05:29,540 --> 00:05:26,430
driven by HBase I am there's grain

122
00:05:30,830 --> 00:05:29,550
surface chemistry ice chemistry but they

123
00:05:32,390 --> 00:05:30,840
essentially the thing is the chemistry

124
00:05:33,920 --> 00:05:32,400
doesn't really change but it's really

125
00:05:36,470 --> 00:05:33,930
just the conditions that are rapidly

126
00:05:38,330 --> 00:05:36,480
changing like density temperature and

127
00:05:40,100 --> 00:05:38,340
the fact that there is like no liquid

128
00:05:42,520 --> 00:05:40,110
phase throughout this process so

129
00:05:45,680 --> 00:05:42,530
essentially and we all know this by now

130
00:05:48,710 --> 00:05:45,690
molecules have been here before earth

131
00:05:50,630 --> 00:05:48,720
was formed and so when earth was formed

132
00:05:53,650 --> 00:05:50,640
a large number of organics was actually

133
00:05:56,810 --> 00:05:53,660
delivered to the surface and eventually

134
00:05:59,210 --> 00:05:56,820
we got more organics when when we got

135
00:06:00,860 --> 00:05:59,220
bombarded later on which we responds

136
00:06:02,720 --> 00:06:00,870
with which we think is responsible for

137
00:06:05,360 --> 00:06:02,730
current life because that delivered like

138
00:06:07,370 --> 00:06:05,370

trillions of kilograms of organics that

139
00:06:11,600 --> 00:06:07,380
would be necessary for life to actually

140
00:06:13,430 --> 00:06:11,610
start so let's get on that a little bit

141
00:06:14,750 --> 00:06:13,440
more so comets are all over right like

142
00:06:19,180 --> 00:06:14,760
we always hear about them they're just

143
00:06:21,770 --> 00:06:19,190
pushing in and out they're on a highly

144
00:06:24,590 --> 00:06:21,780
inclined plane compared to Earth's

145
00:06:26,090 --> 00:06:24,600
playing around the Sun so they're just

146
00:06:27,620 --> 00:06:26,100
crazy like you I mean you come on you

147
00:06:29,600 --> 00:06:27,630
see here so sometimes they get really

148
00:06:32,030 --> 00:06:29,610
close sometimes they get really far and

149
00:06:34,490 --> 00:06:32,040
then when they get really close they can

150
00:06:36,080 --> 00:06:34,500
you know vaporizing our atmosphere or in

151
00:06:38,630 --> 00:06:36,090
fact like during the late heavy

152
00:06:42,140 --> 00:06:38,640
bombardment that happened guilty you get

153
00:06:43,820 --> 00:06:42,150
yours for Giga years ago eight basically

154
00:06:46,820 --> 00:06:43,830
crashed into Earth and during that

155
00:06:49,760 --> 00:06:46,830
process it signed a custom declaration

156
00:06:50,690 --> 00:06:49,770
form for ingredients of life as it was

157
00:06:53,120 --> 00:06:50,700
coming from

158
00:06:54,140 --> 00:06:53,130
so to all our people who've been

159
00:06:55,460 --> 00:06:54,150
traveling from foreign countries for

160
00:06:59,150 --> 00:06:55,470
this meeting I'm sure you've had to do

161
00:07:01,600 --> 00:06:59,160
that so so did these comets and during

162
00:07:04,010 --> 00:07:01,610
that process they delivered essential

163
00:07:06,080 --> 00:07:04,020

like small molecules highly reactive

164
00:07:08,780 --> 00:07:06,090
small molecules that was used for

165
00:07:13,160 --> 00:07:08,790
elementary prebiotic chemistry so HTN

166
00:07:16,250 --> 00:07:13,170
has been detected in comets and the cool

167
00:07:19,910 --> 00:07:16,260
thing is HCN is a very simple but a very

168
00:07:22,100 --> 00:07:19,920
reactive molecule and what that means is

169
00:07:24,470 --> 00:07:22,110
that when it forms a number of

170
00:07:26,660 --> 00:07:24,480
macromolecules not polymers yet but just

171
00:07:29,320 --> 00:07:26,670
a small number of repetitive chains it

172
00:07:32,270 --> 00:07:29,330
starts the pathway to chemical evolution

173
00:07:36,170 --> 00:07:32,280
so you really start getting the nucleic

174
00:07:39,080 --> 00:07:36,180
acid we start getting basically four

175
00:07:41,630 --> 00:07:39,090
basic biomolecules as nucleic acid

176
00:07:43,730 --> 00:07:41,640
proteins lipids carbohydrates so

177
00:07:45,500 --> 00:07:43,740
basically AC and in aqueous solution is

178
00:07:47,060 --> 00:07:45,510
just very versatile it can just like

179
00:07:50,000 --> 00:07:47,070
repeat itself to follow all these

180
00:07:51,680 --> 00:07:50,010
molecules and it creates the amino acids

181
00:07:55,220 --> 00:07:51,690
which we know are essentials for like

182
00:07:56,540 --> 00:07:55,230
building blocks and so yeah so this is

183
00:07:58,310 --> 00:07:56,550
all interesting and the cool thing about

184
00:08:00,290 --> 00:07:58,320
ACN is that it has this like crazy

185
00:08:02,480 --> 00:08:00,300
strong triple bond that should have

186
00:08:03,950 --> 00:08:02,490
survived cometary impacts so we think

187
00:08:06,020 --> 00:08:03,960
like there's detectable amount of them

188
00:08:08,240 --> 00:08:06,030

like which we can quantify that would

189
00:08:13,490 --> 00:08:08,250
have been there like right after the

190
00:08:14,930 --> 00:08:13,500
heavy bombardment so let's see so the

191
00:08:16,820 --> 00:08:14,940
other thing I want to mention was I

192
00:08:18,260 --> 00:08:16,830
mentioned Spitzer so Spitzer is really

193
00:08:20,150 --> 00:08:18,270
cool because Spitzer has done a lot of

194
00:08:21,950 --> 00:08:20,160
things for us so one of the things that

195
00:08:24,050 --> 00:08:21,960
Spitzer does is it also looks at

196
00:08:27,410 --> 00:08:24,060
protoplanetary discs around like other

197
00:08:29,960 --> 00:08:27,420
stars and in doing so it was able to

198
00:08:32,030 --> 00:08:29,970
actually find some like warm evidence of

199
00:08:33,520 --> 00:08:32,040
warm you know because you can see Dustin

200
00:08:36,469 --> 00:08:33,530
infrared so warm

201
00:08:38,420 --> 00:08:36,479
carbon rich dust at the habitable zone

202
00:08:40,640 --> 00:08:38,430
of another star which basically showed

203
00:08:42,980 --> 00:08:40,650
that That star system also on just

204
00:08:45,140 --> 00:08:42,990
recently underwent a heavy bombardment

205
00:08:46,880 --> 00:08:45,150
period so that's cool you know we have

206
00:08:48,410 --> 00:08:46,890
evidence for heavy bombardment in other

207
00:08:51,820 --> 00:08:48,420
systems which we are like you know it

208
00:08:55,570 --> 00:08:51,830
could have happened with us as well so

209
00:08:57,590 --> 00:08:55,580
right so I talked about Spitzer so

210
00:08:59,990 --> 00:08:57,600
everybody knows the James Webb Space

211
00:09:01,040 --> 00:09:00,000
Telescope is coming up it will launch at

212
00:09:02,320 --> 00:09:01,050
some point I know it keeps getting

213
00:09:04,690 --> 00:09:02,330

delayed

214
00:09:06,910 --> 00:09:04,700
so that's kind of like the new happy

215
00:09:08,590 --> 00:09:06,920
Hubble which like much better bigger you

216
00:09:15,610 --> 00:09:08,600
know here's a size scale for comparison

217
00:09:17,500 --> 00:09:15,620
and one of the cool thing is like so you

218
00:09:19,510 --> 00:09:17,510
know you obviously like most flagship

219
00:09:21,519 --> 00:09:19,520
missions it has a lot of Astrophysical

220
00:09:23,290 --> 00:09:21,529
goals also it's going to look at core

221
00:09:24,579 --> 00:09:23,300
client systems and then it's also going

222
00:09:26,410 --> 00:09:24,589
to look at finder systems and the

223
00:09:29,440 --> 00:09:26,420
origins of life which is what we care

224
00:09:31,990 --> 00:09:29,450
about so one of those telescope science

225
00:09:33,880 --> 00:09:32,000
goal is to study planets that could you

226
00:09:35,710 --> 00:09:33,890
know help shed information on this

227
00:09:38,410 --> 00:09:35,720
origin of life but that doesn't mean

228
00:09:40,060 --> 00:09:38,420
exoplanets only it will also unravel

229
00:09:42,190 --> 00:09:40,070
mysteries held by object in our own

230
00:09:44,710 --> 00:09:42,200
solar systems such as like for marks

231
00:09:47,139 --> 00:09:44,720
outwards Europe Enceladus you know the

232
00:09:48,910 --> 00:09:47,149
ocean planets that may possibly Harbor

233
00:09:52,060 --> 00:09:48,920
life you know under their like icy

234
00:09:53,949 --> 00:09:52,070
plumes are actually one of Webb's first

235
00:09:58,900 --> 00:09:53,959
list of targets with guaranteed

236
00:10:00,250 --> 00:09:58,910
observing time so here are some of the

237
00:10:04,030 --> 00:10:00,260
instruments they're all into infrared

238
00:10:05,530 --> 00:10:04,040

and they can detect like lots of

239
00:10:08,860 --> 00:10:05,540
molecules but I'm not gonna go like

240
00:10:11,980 --> 00:10:08,870
crazy deep into the detail of it so and

241
00:10:13,510 --> 00:10:11,990
so that brings me to my next question is

242
00:10:16,449 --> 00:10:13,520
which what I work on and some of the

243
00:10:17,620 --> 00:10:16,459
other speakers work on is how do we look

244
00:10:19,180 --> 00:10:17,630
at exoplanets like how do we

245
00:10:21,190 --> 00:10:19,190
characterize them so when you look at

246
00:10:23,170 --> 00:10:21,200
you know spectroscopic measurements

247
00:10:24,790 --> 00:10:23,180
treatments that were Hubble Spitzer and

248
00:10:27,220 --> 00:10:24,800
will be on the James Webb Space

249
00:10:29,230 --> 00:10:27,230
Telescope there are ways that they

250
00:10:33,040 --> 00:10:29,240
actually look at the light of planet so

251
00:10:35,230 --> 00:10:33,050
when a an exoplanet transits in our line

252
00:10:38,560 --> 00:10:35,240
of sight as we're looking around the

253
00:10:41,019 --> 00:10:38,570
star as it passes the front of the star

254
00:10:42,970 --> 00:10:41,029
it just flows up the atmosphere around

255
00:10:45,250 --> 00:10:42,980
it and that process is known as primary

256
00:10:47,250 --> 00:10:45,260
transit and with that we can even

257
00:10:51,220 --> 00:10:47,260
identify trace gases in that atmosphere

258
00:10:52,660 --> 00:10:51,230
now as it of course you're looking at

259
00:10:53,949 --> 00:10:52,670
the edge of the orbit right you're

260
00:10:56,110 --> 00:10:53,959
looking at the edge of the transit race

261
00:10:58,540 --> 00:10:56,120
you can also know the planets size from

262
00:11:02,440 --> 00:10:58,550
there so a physical characteristic so as

263
00:11:04,990 --> 00:11:02,450

it goes behind the star then you know

264
00:11:06,610 --> 00:11:05,000
you you get the thermal radiation was

265
00:11:08,260 --> 00:11:06,620
blocked and then it comes out so

266
00:11:09,400 --> 00:11:08,270
basically from that process you can

267
00:11:12,370 --> 00:11:09,410
characterize the thermal radiation

268
00:11:14,500 --> 00:11:12,380
that's solely from the planet so this

269
00:11:15,490 --> 00:11:14,510
process is the secondary Eclipse when it

270
00:11:18,760 --> 00:11:15,500
goes behind the star

271
00:11:21,220 --> 00:11:18,770
and from this data we are can actually

272
00:11:23,080 --> 00:11:21,230
get the thermal structure of the planet

273
00:11:24,760 --> 00:11:23,090
so and then there's another thing you

274
00:11:27,010 --> 00:11:24,770
can do as well like if you look at the

275
00:11:28,300 --> 00:11:27,020
curves over here is as they're going

276
00:11:29,560 --> 00:11:28,310
around you know they're going to

277
00:11:31,630 --> 00:11:29,570
different phases just like the moon

278
00:11:33,880 --> 00:11:31,640
right so this allows ought to do a bit

279
00:11:35,920 --> 00:11:33,890
of like meteorology stuff so we can see

280
00:11:38,050 --> 00:11:35,930
the cyclic variations and the thermal

281
00:11:39,790 --> 00:11:38,060
phase curve in the bright like thermal

282
00:11:42,010 --> 00:11:39,800
brightness of the planet and you can

283
00:11:43,720 --> 00:11:42,020
basically assess variation of properties

284
00:11:46,090 --> 00:11:43,730
that would vary with that such as like

285
00:11:48,730 --> 00:11:46,100
the eccentricity you know how when a

286
00:11:51,700 --> 00:11:48,740
planet is much closer to the Sun then

287
00:11:53,380 --> 00:11:51,710
it's for this point and then you can and

288
00:11:54,940 --> 00:11:53,390

that's also a rotation great thing and

289
00:11:59,650 --> 00:11:54,950
really also have a speaker we'll talk

290
00:12:01,360 --> 00:11:59,660
about that too so finally since we just

291
00:12:03,330 --> 00:12:01,370
introduced how like the whole transit

292
00:12:05,680 --> 00:12:03,340
process work this is my favorite slide

293
00:12:08,800 --> 00:12:05,690
I'm sure you all know about the Trappist

294
00:12:12,310 --> 00:12:08,810
system so the Trappist system has seven

295
00:12:14,320 --> 00:12:12,320
planets in it and in 2015 three of them

296
00:12:16,480 --> 00:12:14,330
were discovered and the last year before

297
00:12:17,110 --> 00:12:16,490
other were discovered via Spitzer Space

298
00:12:18,790 --> 00:12:17,120
Telescope

299
00:12:22,090 --> 00:12:18,800
so yay Spitzer you're doing a lot for us

300
00:12:24,190 --> 00:12:22,100
and then currently three of them are

301
00:12:27,400 --> 00:12:24,200
considered to be in the habitable zone

302
00:12:29,620 --> 00:12:27,410
so that would be e FG and it's marked by

303
00:12:32,380 --> 00:12:29,630
green like even in the circle so you can

304
00:12:34,960 --> 00:12:32,390
know that but honestly like depending on

305
00:12:37,960 --> 00:12:34,970
the definition this could be up to six

306
00:12:39,790 --> 00:12:37,970
like you know if you really want to push

307
00:12:41,260 --> 00:12:39,800
the limits of like habitable zone but I

308
00:12:43,510 --> 00:12:41,270
would recommend not doing that because I

309
00:12:46,210 --> 00:12:43,520
just talked about inner and outer being

310
00:12:48,220 --> 00:12:46,220
limited by how hot and cold it gets so

311
00:12:51,790 --> 00:12:48,230
but within these plan is it can go

312
00:12:54,700 --> 00:12:51,800
anywhere from 170 Kelvin to like 330

313
00:12:58,420 --> 00:12:54,710

Kelvin and if you look at the bottom

314
00:13:00,790 --> 00:12:58,430
plot so E is very similar to Earth in

315
00:13:01,840 --> 00:13:00,800
terms of like size density and also it

316
00:13:05,440 --> 00:13:01,850
just gets about the same amount of

317
00:13:08,380 --> 00:13:05,450
radiation and then there is C which is

318
00:13:11,440 --> 00:13:08,390
the hotter one of which is still within

319
00:13:12,970 --> 00:13:11,450
this range of habitability but you know

320
00:13:14,740 --> 00:13:12,980
you would kind of question that right

321
00:13:16,840 --> 00:13:14,750
because that's overlapping with Venus so

322
00:13:20,170 --> 00:13:16,850
and we know Venus is kind of crazy right

323
00:13:21,520 --> 00:13:20,180
now so okay so I don't really have

324
00:13:23,470 --> 00:13:21,530
talked it's time to talk about anything

325
00:13:26,530 --> 00:13:23,480
else but I'm sure we have we'll have our

326
00:13:28,030 --> 00:13:26,540
you know justin talking about a little

327
00:13:29,020 --> 00:13:28,040
bit about ocean walls and we'll have my

328
00:13:31,360 --> 00:13:29,030
colleague amber Bray talking

329
00:13:33,300 --> 00:13:31,370
a little about Mars rovers later on so