
AbSciCon
2017
MESA, ARIZONA

1
00:00:12,250 --> 00:00:06,150
you

2
00:00:18,690 --> 00:00:14,340
[Music]

3
00:00:20,589 --> 00:00:18,700
thank you very much uh so we're all here

4
00:00:21,850 --> 00:00:20,599
because we're interested in this

5
00:00:24,310 --> 00:00:21,860
question of are we alone in the universe

6
00:00:26,320 --> 00:00:24,320
and there's been so many amazing planet

7
00:00:28,089 --> 00:00:26,330
discoveries in this past year for

8
00:00:29,950 --> 00:00:28,099
example the whole planet around our

9
00:00:35,530 --> 00:00:29,960
closest star Proxima Centauri last

10
00:00:39,939 --> 00:00:35,540
August the three Trappist planets if

11
00:00:42,970 --> 00:00:39,949
this is working if the three Travis

12
00:00:46,180 --> 00:00:42,980
planets that were also found in the

13
00:00:47,860 --> 00:00:46,190

habitable zone and of course LHS 11:40 B

14
00:00:51,430 --> 00:00:47,870
there's just been so many amazing

15
00:00:53,200 --> 00:00:51,440
discoveries recently and and so when we

16
00:00:57,490 --> 00:00:53,210
think about this we're really talking a

17
00:00:59,740 --> 00:00:57,500
lot about these M dwarfs and M dwarfs

18
00:01:01,180 --> 00:00:59,750
are much smaller than the Sun and you

19
00:01:02,950 --> 00:01:01,190
can see this kind of relative size

20
00:01:05,109 --> 00:01:02,960
depiction here and from Kepler we've

21
00:01:07,090 --> 00:01:05,119
learned that one in four members likely

22
00:01:09,100 --> 00:01:07,100
have a habitable planet and so we need

23
00:01:10,330 --> 00:01:09,110
to consider that these planets that

24
00:01:12,430 --> 00:01:10,340
we're going to be finding are going to

25
00:01:15,490 --> 00:01:12,440
be around stars that are very different

26
00:01:18,280 --> 00:01:15,500
from our Sun and so here's just a image

27
00:01:19,600 --> 00:01:18,290
of all the nearby known stars and our

28
00:01:22,990 --> 00:01:19,610
stellar neighborhood and you can see

29
00:01:25,990 --> 00:01:23,000
that 75% of them are M dwarfs and and

30
00:01:29,740 --> 00:01:26,000
relatively few are argue dwarf like like

31
00:01:31,899 --> 00:01:29,750
our Sun so one of the first things that

32
00:01:33,850 --> 00:01:31,909
we need to look at is how does the star

33
00:01:36,280 --> 00:01:33,860
impact the atmosphere the spectral

34
00:01:38,380 --> 00:01:36,290
fingerprints and the bio bio signatures

35
00:01:40,149 --> 00:01:38,390
in in that planet and as we go

36
00:01:43,300 --> 00:01:40,159
astronomers for the non astronomers in

37
00:01:45,100 --> 00:01:43,310
the room as we talk about fgk stars F

38
00:01:46,330 --> 00:01:45,110

are the bigger ones and M are the

39
00:01:47,920 --> 00:01:46,340
smaller ones so I'm going to be using

40
00:01:51,249 --> 00:01:47,930
this terminology throughout the talk of

41
00:01:52,840 --> 00:01:51,259
F G K and M stars G stars like our Sun

42
00:01:55,420 --> 00:01:52,850
and by and large you're going from

43
00:01:57,039 --> 00:01:55,430
higher UV environment to a lower UV

44
00:01:58,330 --> 00:01:57,049
environment with some caveats which I'll

45
00:02:01,090 --> 00:01:58,340
explain in just a second

46
00:02:03,910 --> 00:02:01,100
so UV is interesting because it destroys

47
00:02:06,580 --> 00:02:03,920
some bio signatures such as methane in

48
00:02:08,229 --> 00:02:06,590
the atmosphere perhaps making it harder

49
00:02:10,840 --> 00:02:08,239
to detect around a planet with a lot of

50
00:02:12,610 --> 00:02:10,850
UV but on the other hand UV produces

51
00:02:15,880 --> 00:02:12,620
some bio signatures such as ozone

52
00:02:18,340 --> 00:02:15,890
through the fatalis of oxygen and so and

53
00:02:20,140 --> 00:02:18,350
when we look at reaction rates we really

54
00:02:22,390 --> 00:02:20,150
see that it's the ratio of how much far

55
00:02:24,440 --> 00:02:22,400
UV to near UV that ultimately matters

56
00:02:26,180 --> 00:02:24,450
and you can see that's easiest in the

57
00:02:28,460 --> 00:02:26,190
production and destruction rates of

58
00:02:30,800 --> 00:02:28,470
ozone if you look here the production of

59
00:02:33,410 --> 00:02:30,810
ozone depends primarily on the far UV

60
00:02:36,200 --> 00:02:33,420
radiation whereas ozone destruction can

61
00:02:39,350 --> 00:02:36,210
happen by near UV radiation as well and

62
00:02:42,560 --> 00:02:39,360
going back to that statement I made

63
00:02:44,810 --> 00:02:42,570

earlier of these more massive stars have

64
00:02:47,090 --> 00:02:44,820
higher UV it's really that they have a

65
00:02:49,970 --> 00:02:47,100
higher near UV because they still have

66
00:02:52,970 --> 00:02:49,980
that blackbody continuum flux in the in

67
00:02:55,400 --> 00:02:52,980
the near UV and and these lower mass

68
00:02:57,320 --> 00:02:55,410
stars have a much higher ratio of far UV

69
00:02:59,720 --> 00:02:57,330
to near UV flux so this is what's

70
00:03:01,610 --> 00:02:59,730
changing the different atmospheres

71
00:03:04,310 --> 00:03:01,620
around these different stellar host

72
00:03:06,800 --> 00:03:04,320
stars so we also know that planets

73
00:03:08,390 --> 00:03:06,810
evolved from geology to plate tectonics

74
00:03:10,430 --> 00:03:08,400
in life our own atmosphere has not

75
00:03:12,080 --> 00:03:10,440
stayed the same and we heard you know

76
00:03:14,690 --> 00:03:12,090
possible things we had things like the

77
00:03:16,730 --> 00:03:14,700
idea or the Archaean snowball phases and

78
00:03:19,070 --> 00:03:16,740
the jurassic period and other things in

79
00:03:21,410 --> 00:03:19,080
in our earth history and so this is a

80
00:03:22,790 --> 00:03:21,420
nice little diagram that we're going to

81
00:03:24,320 --> 00:03:22,800
think that bio signatures are going to

82
00:03:26,270 --> 00:03:24,330
also change over this geological time

83
00:03:28,040 --> 00:03:26,280
and you know talking going back to just

84
00:03:29,360 --> 00:03:28,050
talk about possible Hayes's that we're

85
00:03:31,220 --> 00:03:29,370
going to see or different chemistry's

86
00:03:33,020 --> 00:03:31,230
there happen in the atmosphere so here

87
00:03:35,510 --> 00:03:33,030
you can see that at the formation of

88
00:03:38,090 --> 00:03:35,520

Earth we think this is just a broad

89
00:03:39,530 --> 00:03:38,100
schematic picture we don't have exact

90
00:03:41,360 --> 00:03:39,540
numbers for a lot of these things on

91
00:03:44,240 --> 00:03:41,370
early Earth history but there was a lot

92
00:03:46,790 --> 00:03:44,250
more co2 during the early Earth history

93
00:03:48,830 --> 00:03:46,800
there was a rise probably a methane

94
00:03:51,800 --> 00:03:48,840
given the longer lifetime of methane in

95
00:03:55,010 --> 00:03:51,810
the atmosphere without oxygen and the

96
00:03:57,320 --> 00:03:55,020
biosphere being dominated by Genesis and

97
00:03:59,810 --> 00:03:57,330
then oxygen sort of seemed to rise

98
00:04:02,840 --> 00:03:59,820
broadly speaking in two stages so you

99
00:04:04,700 --> 00:04:02,850
had sort of this first rise of oxygen

100
00:04:05,990 --> 00:04:04,710
and then and then a later rise of oxygen

101
00:04:08,420 --> 00:04:06,000
to modern levels when we heard about

102
00:04:11,930 --> 00:04:08,430
this in Sony Hartman's talked earlier in

103
00:04:13,340 --> 00:04:11,940
the in this session before lunch and so

104
00:04:14,750 --> 00:04:13,350
if we look at just I'm going to pull out

105
00:04:15,920 --> 00:04:14,760
four different time points that I'm

106
00:04:17,690 --> 00:04:15,930
going to talk about with you how we

107
00:04:19,340 --> 00:04:17,700
could detect oxygen through geological

108
00:04:20,960 --> 00:04:19,350
time and considering these different

109
00:04:22,940 --> 00:04:20,970
star types so the first one is looking

110
00:04:25,280 --> 00:04:22,950
at sort of a prebiotic planet you know

111
00:04:27,560 --> 00:04:25,290
something with higher co2 some methane

112
00:04:30,710 --> 00:04:27,570
from volcanism but not yet from 'santa

113
00:04:32,800 --> 00:04:30,720

Genesis and and no oxygen and then also

114
00:04:35,750 --> 00:04:32,810
looking at things that are around 1%

115
00:04:37,200 --> 00:04:35,760
modern concentration so that p al you're

116
00:04:38,909 --> 00:04:37,210
going to see a lot of present

117
00:04:43,110 --> 00:04:38,919
spirit level so that's one percent of

118
00:04:46,860 --> 00:04:43,120
our 21% oxygen after the great oxidation

119
00:04:49,620 --> 00:04:46,870
event and then a third time point with

120
00:04:51,689 --> 00:04:49,630
around 10 percent oxygen and then of

121
00:04:59,129 --> 00:04:51,699
course modern earth with our 21 percent

122
00:05:01,860 --> 00:04:59,139
oxygen in the atmosphere so if we look

123
00:05:04,620 --> 00:05:01,870
here this is the oxygen a band at point

124
00:05:06,390 --> 00:05:04,630
7 6 microns and this is just showing in

125
00:05:09,450 --> 00:05:06,400
the first column you see a prebiotic

126
00:05:11,670 --> 00:05:09,460
planet then a 1 percent again modern of

127
00:05:13,529 --> 00:05:11,680
modern concentrations 10 percent P al o

128
00:05:15,749 --> 00:05:13,539
2 and the modern earth this is for

129
00:05:17,730 --> 00:05:15,759
different star types FG km but we

130
00:05:20,370 --> 00:05:17,740
haven't yet considered things like

131
00:05:23,040 --> 00:05:20,380
surface reflectivity or the stellar

132
00:05:24,540 --> 00:05:23,050
impact and so this is just showing that

133
00:05:26,790 --> 00:05:24,550
we're using the same basic oxygen

134
00:05:28,649 --> 00:05:26,800
concentration for each when we put this

135
00:05:30,330 --> 00:05:28,659
in a in a clear sky model where we're

136
00:05:31,980 --> 00:05:30,340
not considering clouds but we are

137
00:05:33,480 --> 00:05:31,990
considering different effects on the

138
00:05:35,909 --> 00:05:33,490

atmosphere like rayleigh scattering and

139
00:05:37,920 --> 00:05:35,919
and whatnot for direct detection spectra

140
00:05:39,180 --> 00:05:37,930
you can see that you see is there a

141
00:05:43,529 --> 00:05:39,190
laser pointer on this one

142
00:05:44,909 --> 00:05:43,539
I don't oh sorry thanks you can see that

143
00:05:48,480 --> 00:05:44,919
you can see that you start to get that

144
00:05:51,089 --> 00:05:48,490
little that little bump for oxygen at 1%

145
00:05:52,980 --> 00:05:51,099
and 10% and then and then the modern

146
00:05:55,020 --> 00:05:52,990
concentrations again there's color code

147
00:05:57,420 --> 00:05:55,030
is for F G K and stars so the hotter

148
00:05:59,879 --> 00:05:57,430
stars are the purple lines going down to

149
00:06:02,490 --> 00:05:59,889
the red for the M stars and when we add

150
00:06:04,589 --> 00:06:02,500
clouds that feature seems to obscure

151
00:06:05,939 --> 00:06:04,599
quite substantially so you whatever

152
00:06:10,320 --> 00:06:05,949
little bump we had here we don't really

153
00:06:11,879 --> 00:06:10,330
see it and even for the 10% cases and so

154
00:06:13,680 --> 00:06:11,889
this led us to think about well okay

155
00:06:16,370 --> 00:06:13,690
what is actually happening with the

156
00:06:19,189 --> 00:06:16,380
effect of clouds on the spectra and so

157
00:06:23,939 --> 00:06:19,199
just looking at the full earth-like

158
00:06:26,370 --> 00:06:23,949
spectra here in the visible if we were

159
00:06:28,020 --> 00:06:26,380
to just assume a hundred percent clouds

160
00:06:29,279 --> 00:06:28,030
at 12 kilometers or six kilometers in

161
00:06:32,510 --> 00:06:29,289
one kilometer that's what these lines

162
00:06:36,689 --> 00:06:32,520
represent the dashed line is a clear sky

163
00:06:39,029 --> 00:06:36,699

model for earth the black line is 100%

164
00:06:42,420 --> 00:06:39,039
clouds at 12 kilometers the red line is

165
00:06:44,430 --> 00:06:42,430
100% at 6 and the blue line is 100%

166
00:06:46,769 --> 00:06:44,440
clouds at one corner so you can see in

167
00:06:48,689 --> 00:06:46,779
the visible for the higher clouds it

168
00:06:50,610 --> 00:06:48,699
really does block a lot of the features

169
00:06:52,409 --> 00:06:50,620
below it as we would expect

170
00:06:54,720 --> 00:06:52,419
and it's a little different in the

171
00:06:57,510 --> 00:06:54,730
infrared here is the again for the

172
00:07:00,240 --> 00:06:57,520
hundred-percent 12 kilometers six

173
00:07:02,370 --> 00:07:00,250
climbers in one kilometer clouds the

174
00:07:04,440 --> 00:07:02,380
infrared differs because it also depends

175
00:07:06,000 --> 00:07:04,450
on the temperature of that cloud layer

176
00:07:07,409 --> 00:07:06,010
and where the species is sitting in the

177
00:07:09,690 --> 00:07:07,419
atmosphere and the temperature of the

178
00:07:11,820 --> 00:07:09,700
absorbing and emitting layer now so if

179
00:07:13,950 --> 00:07:11,830
we look then if we take out what I

180
00:07:15,060 --> 00:07:13,960
wanted to do is just take out all the

181
00:07:17,010 --> 00:07:15,070
things that we were probably going to be

182
00:07:18,300 --> 00:07:17,020
able to correct for with with telescopes

183
00:07:21,360 --> 00:07:18,310
so we're going to be able to observe the

184
00:07:23,280 --> 00:07:21,370
star simultaneously for for example but

185
00:07:24,930 --> 00:07:23,290
we're probably not necessarily going to

186
00:07:26,490 --> 00:07:24,940
know the surface reflectivity so I left

187
00:07:29,070 --> 00:07:26,500
the surface reflectivity in but I took

188
00:07:30,840 --> 00:07:29,080

out the the influence of the stars

189
00:07:34,080 --> 00:07:30,850
ooming that we could completely remove

190
00:07:36,690 --> 00:07:34,090
that signal and here then looking at the

191
00:07:39,120 --> 00:07:36,700
situation with the light blue line is

192
00:07:41,280 --> 00:07:39,130
the one percent the the middle line here

193
00:07:43,230 --> 00:07:41,290
is a ten percent and the hundred percent

194
00:07:45,150 --> 00:07:43,240
oxygen case this is for zero percent

195
00:07:46,890 --> 00:07:45,160
clouds and now we're going to go up to a

196
00:07:48,780 --> 00:07:46,900
hundred percent clouds and so you can

197
00:07:51,930 --> 00:07:48,790
see how the the feature strengths are

198
00:07:55,560 --> 00:07:51,940
diminishing with cloud cloud percentage

199
00:07:58,560 --> 00:07:55,570
for for these different levels of oxygen

200
00:08:00,930 --> 00:07:58,570
and and of course it's much stronger but

201
00:08:05,700 --> 00:08:00,940
effect when you have less of it and and

202
00:08:07,650 --> 00:08:05,710
and you see it's pretty much diminished

203
00:08:10,279 --> 00:08:07,660
for especially the one in ten percent

204
00:08:13,890 --> 00:08:10,289
cases so if we want to consider then

205
00:08:16,350 --> 00:08:13,900
ozone as a possible proxy let's see how

206
00:08:18,540 --> 00:08:16,360
that is influenced by clouds so we have

207
00:08:20,190 --> 00:08:18,550
the same setup with the prebiotic case

208
00:08:23,940 --> 00:08:20,200
the one percent ten percent of modern

209
00:08:26,879 --> 00:08:23,950
earth and here you have already with our

210
00:08:28,680 --> 00:08:26,889
clear sky models we we see these strong

211
00:08:32,100 --> 00:08:28,690
features of ozone especially for the F

212
00:08:34,980 --> 00:08:32,110
and G stars early on with only one

213
00:08:36,959 --> 00:08:34,990

percent oxygen levels and and then of

214
00:08:39,770 --> 00:08:36,969
course the feature is quite strong going

215
00:08:43,020 --> 00:08:39,780
up until modern when we add clouds

216
00:08:45,240 --> 00:08:43,030
there's less of a less of a diminishing

217
00:08:47,190 --> 00:08:45,250
effect of those clouds on the ozone

218
00:08:48,420 --> 00:08:47,200
feature and I think this is most

219
00:08:51,810 --> 00:08:48,430
striking if you compare these two

220
00:08:55,440 --> 00:08:51,820
side-by-side with the oxygen feature and

221
00:08:57,440 --> 00:08:55,450
the ozone feature this is assuming a 60%

222
00:09:00,480 --> 00:08:57,450
cloud similar to what we have on earth

223
00:09:03,330 --> 00:09:00,490
with cloud layers at one commerce

224
00:09:06,870 --> 00:09:03,340
more than 12 kilometers you see here's

225
00:09:09,150 --> 00:09:06,880
the prebiotic case the 1% P al to 10%

226
00:09:10,590 --> 00:09:09,160
and the modern earth concentrations and

227
00:09:13,650 --> 00:09:10,600
you would be able to detect that

228
00:09:16,140 --> 00:09:13,660
presence through the ozone feature much

229
00:09:19,890 --> 00:09:16,150
earlier in Earth's history and so if we

230
00:09:21,510 --> 00:09:19,900
look at also the detect ability of o2 is

231
00:09:23,100 --> 00:09:21,520
Lavar now this is using the chronograph

232
00:09:24,720 --> 00:09:23,110
simulator that has already been I think

233
00:09:27,450 --> 00:09:24,730
mentioned three or four times in this

234
00:09:29,670 --> 00:09:27,460
session from tae Robinson if we look at

235
00:09:32,040 --> 00:09:29,680
this and calculate what are the rough

236
00:09:35,490 --> 00:09:32,050
integration times that we could get with

237
00:09:37,890 --> 00:09:35,500
Lubar to detect oxygen with different

238
00:09:39,390 --> 00:09:37,900

cloud coverages and altitudes so here we

239
00:09:41,160 --> 00:09:39,400
have increasing cloud coverage and

240
00:09:43,470 --> 00:09:41,170
different cloud layers so you'll notice

241
00:09:46,110 --> 00:09:43,480
it's actually easiest to detect with a

242
00:09:48,360 --> 00:09:46,120
higher percentage of clouds which might

243
00:09:50,340 --> 00:09:48,370
encounter intuitive but you get a higher

244
00:09:52,200 --> 00:09:50,350
signal with the like the added

245
00:09:54,870 --> 00:09:52,210
reflectivity and if it's a low layer

246
00:09:56,400 --> 00:09:54,880
cloud that oxygen still above the cloud

247
00:09:58,830 --> 00:09:56,410
deck and so you are going to increase

248
00:10:01,650 --> 00:09:58,840
your signal that way whereas if you have

249
00:10:03,810 --> 00:10:01,660
higher clouds and a higher cloud

250
00:10:08,100 --> 00:10:03,820
altitude then it becomes harder to

251
00:10:10,860 --> 00:10:08,110
detect and so the last thing I want to

252
00:10:12,090 --> 00:10:10,870
show you is is looking at the bio

253
00:10:13,890 --> 00:10:12,100
signature detection then through

254
00:10:17,480 --> 00:10:13,900
geological time if we just pull out

255
00:10:22,200 --> 00:10:17,490
things in the IR here this is again the

256
00:10:24,480 --> 00:10:22,210
3.9 giga year are so pre life phase a IR

257
00:10:29,190 --> 00:10:24,490
spectra for different spectral types and

258
00:10:32,910 --> 00:10:29,200
if we go down to the 1% PIL case the 10%

259
00:10:35,310 --> 00:10:32,920
PA l case and the modern earth case we

260
00:10:37,590 --> 00:10:35,320
can see that the first again the first

261
00:10:39,660 --> 00:10:37,600
combination especially a bio signatures

262
00:10:42,930 --> 00:10:39,670
is going to happen when you can detect

263
00:10:45,750 --> 00:10:42,940

possibly ozone in combination with

264
00:10:47,940 --> 00:10:45,760
methane in the IR and you can most

265
00:10:50,100 --> 00:10:47,950
easily do this for these hotter spectral

266
00:10:51,660 --> 00:10:50,110
types for early levels of oxygen where

267
00:10:53,460 --> 00:10:51,670
you're going to get that production rate

268
00:10:56,010 --> 00:10:53,470
and be able to see those together and

269
00:10:58,140 --> 00:10:56,020
then by around 10% PL you can detect it

270
00:11:00,690 --> 00:10:58,150
for a lot of different star types and

271
00:11:02,190 --> 00:11:00,700
and that's that's maybe one

272
00:11:04,920 --> 00:11:02,200
consideration we should consider when

273
00:11:07,890 --> 00:11:04,930
we're looking for these planets around

274
00:11:10,980 --> 00:11:07,900
other stars - at what geological phases

275
00:11:13,540 --> 00:11:10,990
we might be able to best detect life so

276
00:11:16,570 --> 00:11:13,550
in summary we know that the

277
00:11:18,940 --> 00:11:16,580
UV is going to be a huge player in and

278
00:11:20,710 --> 00:11:18,950
the spectral type of the star I think

279
00:11:22,780 --> 00:11:20,720
this really highlights the need for we

280
00:11:24,670 --> 00:11:22,790
need simultaneous UV observations of

281
00:11:26,170 --> 00:11:24,680
these two stars and after Hubble without

282
00:11:28,210 --> 00:11:26,180
a UV mission we need to do something

283
00:11:30,639 --> 00:11:28,220
about that because the UV dominates so

284
00:11:32,980 --> 00:11:30,649
much of our modeling and for retrieval

285
00:11:35,319 --> 00:11:32,990
methods this will really be vital for

286
00:11:36,460 --> 00:11:35,329
understanding planets will be at a wide

287
00:11:38,440 --> 00:11:36,470
range of different evolutionary

288
00:11:39,759 --> 00:11:38,450

histories I just highlighted some things

289
00:11:41,860 --> 00:11:39,769
from Earth on history but we're going to

290
00:11:43,569 --> 00:11:41,870
see such a huge range even beyond that

291
00:11:44,769 --> 00:11:43,579
so we need to be considering those as a

292
00:11:46,840 --> 00:11:44,779
lot of other talks have already done

293
00:11:48,490 --> 00:11:46,850
today and also you know clouds for

294
00:11:50,280 --> 00:11:48,500
oxygen it might it might be a little sad

295
00:11:53,110 --> 00:11:50,290
but you can still see ozone quite

296
00:12:03,280 --> 00:11:53,120
strongly throughout so I'll stop there

297
00:12:05,259 --> 00:12:03,290
with any questions thank you so much

298
00:12:07,150 --> 00:12:05,269
there a please if you have any questions

299
00:12:13,660 --> 00:12:07,160
come up to one of the microphones in the

300
00:12:15,310 --> 00:12:13,670
center of the room so you have some sean

301
00:12:17,290 --> 00:12:15,320
donahoe coleman esse goddard so if you

302
00:12:18,639 --> 00:12:17,300
had a you know you're hinting that if

303
00:12:20,230 --> 00:12:18,649
you had a choice between getting the

304
00:12:22,510 --> 00:12:20,240
oxygen or getting those on you'd go for

305
00:12:25,569 --> 00:12:22,520
the ozone given the clouds problem but

306
00:12:28,030 --> 00:12:25,579
what if the choice is really oxygen with

307
00:12:30,579 --> 00:12:28,040
direct imaging versus ozone with the

308
00:12:32,019 --> 00:12:30,589
transit transmission measurement where

309
00:12:35,199 --> 00:12:32,029
the clouds might become more of an issue

310
00:12:38,500 --> 00:12:35,209
for that kind of measurement so are you

311
00:12:42,280 --> 00:12:38,510
saying ozone in the IR in the in the IR

312
00:12:44,170 --> 00:12:42,290
um yeah I mean foof I'm thinking you

313
00:12:46,510 --> 00:12:44,180

know like if it's a choice between like

314
00:12:48,579 --> 00:12:46,520
a JWST or an Origin Space Telescope

315
00:12:50,050 --> 00:12:48,589
where you can operate any and thread but

316
00:12:53,620 --> 00:12:50,060
you're limited to transit transactions

317
00:12:55,960 --> 00:12:53,630
and UV vis direct imaging yeah I mean

318
00:12:57,790 --> 00:12:55,970
it's hard because ultimately I you know

319
00:12:59,500 --> 00:12:57,800
as we've been talking you kind of need

320
00:13:02,319 --> 00:12:59,510
both and I'm going back to Sonics talk

321
00:13:04,120 --> 00:13:02,329
on this you know especially depending on

322
00:13:05,980 --> 00:13:04,130
what the level of a bad aqaq sejoon

323
00:13:08,829 --> 00:13:05,990
could be reached and hell and then what

324
00:13:10,420 --> 00:13:08,839
ozone level that could be detectable for

325
00:13:13,600 --> 00:13:10,430
these features it might be ambiguous

326
00:13:15,819 --> 00:13:13,610
even even detecting ozone as well you

327
00:13:17,650 --> 00:13:15,829
know I think Vicky once said that she's

328
00:13:20,110 --> 00:13:17,660
like I want both you know I want I want

329
00:13:21,650 --> 00:13:20,120
to detect the the oxygen because that

330
00:13:24,499 --> 00:13:21,660
gives you an

331
00:13:26,329 --> 00:13:24,509
which is really useful and we also want

332
00:13:27,799 --> 00:13:26,339
to detect you know the IR features are

333
00:13:30,919 --> 00:13:27,809
just an easier place to detect molecules

334
00:13:33,650 --> 00:13:30,929
and gases I personally prefer the IR but

335
00:13:35,299 --> 00:13:33,660
I do think ultimately getting we need

336
00:13:37,819 --> 00:13:35,309
the UV so I also want to I don't know I

337
00:13:42,759 --> 00:13:37,829
want it all right I didn't really hope

338
00:13:56,569 --> 00:13:45,919

okay can you get we have few more

339
00:13:59,359 --> 00:13:56,579
minutes stuff time so yep yeah all right

340
00:14:00,679 --> 00:13:59,369
I'll just do this so which aspects of so

341
00:14:03,499 --> 00:14:00,689
this was looking at sort of earth-like

342
00:14:05,359 --> 00:14:03,509
chemistry's as we move away from planets

343
00:14:07,449 --> 00:14:05,369
that may not be like earth which aspects

344
00:14:09,980 --> 00:14:07,459
of sort of degassing chemistry or

345
00:14:12,739 --> 00:14:09,990
geology are really are going to affect

346
00:14:15,169 --> 00:14:12,749
the strength of that ozone signal the

347
00:14:17,629 --> 00:14:15,179
strength of the ozone him well you were

348
00:14:19,879 --> 00:14:17,639
talking about ozone so if the chemistry

349
00:14:23,090 --> 00:14:19,889
was different than the earth are there

350
00:14:24,470 --> 00:14:23,100
ways of putting reductants into the

351
00:14:27,049 --> 00:14:24,480
atmosphere that could change her ozone

352
00:14:29,389 --> 00:14:27,059
signal so how could you could you model

353
00:14:30,980 --> 00:14:29,399
that as well sure so definitely

354
00:14:33,169 --> 00:14:30,990
depending I think because ozone

355
00:14:34,939 --> 00:14:33,179
primarily comes from oxygen so we're

356
00:14:38,449 --> 00:14:34,949
talking about how much oxygen could be

357
00:14:40,309 --> 00:14:38,459
there so so I refer you to several

358
00:14:42,829 --> 00:14:40,319
papers that have been done on this this

359
00:14:44,629 --> 00:14:42,839
balance of infection on donegal Goldman

360
00:14:46,039 --> 00:14:44,639
has a great paper talking about the

361
00:14:48,410 --> 00:14:46,049
different types of reducing plant

362
00:14:50,569 --> 00:14:48,420
Affairs and then where you can get how

363
00:14:53,359 --> 00:14:50,579

much oxygen you could get and then you

364
00:14:54,980 --> 00:14:53,369
can use from that ozone as well and so I

365
00:15:00,980 --> 00:14:54,990
would I would refer to Sean Donnell

366
00:15:03,650 --> 00:15:00,990
Goldman's 2014 paper hi Sarah nice talk

367
00:15:05,179 --> 00:15:03,660
good to see you again good to see so you

368
00:15:07,489 --> 00:15:05,189
said the very end that you wanted

369
00:15:09,410 --> 00:15:07,499
simultaneous UV can you comment more on

370
00:15:14,269 --> 00:15:09,420
the balance between simultaneous sources

371
00:15:16,549 --> 00:15:14,279
contemporaneous UV yes so I think with M

372
00:15:18,139 --> 00:15:16,559
stars that are flaring and having high

373
00:15:20,179 --> 00:15:18,149
activity levels it would be really great

374
00:15:23,900 --> 00:15:20,189
to know kind of what what's happening

375
00:15:26,600 --> 00:15:23,910
ideally some at the same time for stars

376
00:15:28,369 --> 00:15:26,610
that are quieter like fgk stars you

377
00:15:32,329 --> 00:15:28,379
probably can just get an idea of what's

378
00:15:33,499 --> 00:15:32,339
happening with the UV in general I know

379
00:15:34,540 --> 00:15:33,509
there's some models that are trying to

380
00:15:37,240 --> 00:15:34,550
develop too

381
00:15:39,220 --> 00:15:37,250
how we get this 4m stars but I with with

382
00:15:41,889 --> 00:15:39,230
the amount of variability within M stars

383
00:15:44,470 --> 00:15:41,899
and also the extreme influence that has

384
00:15:46,210 --> 00:15:44,480
on our ability to tease out these false

385
00:15:48,220 --> 00:15:46,220
positives especially which tend to be

386
00:15:51,310 --> 00:15:48,230
predominantly for M stars

387
00:15:53,410 --> 00:15:51,320
I want as simultaneous as we can get for

388
00:15:54,970 --> 00:15:53,420

UV I think would be useful if not at

389
00:15:56,019 --> 00:15:54,980
least having an idea of how frequent are

390
00:15:58,449 --> 00:15:56,029
these flares

391
00:16:00,910 --> 00:15:58,459
what is the the state's you know the

392
00:16:02,380 --> 00:16:00,920
study states between the flaring state

393
00:16:04,660 --> 00:16:02,390
and acquire some states so that we can

394
00:16:05,740 --> 00:16:04,670
use that into our retrieval models and

395
00:16:07,030 --> 00:16:05,750
make sure that the atmosphere is not

396
00:16:10,630 --> 00:16:07,040
changing quite so much in that time

397
00:16:13,389 --> 00:16:10,640
scale so you think then the response

398
00:16:15,430 --> 00:16:13,399
time is instantaneous from a UV flare or

399
00:16:18,600 --> 00:16:15,440
fires instantaneous there's actually

400
00:16:23,710 --> 00:16:18,610
there's actually a paper that came out

401
00:16:26,050 --> 00:16:23,720
last year I I can send you the reference

402
00:16:28,240 --> 00:16:26,060
I'm blanking on the name in my in my

403
00:16:29,829 --> 00:16:28,250
brain right now but now I think that

404
00:16:31,240 --> 00:16:29,839
looks at the you know the hysteresis

405
00:16:32,889 --> 00:16:31,250
affective response times of the

406
00:16:37,590 --> 00:16:32,899
atmosphere after a flare and I think

407
00:16:39,940 --> 00:16:37,600
it's like ah if I remember 10 to the 7

408
00:16:42,310 --> 00:16:39,950
I'm not going to say a number because I

409
00:16:44,019 --> 00:16:42,320
could be wrong but there is some there's

410
00:16:45,970 --> 00:16:44,029
some like legs time between these

411
00:16:47,980 --> 00:16:45,980
responses and then multiple flares on

412
00:16:52,150 --> 00:16:47,990
how it gets to a different atmospheric

413
00:16:53,680 --> 00:16:52,160

state thanks think think looks like