
AbSciCon
2017
MESA, ARIZONA

1
00:00:18,710 --> 00:00:12,250
[Music]

2
00:00:20,750 --> 00:00:18,720
yes it said and I'm going to be taking a

3
00:00:24,769 --> 00:00:20,760
small step outside the box of pigments

4
00:00:27,170 --> 00:00:24,779
and having a look at how fluorescents

5
00:00:30,670 --> 00:00:27,180
might be a potential bio signature for

6
00:00:36,160 --> 00:00:30,680
planets that experience higher UV

7
00:00:39,770 --> 00:00:36,170
radiation than more earth-like planets

8
00:00:42,290 --> 00:00:39,780
and so what I'm going to do today is to

9
00:00:44,330 --> 00:00:42,300
talk about how we came up with the idea

10
00:00:48,260 --> 00:00:44,340
of looking at fluorescents add a surface

11
00:00:50,540 --> 00:00:48,270
bio signature and so the main problem we

12
00:00:51,710 --> 00:00:50,550
had was that a lot of the first planets

13
00:00:53,870 --> 00:00:51,720

that we're going to be able to

14
00:00:58,160 --> 00:00:53,880
characterize in the habitable zones of

15
00:01:01,160 --> 00:00:58,170
stars are these n star planets that are

16
00:01:04,759 --> 00:01:01,170
very close in to their their host stars

17
00:01:07,190 --> 00:01:04,769
and these M star can be very active they

18
00:01:11,030 --> 00:01:07,200
can flare very frequently and these

19
00:01:14,240 --> 00:01:11,040
players can often in x-ray or extreme UV

20
00:01:16,880 --> 00:01:14,250
wavelengths or at the longer wavelength

21
00:01:18,770 --> 00:01:16,890
UV that can be detrimental to any

22
00:01:21,320 --> 00:01:18,780
surface life that might be exposed to it

23
00:01:23,300 --> 00:01:21,330
and so we want what we wanted to to do

24
00:01:25,790 --> 00:01:23,310
is to try and think of ways in which

25
00:01:28,880 --> 00:01:25,800
life could exist on these planets but

26
00:01:31,700 --> 00:01:28,890
actually still be detectable because it

27
00:01:34,039 --> 00:01:31,710
because if you live it on a UV bathed

28
00:01:35,660 --> 00:01:34,049
world in order to protect yourself your

29
00:01:37,870 --> 00:01:35,670
protection mechanisms like living

30
00:01:40,460 --> 00:01:37,880
underground or living underwater then

31
00:01:42,620 --> 00:01:40,470
don't lend themselves to us remotely

32
00:01:45,410 --> 00:01:42,630
detecting life and that's where we came

33
00:01:47,710 --> 00:01:45,420
up with the idea of fluorescence which

34
00:01:50,660 --> 00:01:47,720
could be used as a sort of UV protection

35
00:01:52,370 --> 00:01:50,670
method which has knock-on effect of

36
00:01:54,020 --> 00:01:52,380
actually if there's enough aversion

37
00:01:55,910 --> 00:01:54,030
that's bright enough could actually

38
00:01:58,940 --> 00:01:55,920

signal the presence of life on the

39
00:02:01,280 --> 00:01:58,950
surface compared to these other source

40
00:02:04,160 --> 00:02:01,290
UV protection mechanisms that life can

41
00:02:06,170 --> 00:02:04,170
use and so I'm going to start just by

42
00:02:08,149 --> 00:02:06,180
doing a brief overview of fluorescence

43
00:02:11,600 --> 00:02:08,159
in the natural world

44
00:02:13,399 --> 00:02:11,610
it is everywhere in some form the

45
00:02:16,039 --> 00:02:13,409
brightness of fluorescence changes from

46
00:02:18,679 --> 00:02:16,049
organism to organism it's especially

47
00:02:20,659 --> 00:02:18,689
prevalent in marine organisms for a

48
00:02:24,240 --> 00:02:20,669
variety of reasons there they use it for

49
00:02:26,730 --> 00:02:24,250
communication they use it for

50
00:02:28,710 --> 00:02:26,740
into in some coral species species they

51
00:02:30,720 --> 00:02:28,720
might be using this as a UV protection

52
00:02:33,660 --> 00:02:30,730
mechanism which is where we've got this

53
00:02:37,320 --> 00:02:33,670
idea from and and the idea of

54
00:02:40,110 --> 00:02:37,330
fluorescence being a globally detectable

55
00:02:42,300 --> 00:02:40,120
surface by a signature is illustrated

56
00:02:45,660 --> 00:02:42,310
quite well by chlorophyll fluorescence

57
00:02:47,850 --> 00:02:45,670
on earth so chlorophyll in surface

58
00:02:52,080 --> 00:02:47,860
vegetation fluorescence when it's

59
00:02:54,210 --> 00:02:52,090
exposed to UV wavelengths now this this

60
00:02:56,100 --> 00:02:54,220
fluorescence effect is happening at such

61
00:02:58,080 --> 00:02:56,110
a low level that it's completely drowned

62
00:03:00,990 --> 00:02:58,090
out by the ambient light environment on

63
00:03:03,450 --> 00:03:01,000

earth but if you take surface

64
00:03:06,450 --> 00:03:03,460
observations of the planet and you

65
00:03:08,400 --> 00:03:06,460
subtract the solar radiation component

66
00:03:10,050 --> 00:03:08,410
and this orbit the other reflectance

67
00:03:12,000 --> 00:03:10,060
features so that you just leave the

68
00:03:14,040 --> 00:03:12,010
fluorescence behind you get this very

69
00:03:16,320 --> 00:03:14,050
clear image of exactly where the

70
00:03:18,570 --> 00:03:16,330
vegetation is and then this fluorescent

71
00:03:21,390 --> 00:03:18,580
fluorescent signature provides a good

72
00:03:24,150 --> 00:03:21,400
indication of plant health you can see

73
00:03:26,700 --> 00:03:24,160
seasons changing as vegetation loses

74
00:03:30,420 --> 00:03:26,710
leaves and your regains the leaves in

75
00:03:34,020 --> 00:03:30,430
spring and so it's a very good marker

76
00:03:36,360 --> 00:03:34,030
for and what surface vegetation on earth

77
00:03:40,100 --> 00:03:36,370
is doing it just happens to be not a

78
00:03:42,540 --> 00:03:40,110
very bright effect but when it comes to

79
00:03:44,430 --> 00:03:42,550
defining potential bias signatures it's

80
00:03:48,180 --> 00:03:44,440
very good to start thinking outside the

81
00:03:49,920 --> 00:03:48,190
box slightly so if you can get this kind

82
00:03:53,009 --> 00:03:49,930
of detectable effect from fluorescence

83
00:03:55,170 --> 00:03:53,019
but at a low level how how much can we

84
00:03:56,880 --> 00:03:55,180
scale this up such that we could

85
00:04:00,960 --> 00:03:56,890
actually have a remote to the observable

86
00:04:02,820 --> 00:04:00,970
fluorescent bio signature and and so

87
00:04:06,690 --> 00:04:02,830
what we did is we took corals as an

88
00:04:09,570 --> 00:04:06,700

example so corals are some of the most

89
00:04:12,930 --> 00:04:09,580
well studied flores's in the animal

90
00:04:15,150 --> 00:04:12,940
kingdom and and we had a conversation

91
00:04:17,520 --> 00:04:15,160
with some coral biologists who are able

92
00:04:21,780 --> 00:04:17,530
to give us some measurements on how

93
00:04:23,610 --> 00:04:21,790
coral for proteins respond to UV and

94
00:04:26,490 --> 00:04:23,620
blue wavelengths and how all the

95
00:04:30,210 --> 00:04:26,500
absorption absorption and mission

96
00:04:31,800 --> 00:04:30,220
profiles change and so that the very

97
00:04:35,190 --> 00:04:31,810
basic overview of fluorescence is you're

98
00:04:37,480 --> 00:04:35,200
taking in high-energy photons they're

99
00:04:39,730 --> 00:04:37,490
absorbed by whatever molecule is

100
00:04:41,499 --> 00:04:39,740
absorbing them energy level of an

101
00:04:43,659 --> 00:04:41,509
electron is raised up and as that

102
00:04:46,890 --> 00:04:43,669
electron then relaxes back down a tree

103
00:04:51,010 --> 00:04:46,900
releases a photon at a longer wavelength

104
00:04:55,510 --> 00:04:51,020
and so this is why UV protection is one

105
00:04:57,879 --> 00:04:55,520
of these possibilities for corals and

106
00:05:00,700 --> 00:04:57,889
other organisms that are exposed to that

107
00:05:02,529 --> 00:05:00,710
there can be exposed to high UV because

108
00:05:04,960 --> 00:05:02,539
you can take in a UV photon which can be

109
00:05:07,589 --> 00:05:04,970
biologically damaging and you can shift

110
00:05:11,140 --> 00:05:07,599
it to a longer and safer wavelength

111
00:05:13,570 --> 00:05:11,150
protecting this is a biological material

112
00:05:15,700 --> 00:05:13,580
around the fluorescent pigments or in

113
00:05:18,309 --> 00:05:15,710

the case of flora corals protect

114
00:05:25,120 --> 00:05:18,319
potentially the symbiotic algae that

115
00:05:28,480 --> 00:05:25,130
live within the coral and so why why is

116
00:05:30,909 --> 00:05:28,490
this a problem for n star planets but as

117
00:05:32,860 --> 00:05:30,919
I mentioned they're very active stars or

118
00:05:35,020 --> 00:05:32,870
they can be very active stars and we

119
00:05:37,899 --> 00:05:35,030
know that certainly for the planet slick

120
00:05:40,180 --> 00:05:37,909
rocks would be at the plant and the trap

121
00:05:43,600 --> 00:05:40,190
is one planet their host stars are very

122
00:05:45,790 --> 00:05:43,610
active to a point that it earth-like

123
00:05:47,850 --> 00:05:45,800
planets an earth-like atmosphere would

124
00:05:52,510 --> 00:05:47,860
certainly be very affected by this and

125
00:05:54,879 --> 00:05:52,520
the flares in the e UV and x-ray x-ray

126
00:05:57,330 --> 00:05:54,889
wavelengths can have effects on a

127
00:05:59,499 --> 00:05:57,340
planet's atmosphere they can Road away

128
00:06:02,050 --> 00:05:59,509
atmospheres over time if the star is

129
00:06:03,310 --> 00:06:02,060
constantly flaring regularly and so you

130
00:06:05,680 --> 00:06:03,320
could end up which much with much

131
00:06:09,999 --> 00:06:05,690
thinner atmospheres you can destroy

132
00:06:12,999 --> 00:06:10,009
ozone in the atmosphere and and this all

133
00:06:17,620 --> 00:06:13,009
can lead to higher surface UV fluxes

134
00:06:20,339 --> 00:06:17,630
then we got on earth and in terms of UV

135
00:06:23,740 --> 00:06:20,349
and we need to start thinking about the

136
00:06:28,270 --> 00:06:23,750
biologically relevant UV so you can

137
00:06:32,770 --> 00:06:28,280
split UV into three different sort of

138
00:06:34,839 --> 00:06:32,780

wavelength bands and these in terms of

139
00:06:37,559 --> 00:06:34,849
the biological effects they have in

140
00:06:40,270 --> 00:06:37,569
terms of destroying DNA or causing

141
00:06:42,610 --> 00:06:40,280
mutations or various other kinds of

142
00:06:44,469 --> 00:06:42,620
biological damage the effects that

143
00:06:48,219 --> 00:06:44,479
different wavelengths of UV have on

144
00:06:50,800 --> 00:06:48,229
organisms some scales with decreasing

145
00:06:52,480 --> 00:06:50,810
wavelength so the UVA we

146
00:06:55,710 --> 00:06:52,490
which is most of the UV that reaches the

147
00:06:59,170 --> 00:06:55,720
surface on earth is fairly benign

148
00:07:01,659 --> 00:06:59,180
compared to UVB which can cause an order

149
00:07:03,400 --> 00:07:01,669
or two of magnitude more damage and I'm

150
00:07:05,230 --> 00:07:03,410
at the moment I'm a walking example of

151
00:07:07,480 --> 00:07:05,240
this because having spent three days in

152
00:07:11,950 --> 00:07:07,490
San Francisco in the Sun my UVB exposure

153
00:07:14,530 --> 00:07:11,960
is turning bright red if I had that

154
00:07:16,870 --> 00:07:14,540
length that same time exposure to UV see

155
00:07:19,330 --> 00:07:16,880
I wouldn't be here right now so these

156
00:07:22,570 --> 00:07:19,340
these effects really do scale up

157
00:07:25,090 --> 00:07:22,580
dramatically but on earth so if you see

158
00:07:27,040 --> 00:07:25,100
the drawing the UV surface cut off on

159
00:07:30,790 --> 00:07:27,050
earth ozone is very good at filtering

160
00:07:33,129 --> 00:07:30,800
out the worst of the UV for life so UVA

161
00:07:34,990 --> 00:07:33,139
UVB can still cause damage but the

162
00:07:41,020 --> 00:07:35,000
damage rate happens at the slope for a

163
00:07:42,940 --> 00:07:41,030

slow slow rate and it can easily be so

164
00:07:45,850 --> 00:07:42,950
the biological organisms can easily

165
00:07:47,980 --> 00:07:45,860
repair themselves using various various

166
00:07:51,129 --> 00:07:47,990
different methods but if you have an M

167
00:07:54,100 --> 00:07:51,139
style planet and that is letting in more

168
00:07:56,560 --> 00:07:54,110
of this UV either because it has less

169
00:08:00,130 --> 00:07:56,570
ozone or has a thinner atmosphere then

170
00:08:02,290 --> 00:08:00,140
the surface UV environment can make the

171
00:08:06,219 --> 00:08:02,300
surface a lot more inheritable for life

172
00:08:08,260 --> 00:08:06,229
and now life has various ways of

173
00:08:10,150 --> 00:08:08,270
protecting itself but as I said before

174
00:08:12,580 --> 00:08:10,160
these protection mechanisms like living

175
00:08:14,350 --> 00:08:12,590
underground or underwater aren't so good

176
00:08:17,620 --> 00:08:14,360
for us to then be able to checked

177
00:08:19,870 --> 00:08:17,630
surface biosignatures because you get so

178
00:08:21,790 --> 00:08:19,880
the reflectance spectrum as they sound

179
00:08:23,500 --> 00:08:21,800
or water mixed in with whatever it is

180
00:08:26,830 --> 00:08:23,510
that's living on the surface or near the

181
00:08:28,990 --> 00:08:26,840
surface but threatens is potentially one

182
00:08:31,840 --> 00:08:29,000
way of getting around this and so what

183
00:08:34,600 --> 00:08:31,850
we wanted to do is just do this with

184
00:08:37,510 --> 00:08:34,610
first order of magnitude let's have a

185
00:08:39,130 --> 00:08:37,520
look at how fluorescence or how much

186
00:08:42,579 --> 00:08:39,140
fluorescence we could we would need

187
00:08:45,880 --> 00:08:42,589
based on these coral proteins to cause a

188
00:08:47,380 --> 00:08:45,890

detectable signature so we'd have the

189
00:08:49,750 --> 00:08:47,390
reflectance spectrum of whatever

190
00:08:51,790 --> 00:08:49,760
organism with modeling our surface

191
00:08:53,829 --> 00:08:51,800
biosphere on which in this case we use

192
00:08:55,190 --> 00:08:53,839
corals because we're working with coral

193
00:08:58,940 --> 00:08:55,200
biologists

194
00:09:00,710 --> 00:08:58,950
and we had all the spectra from them but

195
00:09:03,170 --> 00:09:00,720
this could equally work with any other

196
00:09:07,280 --> 00:09:03,180
kind of organism that could potentially

197
00:09:09,290 --> 00:09:07,290
evolve and then we added a fluorescence

198
00:09:11,569 --> 00:09:09,300
effect based on the coral fluorescent

199
00:09:14,110 --> 00:09:11,579
proteins which gives you an increased

200
00:09:17,300 --> 00:09:14,120
emission to add on to the surface

201
00:09:19,100 --> 00:09:17,310
reflectance feature which which could

202
00:09:21,590 --> 00:09:19,110
then cause a detectable spike in a

203
00:09:24,470 --> 00:09:21,600
certain wavelength and and so this is

204
00:09:28,220 --> 00:09:24,480
what we did so we used them as a global

205
00:09:32,710 --> 00:09:28,230
coverage of this model biosphere of

206
00:09:37,030 --> 00:09:32,720
corals we added in atmosphere as

207
00:09:39,829 --> 00:09:37,040
earth-like atmosphere over the top but

208
00:09:42,860 --> 00:09:39,839
adapted so as an earth-like atmosphere

209
00:09:44,180 --> 00:09:42,870
would appear around an M star and then

210
00:09:45,769 --> 00:09:44,190
we looked at different fractions of

211
00:09:47,509 --> 00:09:45,779
coverage on the surface so we started

212
00:09:50,680 --> 00:09:47,519
with a whole biosphere and then we split

213
00:09:53,000 --> 00:09:50,690

it up into fractions of open ocean and

214
00:09:56,030 --> 00:09:53,010
with different cloud coverage over the

215
00:10:01,880 --> 00:09:56,040
top to investigate how detectable this

216
00:10:04,069 --> 00:10:01,890
feature would be and so we we will have

217
00:10:06,290 --> 00:10:04,079
free reign with deciding how strong a

218
00:10:08,060 --> 00:10:06,300
fluorescence could be and so what we

219
00:10:12,230 --> 00:10:08,070
modeled initially as a best-case

220
00:10:14,840 --> 00:10:12,240
scenario was fluorescence that is 100%

221
00:10:18,560 --> 00:10:14,850
efficient so it's taking every photon

222
00:10:20,530 --> 00:10:18,570
that is absorbed it really and then we

223
00:10:24,050 --> 00:10:20,540
assumed we had a very dense coverage and

224
00:10:26,210 --> 00:10:24,060
that effect so that such as quenching

225
00:10:27,530 --> 00:10:26,220
which can turn there which students

226
00:10:29,540 --> 00:10:27,540
effectively destroy a fluorescent

227
00:10:32,269 --> 00:10:29,550
pigments could be reversible which is

228
00:10:35,660 --> 00:10:32,279
something you can see in certain certain

229
00:10:37,639 --> 00:10:35,670
fluorescent proteins and so we ran that

230
00:10:40,430 --> 00:10:37,649
through a model and as you can see at

231
00:10:42,500 --> 00:10:40,440
the bottom there the these reflectance

232
00:10:44,120 --> 00:10:42,510
spectra are slowly adapting based once

233
00:10:48,050 --> 00:10:44,130
we start adding layers of land of

234
00:10:50,150 --> 00:10:48,060
surface of clouds and the sort of spike

235
00:10:51,889 --> 00:10:50,160
you can see just after 500 so we were

236
00:10:55,670 --> 00:10:51,899
looking so the ones I'm showing here are

237
00:10:58,160 --> 00:10:55,680
green fluorescence proteins this is the

238
00:11:00,889 --> 00:10:58,170

sort of sort of like a bit like the

239
00:11:03,259 --> 00:11:00,899
vegetation red edge a very large very

240
00:11:05,130 --> 00:11:03,269
sudden spike in reflectance at a given

241
00:11:07,530 --> 00:11:05,140
wavelength and

242
00:11:10,130 --> 00:11:07,540
but we could then do is plot this onto

243
00:11:13,310 --> 00:11:10,140
the color diagram color color diagram

244
00:11:16,170 --> 00:11:13,320
which is effectively just comparing the

245
00:11:19,230 --> 00:11:16,180
strengths of reflectance at certain

246
00:11:21,780 --> 00:11:19,240
wavelength bands and so Sid is our

247
00:11:23,519 --> 00:11:21,790
resident color colored diagram expert at

248
00:11:26,040 --> 00:11:23,529
the Carl Sagan Institute and so here

249
00:11:29,579 --> 00:11:26,050
we'll go into these these diagrams in a

250
00:11:32,960 --> 00:11:29,589
lot more detail next I think and but the

251
00:11:34,829 --> 00:11:32,970
the main thing here is to see how

252
00:11:38,430 --> 00:11:34,839
fluorescence affects the surface

253
00:11:41,360 --> 00:11:38,440
reflectance of our model planets so when

254
00:11:44,970 --> 00:11:41,370
the coral biosphere is not fluorescing

255
00:11:47,430 --> 00:11:44,980
so we took four different example

256
00:11:50,430 --> 00:11:47,440
species of coral labeled A to D which

257
00:11:52,410 --> 00:11:50,440
are the gray squares on this diagram and

258
00:11:55,380 --> 00:11:52,420
then when fluorescence turns on so you

259
00:11:59,009 --> 00:11:55,390
can imagine this so say a large flare

260
00:12:00,840 --> 00:11:59,019
hits the planet the UV levels spike the

261
00:12:03,269 --> 00:12:00,850
biosphere then starts fluorescing in

262
00:12:06,480 --> 00:12:03,279
response to this huge UV flux increase

263
00:12:11,460 --> 00:12:06,490

and then as it fluorescence it moves its

264
00:12:14,850 --> 00:12:11,470
position in the in color space fairly

265
00:12:16,710 --> 00:12:14,860
significantly and and so this is the

266
00:12:19,860 --> 00:12:16,720
sort of detectable effect we wanted to

267
00:12:22,560 --> 00:12:19,870
start thinking about so a planet is

268
00:12:25,199 --> 00:12:22,570
would effectively be turning itself into

269
00:12:29,069 --> 00:12:25,209
sort of a lighthouse like beacon as this

270
00:12:30,960 --> 00:12:29,079
surface biosphere lights up and so what

271
00:12:32,310 --> 00:12:30,970
I've shown here is the best case so this

272
00:12:34,949 --> 00:12:32,320
is where we just have an entire planet

273
00:12:37,259 --> 00:12:34,959
clear sky is covered in a fluorescent

274
00:12:39,060 --> 00:12:37,269
biosphere and obviously the effect of

275
00:12:41,069 --> 00:12:39,070
this or the magnitude of this change

276
00:12:42,660 --> 00:12:41,079
will change depending on the fraction of

277
00:12:44,610 --> 00:12:42,670
the surface coverage and the brightness

278
00:12:48,569 --> 00:12:44,620
of the effect but this illustrates it

279
00:12:51,420 --> 00:12:48,579
quite nicely and so there are other

280
00:12:52,920 --> 00:12:51,430
things that for us so of all sorts of

281
00:12:54,530 --> 00:12:52,930
things fluoresce as long as you've got

282
00:12:57,870 --> 00:12:54,540
the right structure you can have

283
00:12:59,370 --> 00:12:57,880
something that will fluoresce and one of

284
00:13:04,680 --> 00:12:59,380
the things we wanted to compare to here

285
00:13:05,970 --> 00:13:04,690
is threatened minerals but so we a lot

286
00:13:08,009 --> 00:13:05,980
of the fluorescent minerals that

287
00:13:10,079 --> 00:13:08,019
fluoresced at the same wavelength as the

288
00:13:13,069 --> 00:13:10,089

sort of various coral fluorescent

289
00:13:16,019 --> 00:13:13,079
proteins that we investigated we're all

290
00:13:17,590 --> 00:13:16,029
roughly in that area of this diagram so

291
00:13:20,500 --> 00:13:17,600
they were all fairly separate

292
00:13:22,660 --> 00:13:20,510
and when they were and we're not

293
00:13:24,190 --> 00:13:22,670
fluorescing they hardly moved at all

294
00:13:28,720 --> 00:13:24,200
because the strength of the fluorescence

295
00:13:32,130 --> 00:13:28,730
effect was so low and so we're sort of

296
00:13:35,710 --> 00:13:32,140
using the argument here that if if

297
00:13:37,930 --> 00:13:35,720
fluorescence evolved as a UV protection

298
00:13:40,480 --> 00:13:37,940
mechanism in whatever surface biases

299
00:13:42,520 --> 00:13:40,490
lives on these planets bright

300
00:13:44,140 --> 00:13:42,530
fluorescence would be favored by

301
00:13:46,660 --> 00:13:44,150
evolution if this is an effective

302
00:13:48,130 --> 00:13:46,670
protection mechanism whereas these

303
00:13:50,160 --> 00:13:48,140
fluorescent minerals

304
00:13:52,240 --> 00:13:50,170
would not be subject to some Darwinian

305
00:13:54,670 --> 00:13:52,250
evolutionary rules and so they would

306
00:13:58,930 --> 00:13:54,680
just be fluorescing as they're naturally

307
00:14:00,760 --> 00:13:58,940
low levels and so in a way it could be

308
00:14:04,480 --> 00:14:00,770
distinguishable from false positives

309
00:14:06,120 --> 00:14:04,490
like that and there other possibilities

310
00:14:08,500 --> 00:14:06,130
such as irori

311
00:14:10,360 --> 00:14:08,510
but if you had know something about the

312
00:14:12,970 --> 00:14:10,370
chemical composition of an atmosphere

313
00:14:15,280 --> 00:14:12,980

then if you detect an auroral emission

314
00:14:17,230 --> 00:14:15,290
and you know that a certain molecule is

315
00:14:19,390 --> 00:14:17,240
present that causes that color of

316
00:14:20,710 --> 00:14:19,400
emission then you could argue that we

317
00:14:24,070 --> 00:14:20,720
can say that's not fluorescence at

318
00:14:25,960 --> 00:14:24,080
Aurora so they it could potentially be

319
00:14:29,440 --> 00:14:25,970
distinguished distinguishable from other

320
00:14:32,110 --> 00:14:29,450
false positives and so this is just a

321
00:14:34,090 --> 00:14:32,120
quick illustration of how high the UV

322
00:14:37,150 --> 00:14:34,100
levels can get during the flare so this

323
00:14:39,460 --> 00:14:37,160
is for a very active M star ad Leo and

324
00:14:41,830 --> 00:14:39,470
gray line there is the top of the

325
00:14:44,550 --> 00:14:41,840
atmosphere solar UV emission that we get

326
00:14:47,020 --> 00:14:44,560
on earth and so the star is normally

327
00:14:48,970 --> 00:14:47,030
giving a planet Earth's equivalent

328
00:14:51,040 --> 00:14:48,980
distance a much lower flux the moon get

329
00:14:53,560 --> 00:14:51,050
on earth and but when it flares it can

330
00:14:55,690 --> 00:14:53,570
jump up by an order of magnitude or more

331
00:14:57,400 --> 00:14:55,700
in terms of the UV flux that could reach

332
00:15:00,340 --> 00:14:57,410
these planets so we could get very high

333
00:15:02,650 --> 00:15:00,350
UV fluxes and one thing we've done

334
00:15:06,600 --> 00:15:02,660
recently Lisa and I at the Carl Sagan

335
00:15:08,560 --> 00:15:06,610
Institute we wrote a quick paper for the

336
00:15:10,540 --> 00:15:08,570
proximate Eid for the Trappist one

337
00:15:12,850 --> 00:15:10,550
planet to look at what UV levels they

338
00:15:15,070 --> 00:15:12,860

would get and we look to nurse-like

339
00:15:16,900 --> 00:15:15,080
atmosphere and an earth-like atmosphere

340
00:15:20,020 --> 00:15:16,910
that's been eroded so much thinner and

341
00:15:22,690 --> 00:15:20,030
then a then a completely anoxic

342
00:15:24,760 --> 00:15:22,700
oxygen-free atmosphere and so in all of

343
00:15:27,520 --> 00:15:24,770
these cases this is the oxygen-free

344
00:15:28,870 --> 00:15:27,530
atmosphere you get a lot more UVC coming

345
00:15:29,590 --> 00:15:28,880
to the planet so the really damaging

346
00:15:32,079 --> 00:15:29,600
wavelength

347
00:15:35,590 --> 00:15:32,089
but they're still at a much lower lower

348
00:15:37,180 --> 00:15:35,600
level than I and so UV protection

349
00:15:40,780 --> 00:15:37,190
mechanisms like for essence could

350
00:15:43,870 --> 00:15:40,790
potentially work without UVC completely

351
00:15:47,710 --> 00:15:43,880
destroying everything and and so I'll