AbSciCon 2022

205: Exoplanet Biosignatures the 2020s and Beyond I

1
00:00:04,070 --> 00:00:01,350
good morning everyone welcome to

2
00:00:07,349 --> 00:00:04,080
exoplanet bike signatures for the 2020s

3
00:00:09,350 --> 00:00:07,359
and beyond i'm pleased to be

4
00:00:11,030 --> 00:00:09,360
representing some of our co-commuters

5
00:00:12,470 --> 00:00:11,040
and co-chairs here as we welcome a

6
00:00:14,390 --> 00:00:12,480
number of

7
00:00:16,070 --> 00:00:14,400
lovely talks this morning

8
00:00:18,550 --> 00:00:16,080
that are going to be both in person and

9
00:00:20,070 --> 00:00:18,560
virtual eddie is in the audience uh for

10
00:00:20,790 --> 00:00:20,080
those who are present he's gonna give

11
00:00:22,470 --> 00:00:20,800
you

12
00:00:24,310 --> 00:00:22,480
two minutes and then he'll stand up at

13
00:00:25,589 --> 00:00:24,320

13 tonight we're transitioning to the

14
00:00:28,550 --> 00:00:25,599
next talk

15
00:00:30,870 --> 00:00:28,560
but uh first i would like to welcome

16
00:00:32,150 --> 00:00:30,880
camille

17
00:00:33,670 --> 00:00:32,160
buchus

18
00:00:35,910 --> 00:00:33,680
butkus

19
00:00:50,549 --> 00:00:35,920
to the stand to talk about graphene

20
00:00:55,670 --> 00:00:53,110
okay hello everyone um so we'll be

21
00:00:57,830 --> 00:00:55,680
talking about biosignatures today and

22
00:01:02,549 --> 00:00:57,840
i'll be discussing space weathering as a

23
00:01:04,549 --> 00:01:02,559
source of abiotic methane on exoplanets

24
00:01:06,310 --> 00:01:04,559
and so a little bit of the motivation

25
00:01:08,710 --> 00:01:06,320
for this research is that the james webb

26
00:01:10,390 --> 00:01:08,720
space telescope launched this year and

27
00:01:13,510 --> 00:01:10,400
will be looking for these gaseous

28
00:01:15,350 --> 00:01:13,520
biosignatures on exoplanets so among

29
00:01:17,670 --> 00:01:15,360
those will be oxygen and methane and

30
00:01:19,910 --> 00:01:17,680
we're particularly interested in methane

31
00:01:22,149 --> 00:01:19,920
because it's a relatively

32
00:01:24,789 --> 00:01:22,159
well-known biosignature

33
00:01:27,030 --> 00:01:24,799
and so what we want to look at is if we

34
00:01:29,510 --> 00:01:27,040
can if we're going to detect methane in

35
00:01:30,789 --> 00:01:29,520
an atmosphere is it actually coming from

36
00:01:32,469 --> 00:01:30,799
life or not

37
00:01:34,789 --> 00:01:32,479
so that's the motivation behind this

38
00:01:36,390 --> 00:01:34,799

research

39
00:01:38,469 --> 00:01:36,400
so what makes methane a relatively

40
00:01:40,710 --> 00:01:38,479
robust biosignature is its short

41
00:01:43,910 --> 00:01:40,720
photochemical lifetime so here we just

42
00:01:46,230 --> 00:01:43,920
see how it easily breaks apart by

43
00:01:48,469 --> 00:01:46,240
radiation and so it doesn't last very

44
00:01:50,149 --> 00:01:48,479
long in an atmosphere

45
00:01:52,310 --> 00:01:50,159
and how we get it to stay in an

46
00:01:54,630 --> 00:01:52,320
atmosphere is we have these really large

47
00:01:57,030 --> 00:01:54,640
fluxes and these are mostly produced by

48
00:01:59,350 --> 00:01:57,040
methanogenic microbes that we have here

49
00:02:02,709 --> 00:01:59,360
on earth that sustain the methane in our

50
00:02:05,830 --> 00:02:04,149
but we also know that planetary

51
00:02:07,749 --> 00:02:05,840
chemistry is much more diverse than what

52
00:02:10,070 --> 00:02:07,759
we just have on earth

53
00:02:12,390 --> 00:02:10,080
so earth is relatively an oxidized

54
00:02:14,550 --> 00:02:12,400
mantle redox state that we have here on

55
00:02:16,869 --> 00:02:14,560
the x-axis

56
00:02:19,190 --> 00:02:16,879
and so in this case we might have

57
00:02:20,790 --> 00:02:19,200
volcanoes and they'll produce carbon

58
00:02:22,710 --> 00:02:20,800
dioxide and maybe a little bit of

59
00:02:25,430 --> 00:02:22,720
methane but that should be oxidized

60
00:02:27,270 --> 00:02:25,440
fairly quickly so in the case of a

61
00:02:29,830 --> 00:02:27,280
planet where we have an oxidized manual

62
00:02:32,229 --> 00:02:29,840
redox state if we're still seeing large

63
00:02:33,830 --> 00:02:32,239

quantities of methane in the atmosphere

64
00:02:36,229 --> 00:02:33,840
we can presume that it's coming from

65
00:02:38,229 --> 00:02:36,239
life because it needs to have such a

66
00:02:41,030 --> 00:02:38,239
large flux to sustain it

67
00:02:42,869 --> 00:02:41,040
so this would be a biosignature

68
00:02:44,869 --> 00:02:42,879
now on the opposite end of the spectrum

69
00:02:47,430 --> 00:02:44,879
if we have a relatively reduced mantle

70
00:02:49,270 --> 00:02:47,440
redox state these volcanoes might be

71
00:02:51,509 --> 00:02:49,280
spewing out methane that's not going to

72
00:02:53,589 --> 00:02:51,519
be oxidized so this would be a false

73
00:02:55,350 --> 00:02:53,599
biosignature where we would detect

74
00:02:58,149 --> 00:02:55,360
methane but it's not actually coming

75
00:03:02,550 --> 00:03:00,229
so we're also going to look at altering

76
00:03:04,710 --> 00:03:02,560
the abundance of carbon in the crust so

77
00:03:08,309 --> 00:03:04,720
we'll put that on the y axis with low on

78
00:03:10,309 --> 00:03:08,319
the bottom and high on the top

79
00:03:12,470 --> 00:03:10,319
and in this bottom left corner it's

80
00:03:14,470 --> 00:03:12,480
relatively well known that abundant

81
00:03:16,710 --> 00:03:14,480
abiotic methane is unlikely these are

82
00:03:18,070 --> 00:03:16,720
kind of the conditions for earth so when

83
00:03:21,589 --> 00:03:18,080
we see a lot of methane in the

84
00:03:23,430 --> 00:03:21,599
atmosphere it's likely a biosignature

85
00:03:26,229 --> 00:03:23,440
and so the other three quadrants we have

86
00:03:28,550 --> 00:03:26,239
here are less understood and it gives us

87
00:03:31,670 --> 00:03:28,560
a lot of opportunity to ask how might

88
00:03:33,990 --> 00:03:31,680

methane be produced without life here

89
00:03:36,309 --> 00:03:34,000
so today we're going to focus on the top

90
00:03:38,869 --> 00:03:36,319
right corner where we have a reduced

91
00:03:41,910 --> 00:03:38,879
mantle redox state and a relatively high

92
00:03:43,990 --> 00:03:41,920
abundance of carbon in the crust

93
00:03:45,270 --> 00:03:44,000
and so we'll call this space weathering

94
00:03:46,789 --> 00:03:45,280
for today

95
00:03:49,110 --> 00:03:46,799
where we have a lot of graphite in the

96
00:03:51,750 --> 00:03:49,120
crust a reduced mantle redox state so

97
00:03:54,070 --> 00:03:51,760
lots of hydrogen and this is what we

98
00:03:56,229 --> 00:03:54,080
presume will give us methane

99
00:04:00,550 --> 00:03:56,239
as a potential false biosignature

100
00:04:04,869 --> 00:04:02,789
so we started um this research by

101
00:04:06,869 --> 00:04:04,879
looking at past studies that were done

102
00:04:09,270 --> 00:04:06,879
and we found this experimental analog

103
00:04:10,869 --> 00:04:09,280
called a tokamak and so inside this

104
00:04:12,789 --> 00:04:10,879
tokamak

105
00:04:14,390 --> 00:04:12,799
all of these tiles that line the inside

106
00:04:17,909 --> 00:04:14,400
are made of graphite

107
00:04:18,710 --> 00:04:17,919
and inside hydrogen ions spin around in

108
00:04:21,909 --> 00:04:18,720
the

109
00:04:24,230 --> 00:04:21,919
like this taurus donut shape

110
00:04:26,230 --> 00:04:24,240
under high pressures and relatively high

111
00:04:28,870 --> 00:04:26,240
temperatures and they interact with the

112
00:04:31,030 --> 00:04:28,880
graphite tiles and they erode them and

113
00:04:32,870 --> 00:04:31,040

they produce methane so this is a

114
00:04:34,390 --> 00:04:32,880
problem for the engineers that are you

115
00:04:36,790 --> 00:04:34,400
know creating these devices because they

116
00:04:38,950 --> 00:04:36,800
don't want the graphite tiles to erode

117
00:04:41,030 --> 00:04:38,960
but it's good for us because we know

118
00:04:42,790 --> 00:04:41,040
that this reaction does occur and

119
00:04:46,070 --> 00:04:42,800
produces methane

120
00:04:49,270 --> 00:04:48,070
so if we translate this to the context

121
00:04:50,390 --> 00:04:49,280
of space

122
00:04:53,110 --> 00:04:50,400
blueit

123
00:04:55,990 --> 00:04:53,120
actually proposes that this reaction

124
00:04:58,550 --> 00:04:56,000
also occurs on mercury so solar winds

125
00:05:00,070 --> 00:04:58,560
supply protons for space weathering on

126
00:05:02,710 --> 00:05:00,080
mercury

127
00:05:04,790 --> 00:05:02,720
and just a quote to kind of explain what

128
00:05:06,629 --> 00:05:04,800
blue it's getting at here is heating and

129
00:05:08,469 --> 00:05:06,639
mixing of graphite with solar wind

130
00:05:10,790 --> 00:05:08,479
saturated material which are these

131
00:05:12,629 --> 00:05:10,800
protons may also lead to the production

132
00:05:15,110 --> 00:05:12,639
of methane and might initiate and

133
00:05:17,189 --> 00:05:15,120
sustain the growth of hollows

134
00:05:19,670 --> 00:05:17,199
so what blew it's getting at is that

135
00:05:21,909 --> 00:05:19,680
these protons are bombarding mercury's

136
00:05:23,510 --> 00:05:21,919
surface which has a lot of graphite

137
00:05:26,150 --> 00:05:23,520
and through that interaction they're

138
00:05:27,830 --> 00:05:26,160

producing methane abiotically and as a

139
00:05:29,670 --> 00:05:27,840
result they're forming these hollows

140
00:05:32,310 --> 00:05:29,680
these shallow craters

141
00:05:36,550 --> 00:05:32,320
and we'll also refer to this as ablation

142
00:05:41,430 --> 00:05:39,110
so to go back to kind of the tokamak

143
00:05:43,909 --> 00:05:41,440
experiments where scientists were just

144
00:05:45,749 --> 00:05:43,919
bombarding graphite with protons we can

145
00:05:48,230 --> 00:05:45,759
look at this interaction and the

146
00:05:51,110 --> 00:05:48,240
equations developed by roth and garcia

147
00:05:54,710 --> 00:05:51,120
rosales to quantify how much methane we

148
00:05:58,629 --> 00:05:56,550
so they have this equation they did a

149
00:06:00,070 --> 00:05:58,639
bunch of experiments and then made an

150
00:06:02,230 --> 00:06:00,080
equation to fit

151
00:06:04,230 --> 00:06:02,240
their results of methane yielded and

152
00:06:07,670 --> 00:06:04,240
it's comprised of three terms this

153
00:06:09,510 --> 00:06:07,680
physical thermal and surface erosion

154
00:06:10,629 --> 00:06:09,520
with lots of equations that go into each

155
00:06:12,790 --> 00:06:10,639
part of this

156
00:06:14,070 --> 00:06:12,800
but it's primarily focused on three

157
00:06:16,469 --> 00:06:14,080
parameters

158
00:06:17,830 --> 00:06:16,479
ion energy

159
00:06:19,189 --> 00:06:17,840
flux

160
00:06:21,350 --> 00:06:19,199
and temperature

161
00:06:23,909 --> 00:06:21,360
and so we can see that our experimental

162
00:06:25,830 --> 00:06:23,919
values from roth and garcia rosales

163
00:06:28,230 --> 00:06:25,840

differ quite a bit from

164
00:06:30,070 --> 00:06:28,240
mercury so you know we're going to run

165
00:06:32,070 --> 00:06:30,080
this equation but we're assuming that it

166
00:06:34,710 --> 00:06:32,080
still holds true under

167
00:06:39,510 --> 00:06:34,720
slightly different ion energies fluxes

168
00:06:43,029 --> 00:06:41,830
okay so we have we'll go back to the

169
00:06:45,749 --> 00:06:43,039
slide real quick we have three

170
00:06:49,029 --> 00:06:45,759
independent variables and then our

171
00:06:51,749 --> 00:06:49,039
dependent variable is this

172
00:06:56,150 --> 00:06:51,759
y tote which will be how much methane

173
00:06:58,710 --> 00:06:56,160
we're expecting to see from the reaction

174
00:07:01,430 --> 00:06:58,720
so then that gets us to our graph here

175
00:07:03,510 --> 00:07:01,440
and so we'll just look at the axes first

176
00:07:05,510 --> 00:07:03,520
and then we'll focus on the big colorful

177
00:07:08,070 --> 00:07:05,520
thing in the middle so

178
00:07:10,390 --> 00:07:08,080
on our y axis is temperature on our

179
00:07:13,189 --> 00:07:10,400
x-axis is energy

180
00:07:14,629 --> 00:07:13,199
and on our z-axis is flux

181
00:07:16,309 --> 00:07:14,639
and then so those are our three

182
00:07:18,710 --> 00:07:16,319
independent variables and then our

183
00:07:21,270 --> 00:07:18,720
dependent variable how much methane or

184
00:07:23,589 --> 00:07:21,280
carbon atoms we might expect to see is

185
00:07:25,189 --> 00:07:23,599
in a log scale on this color bar on the

186
00:07:26,070 --> 00:07:25,199
right

187
00:07:27,990 --> 00:07:26,080
so

188
00:07:30,469 --> 00:07:28,000

then we can look at the colors and we

189
00:07:32,550 --> 00:07:30,479
find that methane yields are highest at

190
00:07:35,589 --> 00:07:32,560
moderate temperatures which is around

191
00:07:37,430 --> 00:07:35,599
this like 500 degrees kelvin which is

192
00:07:39,749 --> 00:07:37,440
moderate for mercury but it's obviously

193
00:07:42,230 --> 00:07:39,759
still very hot

194
00:07:45,749 --> 00:07:42,240
these low energies

195
00:07:46,629 --> 00:07:45,759
and it the methane yield increases as we

196
00:07:49,189 --> 00:07:46,639
get

197
00:07:52,230 --> 00:07:49,199
higher flux or higher rate of delivery

198
00:07:54,950 --> 00:07:52,240
of the ions to mercury's surface

199
00:07:57,270 --> 00:07:54,960
so this just lets us see this very upper

200
00:07:59,990 --> 00:07:57,280
bound of how much methane we might

201
00:08:04,390 --> 00:08:00,000
suppose would come from this interaction

202
00:08:08,869 --> 00:08:06,070
so we can take that very upper bound

203
00:08:11,589 --> 00:08:08,879
just to constrain us and convert it to

204
00:08:12,710 --> 00:08:11,599
millimoles per meter squared per year of

205
00:08:15,110 --> 00:08:12,720
methane

206
00:08:17,350 --> 00:08:15,120
coming off of mercury

207
00:08:19,110 --> 00:08:17,360
and just you know for context we can

208
00:08:21,270 --> 00:08:19,120
compare it to a couple things we can

209
00:08:23,350 --> 00:08:21,280
compare it to mars it's several orders

210
00:08:24,469 --> 00:08:23,360
of magnitude higher than the methane we

211
00:08:27,749 --> 00:08:24,479
see

212
00:08:31,029 --> 00:08:27,759
present in mars atmosphere

213
00:08:32,149 --> 00:08:31,039

but much much lower than earth but as we

214
00:08:34,230 --> 00:08:32,159
know earth

215
00:08:36,230 --> 00:08:34,240
has a lot of biotic methane so high

216
00:08:39,029 --> 00:08:36,240
fluxes which sustain the methane in the

217
00:08:40,389 --> 00:08:39,039
atmosphere but we do know of two

218
00:08:42,870 --> 00:08:40,399
abiotic processes

219
00:08:44,870 --> 00:08:42,880
on earth serpentinization which is a

220
00:08:47,670 --> 00:08:44,880
rock water interaction that yields

221
00:08:49,430 --> 00:08:47,680
methane and volcanic outgassing

222
00:08:51,829 --> 00:08:49,440
and so the methane flux we see on

223
00:08:53,590 --> 00:08:51,839
mercury is actually pretty similar to

224
00:08:56,550 --> 00:08:53,600
the amount we would suspect from

225
00:08:58,470 --> 00:08:56,560
serpentinization on earth which you know

226
00:08:59,910 --> 00:08:58,480
it contributes but it's a relatively low

227
00:09:01,590 --> 00:08:59,920
contributor

228
00:09:05,670 --> 00:09:01,600
and it's a little larger than volcanic

229
00:09:10,070 --> 00:09:08,630
so we can return to blewitt's paper

230
00:09:11,910 --> 00:09:10,080
to look at the formation of these

231
00:09:13,829 --> 00:09:11,920
hollows and we find that space

232
00:09:16,150 --> 00:09:13,839
weathering of graphite to methane can

233
00:09:18,230 --> 00:09:16,160
account for a fraction of ablation or

234
00:09:20,470 --> 00:09:18,240
this hollows formation

235
00:09:23,590 --> 00:09:20,480
so again taking that like maximum

236
00:09:26,870 --> 00:09:23,600
methane yield to just constrain us

237
00:09:29,670 --> 00:09:26,880
and converting it to meters of graphite

238
00:09:30,949 --> 00:09:29,680

over the entire lifetime of mercury we

239
00:09:33,509 --> 00:09:30,959
see that

240
00:09:35,910 --> 00:09:33,519
we would get maybe around one meter deep

241
00:09:39,110 --> 00:09:35,920
craters while the mean depth of the

242
00:09:41,509 --> 00:09:39,120
hollows that blew it found was 24 meters

243
00:09:43,190 --> 00:09:41,519
so this interaction could be occurring

244
00:09:47,030 --> 00:09:43,200
but it's not a super significant

245
00:09:51,509 --> 00:09:49,670
so this leads us to kind of sum up some

246
00:09:53,750 --> 00:09:51,519
implications for exoplanets that might

247
00:09:56,310 --> 00:09:53,760
be close to stars because this is where

248
00:09:58,310 --> 00:09:56,320
we want to see if we'll find methane in

249
00:10:00,310 --> 00:09:58,320
an atmosphere

250
00:10:02,630 --> 00:10:00,320
so we know that protons that reach a

251
00:10:04,389 --> 00:10:02,640
surface of a planet can react with

252
00:10:06,069 --> 00:10:04,399
graphite

253
00:10:08,230 --> 00:10:06,079
and again that's just this interaction

254
00:10:10,949 --> 00:10:08,240
of protons with graphite they'll yield

255
00:10:13,110 --> 00:10:10,959
methane abiotically

256
00:10:15,750 --> 00:10:13,120
however we have to you know consider are

257
00:10:18,310 --> 00:10:15,760
these planets habitable so atmospheres

258
00:10:21,430 --> 00:10:18,320
on magnetic fields on habitable planets

259
00:10:23,190 --> 00:10:21,440
might deflect the incoming proton flux

260
00:10:25,590 --> 00:10:23,200
and additionally these conditions for

261
00:10:27,750 --> 00:10:25,600
space weathering which are hot and close

262
00:10:29,269 --> 00:10:27,760
to the star kind of like we see in the

263
00:10:30,069 --> 00:10:29,279

image on the background of this slide

264
00:10:33,030 --> 00:10:30,079
too

265
00:10:35,350 --> 00:10:33,040
are not habitable so this interaction

266
00:10:37,750 --> 00:10:35,360
you know wouldn't occur to give us a

267
00:10:39,670 --> 00:10:37,760
false positive biosignature in the

268
00:10:41,990 --> 00:10:39,680
presence of life also it's kind of one

269
00:10:44,150 --> 00:10:42,000
or the other

270
00:10:45,269 --> 00:10:44,160
so this leads us to roughly conclude

271
00:10:47,829 --> 00:10:45,279
that space weather weathering of

272
00:10:49,990 --> 00:10:47,839
graphite by these stellar protons is

273
00:10:53,509 --> 00:10:50,000
likely not a major source of abiotic

274
00:10:55,190 --> 00:10:53,519
methane on habitable planets

275
00:10:57,190 --> 00:10:55,200
and with that i'd like to thank research

276
00:11:00,310 --> 00:10:57,200
corporation for science advancement for

277
00:11:02,710 --> 00:11:00,320
funding this entire project and my pi

278
00:11:04,790 --> 00:11:02,720
jennifer glass and the glass lab and my

279
00:11:16,949 --> 00:11:04,800
collaborators at university of chicago

280
00:11:28,230 --> 00:11:24,150
if we have any questions

281
00:11:30,710 --> 00:11:28,240
state your name and affiliation uh and

282
00:11:33,030 --> 00:11:30,720
then you can ask your questions

283
00:11:34,389 --> 00:11:33,040
goldman nasa founded space flight center

284
00:11:35,590 --> 00:11:34,399
that was awesome

285
00:11:36,790 --> 00:11:35,600
really really cool stuff have you

286
00:11:38,310 --> 00:11:36,800
thought about other

287
00:11:40,150 --> 00:11:38,320
bio signature casters that might also

288
00:11:42,949 --> 00:11:40,160

have similar weathering

289
00:11:44,630 --> 00:11:42,959
mechanisms for their production

290
00:11:46,630 --> 00:11:44,640
wait can you repeat that sorry are there

291
00:11:48,949 --> 00:11:46,640
other biosignature gases beyond nothing

292
00:11:50,230 --> 00:11:48,959
that might have their own weathering

293
00:11:52,710 --> 00:11:50,240
sources

294
00:11:54,870 --> 00:11:52,720
um yeah so we only looked at methane but

295
00:11:57,190 --> 00:11:54,880
i'm sure that this could

296
00:12:00,230 --> 00:11:57,200
the similar process could be you know

297
00:12:02,069 --> 00:12:00,240
contribute to some other gas um yeah in

298
00:12:03,990 --> 00:12:02,079
the context of this space weathering we

299
00:12:05,350 --> 00:12:04,000
refer to as like graphite hydrogenation

300
00:12:07,350 --> 00:12:05,360
but space weathering can be a lot of

301
00:12:09,829 --> 00:12:07,360
different things so i think it'd

302
00:12:16,790 --> 00:12:09,839
definitely be extrapolated to that cool

303
00:12:21,590 --> 00:12:20,069
hi eliza from uh cycling in paris i was

304
00:12:24,550 --> 00:12:21,600
really cool to see this i'm wondering

305
00:12:26,230 --> 00:12:24,560
like have you tried to compute uh what

306
00:12:27,910 --> 00:12:26,240
would be this detectability for running

307
00:12:29,750 --> 00:12:27,920
the planets for example really closing

308
00:12:32,629 --> 00:12:29,760
the bandwidth star considering it as

309
00:12:34,790 --> 00:12:32,639
nominating field etc just see if it's

310
00:12:37,670 --> 00:12:34,800
deductible

311
00:12:39,829 --> 00:12:37,680
okay question is the methane detector

312
00:12:41,509 --> 00:12:39,839
for a planet that's really close in

313
00:12:44,710 --> 00:12:41,519

oh is it detectable

314
00:12:46,310 --> 00:12:44,720
uh okay um so

315
00:12:48,710 --> 00:12:46,320
you know i don't really know the limits

316
00:12:49,509 --> 00:12:48,720
of what is detectable and not detectable

317
00:12:51,430 --> 00:12:49,519
but

318
00:12:52,470 --> 00:12:51,440
what we found here is that it's a very

319
00:12:54,629 --> 00:12:52,480
very low

320
00:12:56,230 --> 00:12:54,639
quantity

321
00:13:09,509 --> 00:12:56,240
i don't know what james webb space

322
00:13:09,519 --> 00:13:23,910
you have any questions for them

323
00:13:30,550 --> 00:13:26,470
so next up we have um one uh who's going

324
00:13:32,389 --> 00:13:30,560
to talk us about methyl bromide uh so

325
00:13:34,790 --> 00:13:32,399
we should be seeing her slides and take

326
00:13:37,670 --> 00:13:34,800
it away

327
00:13:39,670 --> 00:13:37,680
thanks sonny um and good morning

328
00:13:41,269 --> 00:13:39,680
everyone my name is michaela leung i'm a

329
00:13:42,790 --> 00:13:41,279
phd student at the university of

330
00:13:44,230 --> 00:13:42,800
california riverside and i'll be talking

331
00:13:46,150 --> 00:13:44,240
to you today

332
00:13:48,230 --> 00:13:46,160
about my work on methyl bromide and

333
00:13:50,710 --> 00:13:48,240
specifically its application as a novel

334
00:13:52,470 --> 00:13:50,720
exoplanet biosignature candidate um i'd

335
00:13:53,990 --> 00:13:52,480
like to thank my advisor dr eddie

336
00:13:56,470 --> 00:13:54,000
schwederman i'm on our collaborators

337
00:13:58,230 --> 00:13:56,480
doctors nikki pronto and thomas o'shea

338
00:14:00,550 --> 00:13:58,240

for their helpful

339
00:14:02,389 --> 00:14:00,560
contributions to this project um so

340
00:14:04,550 --> 00:14:02,399
methyl bromide

341
00:14:06,069 --> 00:14:04,560
is the first of a series of novel

342
00:14:08,550 --> 00:14:06,079
methylated biosignatures that we're

343
00:14:09,829 --> 00:14:08,560
investigating um and we're particularly

344
00:14:11,910 --> 00:14:09,839
interested in this group because they

345
00:14:13,269 --> 00:14:11,920
have a number of advantages uh the first

346
00:14:15,509 --> 00:14:13,279
of which is that they have low false

347
00:14:17,829 --> 00:14:15,519
positive potential um so kind of in a

348
00:14:19,509 --> 00:14:17,839
planetary atmospheric context there are

349
00:14:22,550 --> 00:14:19,519
very limited pathways to generating

350
00:14:24,230 --> 00:14:22,560
these gases abiotically um and we don't

351
00:14:25,829 --> 00:14:24,240
think that those processes could

352
00:14:27,509 --> 00:14:25,839
generate the same levels as these

353
00:14:29,430 --> 00:14:27,519
biological fluxes so it's really

354
00:14:31,910 --> 00:14:29,440
unlikely to generate a false positive

355
00:14:34,310 --> 00:14:31,920
signal of these methylated gases

356
00:14:36,150 --> 00:14:34,320
additionally methylated biosignatures

357
00:14:37,829 --> 00:14:36,160
are generated by a common metabolic

358
00:14:39,590 --> 00:14:37,839
process that

359
00:14:41,990 --> 00:14:39,600
is connected to

360
00:14:44,870 --> 00:14:42,000
local environmental detoxification

361
00:14:47,269 --> 00:14:44,880
particularly by microbial species and so

362
00:14:49,910 --> 00:14:47,279
we suspect that that may make it more

363
00:14:52,470 --> 00:14:49,920

likely potentially than other processes

364
00:14:54,470 --> 00:14:52,480
to arise on the exoplanet or under um

365
00:14:56,629 --> 00:14:54,480
different biogeochemistry

366
00:14:58,230 --> 00:14:56,639
um and then finally these uh methylated

367
00:14:59,350 --> 00:14:58,240
biosignatures already have two

368
00:15:01,269 --> 00:14:59,360
established members so there's

369
00:15:03,509 --> 00:15:01,279
methylchloride which was first described

370
00:15:04,949 --> 00:15:03,519
by cigarette all in 2005 and dimethyl

371
00:15:07,189 --> 00:15:04,959
sulfide which was first described by

372
00:15:09,189 --> 00:15:07,199
domobile goldman at all in 2011 and so

373
00:15:10,870 --> 00:15:09,199
those are kind of the first two members

374
00:15:12,470 --> 00:15:10,880
of this group of methylated

375
00:15:15,590 --> 00:15:12,480
biosignatures

376
00:15:17,910 --> 00:15:15,600
so to further explore methyl bromide as

377
00:15:19,269 --> 00:15:17,920
a biosignature we use a series of models

378
00:15:20,870 --> 00:15:19,279
the first of which is the atmos

379
00:15:23,430 --> 00:15:20,880
one-dimensional photochemical model

380
00:15:25,829 --> 00:15:23,440
where we input surface fluxes

381
00:15:27,030 --> 00:15:25,839
and generate atmospheric mixing ratio

382
00:15:29,829 --> 00:15:27,040
profiles

383
00:15:32,150 --> 00:15:29,839
of the gases of interest

384
00:15:34,470 --> 00:15:32,160
we then use those at

385
00:15:36,389 --> 00:15:34,480
atmospheres as inputs into the spectral

386
00:15:38,069 --> 00:15:36,399
mapping and radio transfer code which

387
00:15:39,829 --> 00:15:38,079
allows us to generate transmission and

388
00:15:41,910 --> 00:15:39,839

emission spectra which we'll

389
00:15:43,829 --> 00:15:41,920
particularly use at high resolution and

390
00:15:45,509 --> 00:15:43,839
then we also use the planetary spectrum

391
00:15:47,590 --> 00:15:45,519
generator for spectral and instrumental

392
00:15:50,150 --> 00:15:47,600
modeling um and these three models

393
00:15:51,590 --> 00:15:50,160
enable us to do a fully vertically

394
00:15:53,829 --> 00:15:51,600
integrated observable all the way from

395
00:15:55,030 --> 00:15:53,839
controlling the surface flux levels um

396
00:15:56,550 --> 00:15:55,040
looking at different stellar types

397
00:15:59,030 --> 00:15:56,560
looking at different gases all of that

398
00:16:02,230 --> 00:15:59,040
just simulating a series of

399
00:16:04,710 --> 00:16:02,240
observables with uh synthetic noise

400
00:16:06,790 --> 00:16:04,720
and all of that um so before i talk

401
00:16:08,470 --> 00:16:06,800
about uh methyl bromide we wanted to

402
00:16:09,189 --> 00:16:08,480
talk a little bit about methyl fluoride

403
00:16:10,710 --> 00:16:09,199
so

404
00:16:13,189 --> 00:16:10,720
um methylchloride was originally first

405
00:16:14,629 --> 00:16:13,199
described in 2005 using the atmos model

406
00:16:16,310 --> 00:16:14,639
and since then there have been some

407
00:16:18,150 --> 00:16:16,320
significant changes made to the model

408
00:16:20,629 --> 00:16:18,160
primarily in the form of updating the

409
00:16:22,629 --> 00:16:20,639
reaction rates um and the photochemical

410
00:16:25,030 --> 00:16:22,639
cross sections that kind of are key to

411
00:16:27,430 --> 00:16:25,040
generating this data um and so as a

412
00:16:29,749 --> 00:16:27,440
result of these changes uh the atmos

413
00:16:31,430 --> 00:16:29,759

model no longer directly replicates uh

414
00:16:33,430 --> 00:16:31,440
the previously published results from

415
00:16:34,870 --> 00:16:33,440
cigarette all 2005.

416
00:16:37,670 --> 00:16:34,880
our version of the code specifically

417
00:16:39,670 --> 00:16:37,680
generates a lower atmospheric mixing

418
00:16:40,629 --> 00:16:39,680
ratio profiles but we do maintain the

419
00:16:42,470 --> 00:16:40,639
same

420
00:16:45,590 --> 00:16:42,480
overall conclusions and i'll be using

421
00:16:47,990 --> 00:16:45,600
our version of atmos and our code

422
00:16:49,509 --> 00:16:48,000
to benchmark the methyl bromide results

423
00:16:51,749 --> 00:16:49,519
in the rest of this talk

424
00:16:54,310 --> 00:16:51,759
speaking of which here are some outputs

425
00:16:56,150 --> 00:16:54,320
um from atmos so on the left side you're

426
00:16:58,790 --> 00:16:56,160
seeing methylchloride on the right

427
00:17:00,550 --> 00:16:58,800
methyl bromide we're examining these two

428
00:17:03,269 --> 00:17:00,560
gases for a series of different surface

429
00:17:05,590 --> 00:17:03,279
flux conditions and stellar types

430
00:17:07,429 --> 00:17:05,600
so the green line on both blocks

431
00:17:09,029 --> 00:17:07,439
represents the globally averaged earth's

432
00:17:11,350 --> 00:17:09,039
mixing ratio and the blue line is

433
00:17:12,789 --> 00:17:11,360
showing uh one ppm for the atmospheric

434
00:17:14,470 --> 00:17:12,799
mixing ratio

435
00:17:17,189 --> 00:17:14,480
and you'll notice that as we move

436
00:17:19,590 --> 00:17:17,199
towards later type stars uh the

437
00:17:21,990 --> 00:17:19,600
atmospheric buildup uh increases pretty

438
00:17:23,750 --> 00:17:22,000

significantly and this uh matches with

439
00:17:25,270 --> 00:17:23,760
what was previously reported from muscle

440
00:17:27,429 --> 00:17:25,280
fluoride and what is expected from

441
00:17:29,830 --> 00:17:27,439
methane as well and that is primarily

442
00:17:32,950 --> 00:17:29,840
because the main atmospheric sink for

443
00:17:35,350 --> 00:17:32,960
both of these gases is a reaction with

444
00:17:36,870 --> 00:17:35,360
the hydroxyl radical which is generated

445
00:17:39,110 --> 00:17:36,880
photochemically

446
00:17:41,669 --> 00:17:39,120
and in these late type stars the low nu

447
00:17:44,630 --> 00:17:41,679
b flux results in you know limited

448
00:17:46,390 --> 00:17:44,640
production of that radical which

449
00:17:48,150 --> 00:17:46,400
allows higher levels of atmospheric

450
00:17:49,430 --> 00:17:48,160
buildup

451
00:17:52,950 --> 00:17:49,440
one thing that you can note from the

452
00:17:55,190 --> 00:17:52,960
position of the green lines is that the

453
00:17:56,549 --> 00:17:55,200
atmospheric or sorry the globally

454
00:17:58,150 --> 00:17:56,559
average

455
00:18:00,230 --> 00:17:58,160
flux for

456
00:18:02,870 --> 00:18:00,240
methyl bromide is lower than that of

457
00:18:04,470 --> 00:18:02,880
methyl chloride um but they build up to

458
00:18:06,870 --> 00:18:04,480
within about an order of magnitude of

459
00:18:09,909 --> 00:18:06,880
each other which actually indicates that

460
00:18:11,590 --> 00:18:09,919
uh methyl bromide has a greater relative

461
00:18:13,990 --> 00:18:11,600
atmospheric buildup than methyl fluoride

462
00:18:16,150 --> 00:18:14,000
which is kind of a unique advantage

463
00:18:17,750 --> 00:18:16,160

of this gas which is particularly useful

464
00:18:20,310 --> 00:18:17,760
especially because those fluxes are a

465
00:18:22,390 --> 00:18:20,320
little bit lower here on the earth

466
00:18:24,789 --> 00:18:22,400
so we use these outputs from the

467
00:18:26,470 --> 00:18:24,799
photochemical model as inputs for

468
00:18:29,029 --> 00:18:26,480
spectral simulations what you're looking

469
00:18:30,870 --> 00:18:29,039
at right here is a grid of mid infrared

470
00:18:33,590 --> 00:18:30,880
emission spectra which are simulated for

471
00:18:35,110 --> 00:18:33,600
a future mission capable of um that mid

472
00:18:36,870 --> 00:18:35,120
infrared emission spectroscopy

473
00:18:39,510 --> 00:18:36,880
specifically we're looking here at

474
00:18:41,029 --> 00:18:39,520
nearby small stars so in the top row

475
00:18:42,549 --> 00:18:41,039
you're seeing an atmosphere with methyl

476
00:18:44,310 --> 00:18:42,559
chloride added in the middle row you're

477
00:18:45,990 --> 00:18:44,320
seeing the addition of methyl bromide

478
00:18:47,590 --> 00:18:46,000
and the bottom row shows an atmosphere

479
00:18:50,470 --> 00:18:47,600
with both gases

480
00:18:51,990 --> 00:18:50,480
added and if we kind of go column uh if

481
00:18:54,150 --> 00:18:52,000
you go column by column you're looking

482
00:18:55,110 --> 00:18:54,160
you're comparing the results for each

483
00:18:57,190 --> 00:18:55,120
star

484
00:18:59,590 --> 00:18:57,200
one large feature that really stands out

485
00:19:02,070 --> 00:18:59,600
particularly for the m dwarfs in the top

486
00:19:05,350 --> 00:19:02,080
and bottom atmosphere is the uh

487
00:19:06,710 --> 00:19:05,360
suppression of the 9.65 micron ozone

488
00:19:08,230 --> 00:19:06,720

band which results in a really

489
00:19:11,029 --> 00:19:08,240
significant

490
00:19:13,990 --> 00:19:11,039
drop in that emission flux right around

491
00:19:15,430 --> 00:19:14,000
9.65 and that is actually right next to

492
00:19:17,029 --> 00:19:15,440
where we see the methyl chloride and

493
00:19:18,710 --> 00:19:17,039
methyl bromide absorption features which

494
00:19:20,870 --> 00:19:18,720
are a little bit easier to pick out uh

495
00:19:23,029 --> 00:19:20,880
in the methyl bromide row which is the

496
00:19:24,549 --> 00:19:23,039
middle one um and so the methyl fluoride

497
00:19:27,270 --> 00:19:24,559
and muscle bromide features are actually

498
00:19:30,390 --> 00:19:27,280
located right next to each other um and

499
00:19:33,270 --> 00:19:30,400
that results in kind of a larger feature

500
00:19:35,190 --> 00:19:33,280
um that sort of uh is built from the two

501
00:19:36,150 --> 00:19:35,200
kind of connected to each other um and

502
00:19:37,430 --> 00:19:36,160
you can see that a little bit more

503
00:19:39,909 --> 00:19:37,440
clearly in this slide so these are

504
00:19:42,390 --> 00:19:39,919
simulated observations using the origin

505
00:19:45,110 --> 00:19:42,400
space telescope concept which we use

506
00:19:47,830 --> 00:19:45,120
here as a blueprint for a future

507
00:19:49,350 --> 00:19:47,840
space-based telescope capable of uh

508
00:19:52,150 --> 00:19:49,360
imaging bio signatures in the mid

509
00:19:54,950 --> 00:19:52,160
infrared um specifically one with a low

510
00:19:57,830 --> 00:19:54,960
noise floor at uh these wavelengths so

511
00:19:59,909 --> 00:19:57,840
you could see here around 10 microns the

512
00:20:01,510 --> 00:19:59,919
red line shows the methyl fluoride flux

513
00:20:03,590 --> 00:20:01,520

the blue line shows methyl bromide flux

514
00:20:05,270 --> 00:20:03,600
and again this purple flux is showing an

515
00:20:07,190 --> 00:20:05,280
atmosphere with both gases and you can

516
00:20:10,230 --> 00:20:07,200
see that this uh

517
00:20:12,470 --> 00:20:10,240
both gas atmospheric feature is larger

518
00:20:14,310 --> 00:20:12,480
than either of the two uh features kind

519
00:20:17,029 --> 00:20:14,320
of combined and it results in this

520
00:20:18,390 --> 00:20:17,039
broader overall signal um because these

521
00:20:19,750 --> 00:20:18,400
features are right next to each other

522
00:20:22,950 --> 00:20:19,760
and that's actually not a coincidence

523
00:20:25,110 --> 00:20:22,960
that results uh from the bond energies

524
00:20:26,310 --> 00:20:25,120
uh of methyl chloride and methyl bromide

525
00:20:27,830 --> 00:20:26,320
which is directly related to their

526
00:20:31,350 --> 00:20:27,840
atomic structure and kind of their

527
00:20:34,310 --> 00:20:31,360
nature uh as both methylation products

528
00:20:35,909 --> 00:20:34,320
um you can notice here as well that drop

529
00:20:38,230 --> 00:20:35,919
in the ozone flux right around again

530
00:20:40,390 --> 00:20:38,240
9.65 microns at the prominent ozone

531
00:20:42,549 --> 00:20:40,400
feature there as well um additionally

532
00:20:44,630 --> 00:20:42,559
there's also another feature right here

533
00:20:46,230 --> 00:20:44,640
around 7 microns where you can see again

534
00:20:48,310 --> 00:20:46,240
this atmosphere with both gases is

535
00:20:50,789 --> 00:20:48,320
producing a little bit more signal than

536
00:20:52,149 --> 00:20:50,799
either of the other two cases which kind

537
00:20:53,430 --> 00:20:52,159
of matches with the results that i'm

538
00:20:55,190 --> 00:20:53,440

showing on the right hand side of the

539
00:20:57,510 --> 00:20:55,200
slide here which is this bar chart

540
00:21:00,070 --> 00:20:57,520
showing the number of transits um that

541
00:21:02,310 --> 00:21:00,080
you could you need to detect uh the

542
00:21:05,590 --> 00:21:02,320
methylated gas feature at either 6.9

543
00:21:07,990 --> 00:21:05,600
microns or 10.2 microns um in both cases

544
00:21:10,149 --> 00:21:08,000
the methyl bromide uh flux or sorry the

545
00:21:11,830 --> 00:21:10,159
microbite feature requires more transits

546
00:21:13,909 --> 00:21:11,840
to detect than the methyl chloride

547
00:21:16,870 --> 00:21:13,919
feature but the atmosphere with both

548
00:21:19,590 --> 00:21:16,880
gases is the uh optimal

549
00:21:21,430 --> 00:21:19,600
observation case uh for all of the cases

550
00:21:24,549 --> 00:21:21,440
that we considered here um and

551
00:21:25,990 --> 00:21:24,559
specifically at 10.2 microns for this

552
00:21:27,750 --> 00:21:26,000
productive methyl chloride and methyl

553
00:21:30,390 --> 00:21:27,760
bromide atmosphere we think we can

554
00:21:32,230 --> 00:21:30,400
observe this in about 30 transits

555
00:21:35,029 --> 00:21:32,240
accounting for

556
00:21:36,390 --> 00:21:35,039
the noise per transit and in and out of

557
00:21:39,590 --> 00:21:36,400
transit noise

558
00:21:41,510 --> 00:21:39,600
um so that is sort of the best scenario

559
00:21:43,510 --> 00:21:41,520
for observing uh methyl glycomethyl

560
00:21:45,190 --> 00:21:43,520
bromide so what this is showing right

561
00:21:47,110 --> 00:21:45,200
here is basically one way you could

562
00:21:49,990 --> 00:21:47,120
determine the existence of a methylated

563
00:21:51,190 --> 00:21:50,000

gas feature um and in combination with

564
00:21:52,549 --> 00:21:51,200
high-resolution ground-based

565
00:21:54,789 --> 00:21:52,559
spectroscopy which is what i'm showing

566
00:21:56,789 --> 00:21:54,799
simulations of here um we believe that

567
00:21:59,029 --> 00:21:56,799
you could actually determine um and

568
00:22:00,470 --> 00:21:59,039
characterize the specific methylated gas

569
00:22:03,510 --> 00:22:00,480
that is present

570
00:22:04,870 --> 00:22:03,520
because of the unique uh band structures

571
00:22:07,270 --> 00:22:04,880
of these gases so we're looking at the

572
00:22:09,110 --> 00:22:07,280
same four atmospheres the atmosphere

573
00:22:11,590 --> 00:22:09,120
with no methylated gases with methyl

574
00:22:13,350 --> 00:22:11,600
chloride only with methyl bromide only

575
00:22:15,830 --> 00:22:13,360
and then with both gases and you can see

576
00:22:18,470 --> 00:22:15,840
that these are not identical um and so

577
00:22:20,470 --> 00:22:18,480
we think at uh the high resolution that

578
00:22:22,870 --> 00:22:20,480
we expect to be possible using the

579
00:22:26,149 --> 00:22:22,880
extremely large telescope class that we

580
00:22:27,510 --> 00:22:26,159
would be able to potentially uh uniquely

581
00:22:29,669 --> 00:22:27,520
characterize

582
00:22:32,230 --> 00:22:29,679
the specific methylated gas and so

583
00:22:34,390 --> 00:22:32,240
that's a kind of a useful

584
00:22:36,390 --> 00:22:34,400
synergy between the grounded space based

585
00:22:38,470 --> 00:22:36,400
telescopes that would enable us to first

586
00:22:40,230 --> 00:22:38,480
identify a mathematical gas feature and

587
00:22:41,909 --> 00:22:40,240
then potentially determine the identity

588
00:22:44,390 --> 00:22:41,919

of that methylated gas feature using the

589
00:22:45,909 --> 00:22:44,400
two different observing methods so one

590
00:22:47,430 --> 00:22:45,919
thing i really want to emphasize here is

591
00:22:49,190 --> 00:22:47,440
that we're talking about methyl bromide

592
00:22:50,870 --> 00:22:49,200
as what we're calling a capstone

593
00:22:52,710 --> 00:22:50,880
biosignature and this is specifically

594
00:22:53,830 --> 00:22:52,720
because uh you know these these number

595
00:22:55,190 --> 00:22:53,840
of transits that i've shared are a

596
00:22:56,630 --> 00:22:55,200
little bit high this is not something

597
00:23:00,310 --> 00:22:56,640
that we would necessarily be able to

598
00:23:02,470 --> 00:23:00,320
detect right away or using jwst um

599
00:23:04,310 --> 00:23:02,480
however the methyl bromide has a very

600
00:23:07,029 --> 00:23:04,320
low abiotic potential which sort of

601
00:23:08,789 --> 00:23:07,039
results um in it potentially being used

602
00:23:11,190 --> 00:23:08,799
as a tool to differentiate false

603
00:23:13,350 --> 00:23:11,200
positive and true positive scenarios and

604
00:23:15,110 --> 00:23:13,360
so um like i showed a few slides ago

605
00:23:17,909 --> 00:23:15,120
methyl bromide can actually be detected

606
00:23:19,190 --> 00:23:17,919
alongside ozone features because they

607
00:23:22,230 --> 00:23:19,200
sit right next to each other in the mid

608
00:23:24,310 --> 00:23:22,240
infrared or potentially detection of a

609
00:23:25,430 --> 00:23:24,320
primary biosignature like oxygen or

610
00:23:28,149 --> 00:23:25,440
ozone that is a little bit more

611
00:23:29,750 --> 00:23:28,159
ambiguous uh could motivate intensive

612
00:23:32,549 --> 00:23:29,760
follow-up observations like what would

613
00:23:34,549 --> 00:23:32,559

be necessary to detect uh methyl bromide

614
00:23:36,310 --> 00:23:34,559
um and somaphobromide is actually just

615
00:23:37,750 --> 00:23:36,320
the first in a kind of a series of

616
00:23:39,990 --> 00:23:37,760
methylated biosignatures that we're

617
00:23:41,669 --> 00:23:40,000
really interested in looking at so the

618
00:23:43,350 --> 00:23:41,679
next steps from here are we're going to

619
00:23:45,430 --> 00:23:43,360
look at iodine species specifically

620
00:23:47,350 --> 00:23:45,440
methyl iodine which is kind of the third

621
00:23:48,630 --> 00:23:47,360
methyl halide that fits with methyl

622
00:23:50,630 --> 00:23:48,640
chloride and methyl bromide that i've

623
00:23:51,909 --> 00:23:50,640
already described um we're also

624
00:23:54,149 --> 00:23:51,919
interested in looking at what are called

625
00:23:56,230 --> 00:23:54,159
polyhalo methanes um which are these

626
00:23:57,430 --> 00:23:56,240
sort of more complex molecules where

627
00:23:59,269 --> 00:23:57,440
there's both a methyl group and

628
00:24:00,870 --> 00:23:59,279
potentially a bromine and a chlorine or

629
00:24:03,830 --> 00:24:00,880
a chlorine and iodine or some kind of

630
00:24:05,590 --> 00:24:03,840
more complicated uh structure there and

631
00:24:08,470 --> 00:24:05,600
that is specifically because here on the

632
00:24:10,630 --> 00:24:08,480
earth these poly halo methanes um have

633
00:24:11,909 --> 00:24:10,640
fluxes that are equivalent to or higher

634
00:24:13,510 --> 00:24:11,919
than these gases that we've already

635
00:24:15,830 --> 00:24:13,520
studied so we kind of qualitatively

636
00:24:17,750 --> 00:24:15,840
expect that both adding the methyl

637
00:24:19,669 --> 00:24:17,760
iodine and these polyhalo methanes will

638
00:24:21,430 --> 00:24:19,679

improve the size of our methylated gas

639
00:24:22,950 --> 00:24:21,440
feature and decrease the number of

640
00:24:25,510 --> 00:24:22,960
transits necessary to detect a

641
00:24:27,430 --> 00:24:25,520
methylated gas feature um

642
00:24:29,110 --> 00:24:27,440
and a lot of these gases are produced by

643
00:24:30,470 --> 00:24:29,120
the same organisms or in the same local

644
00:24:32,870 --> 00:24:30,480
environment so it's something we would

645
00:24:35,110 --> 00:24:32,880
potentially expect to see many of these

646
00:24:37,510 --> 00:24:35,120
present under the same atmospheric or

647
00:24:39,190 --> 00:24:37,520
local environmental conditions um we're

648
00:24:41,590 --> 00:24:39,200
additionally interested in kind of

649
00:24:43,909 --> 00:24:41,600
expanding on the work that was done on

650
00:24:45,830 --> 00:24:43,919
dimethyl sulfide and expanding into

651
00:24:48,310 --> 00:24:45,840
looking at selenium and tellurium which

652
00:24:51,669 --> 00:24:48,320
are kind of the elemental

653
00:24:54,230 --> 00:24:51,679
analogs at heavier weight for sulfide

654
00:24:56,070 --> 00:24:54,240
and particularly looking at

655
00:24:58,789 --> 00:24:56,080
how those might also influence the

656
00:25:00,789 --> 00:24:58,799
spectrum of our methylated gas feature

657
00:25:03,350 --> 00:25:00,799
another component of this work that is

658
00:25:05,830 --> 00:25:03,360
not using uh the modeling uh pipeline is

659
00:25:07,430 --> 00:25:05,840
where we hope to do laboratory and field

660
00:25:09,350 --> 00:25:07,440
measurements of the fluxes of these

661
00:25:11,990 --> 00:25:09,360
methylated gases specifically to inform

662
00:25:13,350 --> 00:25:12,000
that model input um and specifically

663
00:25:15,029 --> 00:25:13,360

looking in

664
00:25:17,750 --> 00:25:15,039
local environments that are connected to

665
00:25:19,590 --> 00:25:17,760
the environmental detoxification process

666
00:25:23,669 --> 00:25:19,600
and kind of thinking about where can we

667
00:25:25,669 --> 00:25:23,679
apply uh these gases on exoplanets uh

668
00:25:27,750 --> 00:25:25,679
realistically and have it kind of um

669
00:25:29,350 --> 00:25:27,760
make sense and be appropriate for the

670
00:25:31,350 --> 00:25:29,360
rest of the context

671
00:25:33,750 --> 00:25:31,360
um so we do have a paper currently under

672
00:25:35,269 --> 00:25:33,760
review at abc so hopefully that will be

673
00:25:37,269 --> 00:25:35,279
out um sometime this summer so

674
00:25:39,269 --> 00:25:37,279
definitely keep your eyes

675
00:25:40,549 --> 00:25:39,279
out for that i mean with that i'll leave

676
00:25:41,990 --> 00:25:40,559
you with my conclusions and i'll be

677
00:25:43,830 --> 00:25:42,000
happy to take any questions that you

678
00:25:45,430 --> 00:25:43,840
have now or you can shoot me an email my

679
00:25:46,630 --> 00:25:45,440
emails on the slides and i'd be happy to

680
00:26:02,230 --> 00:25:46,640
chat more

681
00:26:06,710 --> 00:26:04,470
hi michaela ambre young from northern

682
00:26:09,669 --> 00:26:06,720
arizona university awesome talk really

683
00:26:11,510 --> 00:26:09,679
great work i was just curious to know if

684
00:26:14,230 --> 00:26:11,520
whether or not we might be able to

685
00:26:17,590 --> 00:26:14,240
detect methyl bromide in reflected light

686
00:26:19,510 --> 00:26:17,600
observations so basically maybe 0.8 to 2

687
00:26:21,830 --> 00:26:19,520
microns then the absorption feature is

688
00:26:24,789 --> 00:26:21,840

in that wavelength range

689
00:26:26,390 --> 00:26:24,799
um so as far as we've looked at the

690
00:26:28,470 --> 00:26:26,400
absorption features don't really start

691
00:26:29,190 --> 00:26:28,480
until from methyl bromide i want to say

692
00:26:33,430 --> 00:26:29,200
like

693
00:26:34,870 --> 00:26:33,440
right now reflected light would be a

694
00:26:37,269 --> 00:26:34,880
good option for those unless we're able

695
00:26:39,110 --> 00:26:37,279
to identify some kind of shorter

696
00:26:41,190 --> 00:26:39,120
absorption feature gotcha well

697
00:26:42,789 --> 00:26:41,200
nonetheless the transit uh features

698
00:26:44,950 --> 00:26:42,799
definitely look really deep so it's

699
00:26:49,669 --> 00:26:44,960
exciting work really cool thank you

700
00:26:53,750 --> 00:26:51,269
hi michaela thank you for really a great

701
00:26:55,990 --> 00:26:53,760
talk uh just a couple of uh sorry super

702
00:26:57,430 --> 00:26:56,000
grandchild northwestern university i was

703
00:26:59,190 --> 00:26:57,440
wondering if you could comment on the

704
00:27:00,789 --> 00:26:59,200
stellar and planetary parameters kind of

705
00:27:03,269 --> 00:27:00,799
assumed in these simulations as well as

706
00:27:06,149 --> 00:27:03,279
what the noise floor is into us

707
00:27:08,710 --> 00:27:06,159
yeah so as for the specific noise floor

708
00:27:11,830 --> 00:27:08,720
um we use the origin space uh telescope

709
00:27:13,029 --> 00:27:11,840
concept as modeled in psg so that's a

710
00:27:14,149 --> 00:27:13,039
question that i would have to get back

711
00:27:17,269 --> 00:27:14,159
to you on because i'm not familiar with

712
00:27:18,710 --> 00:27:17,279
the exact uh noise modeling specifics

713
00:27:21,590 --> 00:27:18,720

and then for the planetary and stellar

714
00:27:23,909 --> 00:27:21,600
parameters um we use a series of

715
00:27:26,149 --> 00:27:23,919
different stellar spectra that

716
00:27:28,789 --> 00:27:26,159
are sort of input into atmos and then

717
00:27:31,669 --> 00:27:28,799
the uh radio transfer models as well for

718
00:27:33,190 --> 00:27:31,679
the planetary parameters we assume um

719
00:27:35,750 --> 00:27:33,200
basically just an er we assume an

720
00:27:37,830 --> 00:27:35,760
earth-like atmosphere um for start and

721
00:27:39,590 --> 00:27:37,840
then for the case of proxima centauri

722
00:27:41,190 --> 00:27:39,600
and trappist we're actually specifically

723
00:27:43,750 --> 00:27:41,200
considering the planetary parameters of

724
00:27:44,710 --> 00:27:43,760
proxima centauri b and trappist-1e

725
00:27:46,230 --> 00:27:44,720
um

726
00:27:48,630 --> 00:27:46,240
but for other than that we're just sort

727
00:27:50,470 --> 00:27:48,640
of using a generic uh earth-like

728
00:27:52,630 --> 00:27:50,480
atmosphere and earth-sized planet to

729
00:27:59,110 --> 00:27:52,640
start with

730
00:28:03,750 --> 00:28:01,590
hi michaela nick wogen here from

731
00:28:06,149 --> 00:28:03,760
university of washington in seattle

732
00:28:08,389 --> 00:28:06,159
um i was wondering what concentrations

733
00:28:09,029 --> 00:28:08,399
of methyl bromide you would expect on

734
00:28:10,389 --> 00:28:09,039
the

735
00:28:14,389 --> 00:28:10,399
earth or

736
00:28:16,789 --> 00:28:14,399
an archaean earth around an m stone

737
00:28:18,549 --> 00:28:16,799
that's a great question um and probably

738
00:28:20,470 --> 00:28:18,559

something that i would have to

739
00:28:23,430 --> 00:28:20,480
think a little bit more about we are

740
00:28:26,470 --> 00:28:23,440
planning to sort of expand into uh

741
00:28:28,389 --> 00:28:26,480
simulating these fluxes in anoxic

742
00:28:30,389 --> 00:28:28,399
atmospheres and then also potentially

743
00:28:33,909 --> 00:28:30,399
doing some laboratory experiments to

744
00:28:37,190 --> 00:28:33,919
determine um what these fluxes uh could

745
00:28:41,190 --> 00:28:37,200
be kind of under an anoxic or archaean

746
00:28:43,029 --> 00:28:41,200
like atmosphere so i don't know yet but

747
00:28:45,590 --> 00:28:43,039
hopefully i can get back to you um when

748
00:28:47,350 --> 00:28:45,600
we looked into that a little bit more

749
00:28:54,070 --> 00:28:47,360
cool thanks

750
00:28:56,950 --> 00:28:55,669
and then we have a talk from fisher

751
00:28:59,669 --> 00:28:56,960
who's going to walk us through some

752
00:29:03,110 --> 00:28:59,679
chemical reaction network topology

753
00:29:05,029 --> 00:29:03,120
hello good morning to you all um so yes

754
00:29:07,190 --> 00:29:05,039
cutting straight to the chase

755
00:29:09,190 --> 00:29:07,200
so as i'm sure most of you are aware the

756
00:29:10,070 --> 00:29:09,200
major challenge with

757
00:29:12,230 --> 00:29:10,080
um

758
00:29:14,149 --> 00:29:12,240
studying exoplanet biosignatures is the

759
00:29:16,710 --> 00:29:14,159
difficulty that comes from going from a

760
00:29:18,950 --> 00:29:16,720
one-dimensional spectral plot to being

761
00:29:23,430 --> 00:29:18,960
able to confidently say that a biosphere

762
00:29:28,149 --> 00:29:26,310
increasingly difficult um in addition by

763
00:29:30,070 --> 00:29:28,159

the fact that in the last couple years

764
00:29:32,149 --> 00:29:30,080
we've realized that a lot of gases that

765
00:29:34,710 --> 00:29:32,159
we normally associate with biological

766
00:29:36,230 --> 00:29:34,720
activity like oxygen and methane can

767
00:29:38,870 --> 00:29:36,240
also be generated through completely

768
00:29:41,669 --> 00:29:38,880
abiotic processes raising the very real

769
00:29:42,710 --> 00:29:41,679
risk of false positives and on top of

770
00:29:44,870 --> 00:29:42,720
that

771
00:29:46,230 --> 00:29:44,880
if we may not even be able to accurately

772
00:29:49,190 --> 00:29:46,240
predict what

773
00:29:50,630 --> 00:29:49,200
biological gases may be relevant to

774
00:29:52,870 --> 00:29:50,640
biochemistries that are radically

775
00:29:55,830 --> 00:29:52,880
different from our own

776
00:29:57,269 --> 00:29:55,840
so my goal for my dissertation has been

777
00:30:00,230 --> 00:29:57,279
trying to figure out how do we work

778
00:30:01,750 --> 00:30:00,240
around these problems

779
00:30:03,750 --> 00:30:01,760
the approach we started with the idea

780
00:30:05,750 --> 00:30:03,760
that let's think about life as a pattern

781
00:30:07,669 --> 00:30:05,760
of interactions after all we usually do

782
00:30:10,630 --> 00:30:07,679
not find life in isolation here on

783
00:30:13,990 --> 00:30:10,640
planet it's usually in the context of an

784
00:30:16,149 --> 00:30:14,000
ecosystem a pattern of behaviors and

785
00:30:19,029 --> 00:30:16,159
interactions with other life forms and

786
00:30:21,510 --> 00:30:19,039
its physical environment

787
00:30:23,190 --> 00:30:21,520
now one good way to study how complex

788
00:30:25,029 --> 00:30:23,200

systems interact with each other is

789
00:30:27,430 --> 00:30:25,039
using networks essentially you can take

790
00:30:29,990 --> 00:30:27,440
any complex system and represent it as a

791
00:30:33,029 --> 00:30:30,000
network by simply assigning each

792
00:30:35,269 --> 00:30:33,039
component of the network point or node

793
00:30:36,470 --> 00:30:35,279
and then connecting these nodes to each

794
00:30:38,549 --> 00:30:36,480
other to

795
00:30:40,389 --> 00:30:38,559
via

796
00:30:42,789 --> 00:30:40,399
lines or edges

797
00:30:44,950 --> 00:30:42,799
that represent the interactions between

798
00:30:47,190 --> 00:30:44,960
these sub-components

799
00:30:48,710 --> 00:30:47,200
class example and then from there you

800
00:30:50,630 --> 00:30:48,720
can

801
00:30:52,149 --> 00:30:50,640
mathematically analyze the shape and

802
00:30:54,310 --> 00:30:52,159
structure of the network which will give

803
00:30:56,310 --> 00:30:54,320
you insight about the nature and

804
00:30:59,110 --> 00:30:56,320
behavior of the system you're looking at

805
00:31:01,509 --> 00:30:59,120
classic example is that the structure of

806
00:31:03,509 --> 00:31:01,519
the sort of crisscrossing of the us

807
00:31:05,750 --> 00:31:03,519
interstate highway system

808
00:31:07,430 --> 00:31:05,760
has a very different shape and topology

809
00:31:10,470 --> 00:31:07,440
from the spug

810
00:31:13,190 --> 00:31:10,480
hub and smoke system used by

811
00:31:14,870 --> 00:31:13,200
the airline industries

812
00:31:16,950 --> 00:31:14,880
and that these can be mathematically

813
00:31:18,549 --> 00:31:16,960

quantified

814
00:31:20,230 --> 00:31:18,559
so some of the network measurements

815
00:31:22,230 --> 00:31:20,240
we're talking about that are talking

816
00:31:24,789 --> 00:31:22,240
about today are actually pretty

817
00:31:26,549 --> 00:31:24,799
straightforward um first one is degree

818
00:31:29,029 --> 00:31:26,559
which in plain english is the number of

819
00:31:30,710 --> 00:31:29,039
connections or edges going into a given

820
00:31:32,149 --> 00:31:30,720
node

821
00:31:34,470 --> 00:31:32,159
you can then zoom out and look at the

822
00:31:36,149 --> 00:31:34,480
entire network and take the mean degree

823
00:31:39,190 --> 00:31:36,159
which as the name suggests is the

824
00:31:41,669 --> 00:31:39,200
average number of degrees of any given

825
00:31:43,350 --> 00:31:41,679
node in the network

826
00:31:45,350 --> 00:31:43,360
similarly speaking the shortest path

827
00:31:46,870 --> 00:31:45,360
length you guessed it is the shortest

828
00:31:48,789 --> 00:31:46,880
distance between any two nodes in the

829
00:31:51,750 --> 00:31:48,799
network and you can also take the

830
00:31:56,149 --> 00:31:51,760
average for this to learn more about the

831
00:31:59,590 --> 00:31:57,669
one last cool thing you can do with

832
00:32:02,070 --> 00:31:59,600
networks is to incorporate information

833
00:32:04,389 --> 00:32:02,080
you may have about the nature of the

834
00:32:07,190 --> 00:32:04,399
interactions into the edges

835
00:32:08,549 --> 00:32:07,200
of the network um for example if this

836
00:32:10,070 --> 00:32:08,559
were an unweighted network and you

837
00:32:12,630 --> 00:32:10,080
wanted to know what the shortest path

838
00:32:15,350 --> 00:32:12,640

between points a and c is it's pretty

839
00:32:17,190 --> 00:32:15,360
simple you go from a to b to c

840
00:32:18,789 --> 00:32:17,200
but let's take the weights and assume

841
00:32:20,630 --> 00:32:18,799
that they represent for example physical

842
00:32:22,230 --> 00:32:20,640
distance in that case the shortest

843
00:32:25,509 --> 00:32:22,240
distance between a and c is actually

844
00:32:28,549 --> 00:32:25,519
going from a to b to d to c because that

845
00:32:30,470 --> 00:32:28,559
had a has a weighted shortest path five

846
00:32:33,029 --> 00:32:30,480
versus going from a to b to c which has

847
00:32:36,149 --> 00:32:33,039
a weighted shortest path of six

848
00:32:37,190 --> 00:32:36,159
um so this can make network

849
00:32:39,750 --> 00:32:37,200
um

850
00:32:41,269 --> 00:32:39,760
analysis a very powerful tool for

851
00:32:43,430 --> 00:32:41,279
understanding these sorts of complex

852
00:32:45,029 --> 00:32:43,440
systems

853
00:32:46,630 --> 00:32:45,039
now you may be asking yourself okay

854
00:32:49,029 --> 00:32:46,640
that's great how do we apply this to

855
00:32:50,549 --> 00:32:49,039
atmospheres well you can do the exact

856
00:32:53,430 --> 00:32:50,559
same thing with any set of chemical

857
00:32:56,470 --> 00:32:53,440
reactions by assigning each species

858
00:32:57,990 --> 00:32:56,480
present a node and then connecting them

859
00:32:59,990 --> 00:32:58,000
to each other based off of what

860
00:33:01,909 --> 00:33:00,000
reactions they go participate in for

861
00:33:03,029 --> 00:33:01,919
example with this very simple set of

862
00:33:05,590 --> 00:33:03,039
reactions

863
00:33:07,029 --> 00:33:05,600

um you can represent it as a network

864
00:33:09,110 --> 00:33:07,039
then take measurements about it the mean

865
00:33:11,750 --> 00:33:09,120
degree for example is 2.3 which in this

866
00:33:13,029 --> 00:33:11,760
case represents that each species

867
00:33:14,070 --> 00:33:13,039
on average

868
00:33:16,870 --> 00:33:14,080
is

869
00:33:19,430 --> 00:33:16,880
active in about

870
00:33:22,470 --> 00:33:19,440
2.3 reactions and the average source

871
00:33:25,590 --> 00:33:22,480
path length is 1.54 so each species is

872
00:33:27,029 --> 00:33:25,600
about 1.54 steps removed from any other

873
00:33:29,750 --> 00:33:27,039
species

874
00:33:33,669 --> 00:33:31,430
the reason we took this approach is

875
00:33:35,750 --> 00:33:33,679
because way back in 2004 two network

876
00:33:37,190 --> 00:33:35,760
theorists solay and montanu

877
00:33:40,549 --> 00:33:37,200
mostly out of curiosity more than

878
00:33:41,909 --> 00:33:40,559
anything else decided to

879
00:33:43,990 --> 00:33:41,919
represent

880
00:33:46,310 --> 00:33:44,000
all the major planetary atmospheres in

881
00:33:47,990 --> 00:33:46,320
our social systems and their chemistries

882
00:33:50,149 --> 00:33:48,000
as networks

883
00:33:51,830 --> 00:33:50,159
and the vast majority of them ended up

884
00:33:53,269 --> 00:33:51,840
looking like this sort of this jumbled

885
00:33:55,110 --> 00:33:53,279
mess of spaghetti i believe this one is

886
00:33:56,630 --> 00:33:55,120
of mars in particular

887
00:33:59,750 --> 00:33:56,640
however

888
00:34:01,830 --> 00:33:59,760

earth look like this which is pretty

889
00:34:03,430 --> 00:34:01,840
noticeable it has a structure to it that

890
00:34:06,549 --> 00:34:03,440
the other networks did not have it is

891
00:34:08,389 --> 00:34:06,559
modular it is hierarchical um and so

892
00:34:09,750 --> 00:34:08,399
this really got us wondering you know

893
00:34:12,149 --> 00:34:09,760
maybe this is due to the presence of a

894
00:34:12,950 --> 00:34:12,159
biosphere

895
00:34:15,669 --> 00:34:12,960
so

896
00:34:16,950 --> 00:34:15,679
network theorists they weren't

897
00:34:18,550 --> 00:34:16,960
atmospheric chemists or planetary

898
00:34:20,470 --> 00:34:18,560
scientists or astronomers they were

899
00:34:21,589 --> 00:34:20,480
mostly just doing it because they wanted

900
00:34:23,190 --> 00:34:21,599
to see what would happen and that was

901
00:34:24,869 --> 00:34:23,200
about it so we wanted to take their

902
00:34:27,190 --> 00:34:24,879
approach and do it in a much more

903
00:34:29,909 --> 00:34:27,200
chemically rigorous way

904
00:34:32,230 --> 00:34:29,919
to sort of like do a proof of concept we

905
00:34:33,589 --> 00:34:32,240
used jupiter's at first

906
00:34:35,030 --> 00:34:33,599
because they're relatively simple

907
00:34:36,470 --> 00:34:35,040
compared to terrestrial planets they're

908
00:34:37,750 --> 00:34:36,480
only a couple of

909
00:34:39,829 --> 00:34:37,760
major physical constraints like

910
00:34:42,550 --> 00:34:39,839
temperature and initial composition

911
00:34:43,990 --> 00:34:42,560
um and we actually have a paper that has

912
00:34:45,669 --> 00:34:44,000
been accepted at the astronomical

913
00:34:46,629 --> 00:34:45,679

journal about this research if you're

914
00:34:47,510 --> 00:34:46,639
curious

915
00:34:48,389 --> 00:34:47,520
um

916
00:34:50,790 --> 00:34:48,399
and

917
00:34:54,230 --> 00:34:50,800
we discovered that the

918
00:34:56,389 --> 00:34:54,240
network topology does correlate to how

919
00:34:57,829 --> 00:34:56,399
far away you are removed from

920
00:34:59,670 --> 00:34:57,839
chemical equilibrium in this case

921
00:35:02,470 --> 00:34:59,680
quantifying chemical equilibrium using

922
00:35:04,069 --> 00:35:02,480
the vertical mixing coefficient or kzz

923
00:35:05,589 --> 00:35:04,079
so that was really encouraging you know

924
00:35:07,270 --> 00:35:05,599
we can actually tie

925
00:35:09,109 --> 00:35:07,280
network properties of chemical reaction

926
00:35:10,550 --> 00:35:09,119
networks to

927
00:35:12,310 --> 00:35:10,560
stuff that is actually happening

928
00:35:14,069 --> 00:35:12,320
physically in the chemical system we're

929
00:35:15,270 --> 00:35:14,079
modeling

930
00:35:16,630 --> 00:35:15,280
there's also correlations with

931
00:35:19,190 --> 00:35:16,640
temperature as well which was cool to

932
00:35:24,390 --> 00:35:20,950
now you may be wondering what our

933
00:35:26,550 --> 00:35:24,400
pipeline was for this well um

934
00:35:28,150 --> 00:35:26,560
based off of observations or in the case

935
00:35:30,310 --> 00:35:28,160
of terrestrial planets which is what i'm

936
00:35:31,910 --> 00:35:30,320
about to get into we take modeled

937
00:35:33,270 --> 00:35:31,920
atmospheres

938
00:35:34,470 --> 00:35:33,280

or if

939
00:35:37,030 --> 00:35:34,480
we're dealing with hot jupiter's the

940
00:35:39,910 --> 00:35:37,040
actual spectral lines

941
00:35:42,069 --> 00:35:39,920
build a model let it converge extract

942
00:35:44,950 --> 00:35:42,079
the reaction list and use that to build

943
00:35:46,950 --> 00:35:44,960
the network and then weight the edges of

944
00:35:49,829 --> 00:35:46,960
the network using the calculated

945
00:35:53,109 --> 00:35:49,839
reaction rates generated by the model

946
00:35:55,270 --> 00:35:53,119
and then measure the properties of those

947
00:35:57,030 --> 00:35:55,280
networks and the end result is a

948
00:35:58,390 --> 00:35:57,040
distribution of network properties

949
00:35:59,910 --> 00:35:58,400
because we're usually doing this with

950
00:36:01,910 --> 00:35:59,920
thousands of models

951
00:36:04,390 --> 00:36:01,920
where if you see in this last plot at

952
00:36:06,710 --> 00:36:04,400
the bottom center each point in the

953
00:36:09,270 --> 00:36:06,720
curves represents the given network

954
00:36:12,790 --> 00:36:09,280
property of a modeled atmosphere and its

955
00:36:14,870 --> 00:36:12,800
corresponding network

956
00:36:17,109 --> 00:36:14,880
so we now move to what we're really here

957
00:36:19,190 --> 00:36:17,119
for which is looking at biosignatures

958
00:36:22,790 --> 00:36:19,200
specifically in this case terrestrial

959
00:36:23,589 --> 00:36:22,800
planets or and the archaean earth

960
00:36:25,990 --> 00:36:23,599
to

961
00:36:27,829 --> 00:36:26,000
better quantify how distinguishable

962
00:36:29,109 --> 00:36:27,839
these distributions of network

963
00:36:31,030 --> 00:36:29,119

properties are from each other rather

964
00:36:33,670 --> 00:36:31,040
than just eyeballing it we'll also use

965
00:36:36,390 --> 00:36:33,680
the kolmogorov smirnoff metric which

966
00:36:37,750 --> 00:36:36,400
real quick is basically just a tool that

967
00:36:39,270 --> 00:36:37,760
tells you how statistically

968
00:36:41,030 --> 00:36:39,280
distinguishable two distributions are

969
00:36:42,550 --> 00:36:41,040
from each other it gives you a value

970
00:36:43,589 --> 00:36:42,560
from zero to one

971
00:36:45,109 --> 00:36:43,599
the higher it is the more

972
00:36:47,310 --> 00:36:45,119
distinguishable it also gives you a

973
00:36:49,589 --> 00:36:47,320
p-value which tells you how

974
00:36:50,710 --> 00:36:49,599
statistically significant

975
00:36:52,069 --> 00:36:50,720
those

976
00:36:55,270 --> 00:36:52,079
that

977
00:36:57,829 --> 00:36:55,280
zero to one value is so you know again

978
00:36:59,670 --> 00:36:57,839
just a handy shortcut for quantifying

979
00:37:02,470 --> 00:36:59,680
how different these distributions are

980
00:37:06,550 --> 00:37:03,430
so

981
00:37:09,270 --> 00:37:06,560
for our first batch we modeled

982
00:37:11,670 --> 00:37:09,280
um ten thousand terrestrial archaean

983
00:37:14,230 --> 00:37:11,680
earth atmospheres um with a gaussian

984
00:37:16,230 --> 00:37:14,240
distribution of methane fluxes

985
00:37:22,470 --> 00:37:16,240
um

986
00:37:30,630 --> 00:37:25,349
oh that is the wrong figure on the left

987
00:37:35,190 --> 00:37:33,109
oh never mind one of my slides got eaten

988
00:37:37,030 --> 00:37:35,200

so anyways

989
00:37:39,589 --> 00:37:37,040
just imagine in your head the first set

990
00:37:43,190 --> 00:37:39,599
we did was um a set of ten thousand

991
00:37:45,910 --> 00:37:43,200
planets five thousand that had a

992
00:37:46,710 --> 00:37:45,920
presence of a methanogenic biosphere the

993
00:37:49,589 --> 00:37:46,720
other

994
00:37:50,470 --> 00:37:49,599
five thousand just had abiotic methane

995
00:37:51,430 --> 00:37:50,480
fluxes

996
00:37:53,670 --> 00:37:51,440
um

997
00:37:56,150 --> 00:37:53,680
and it showed that the

998
00:37:58,470 --> 00:37:56,160
network measurements could distinguish

999
00:38:00,310 --> 00:37:58,480
between the two however the resulting

1000
00:38:01,910 --> 00:38:00,320
methane fluxes for the biotic planets

1001
00:38:05,109 --> 00:38:01,920
was also much much higher than for the

1002
00:38:06,950 --> 00:38:05,119
abiotics abiotic flux planets so

1003
00:38:08,390 --> 00:38:06,960
you know it's great to know that the

1004
00:38:09,750 --> 00:38:08,400
network measurements again are

1005
00:38:12,550 --> 00:38:09,760
representing something that is

1006
00:38:13,750 --> 00:38:12,560
physically happening on a planet um but

1007
00:38:16,950 --> 00:38:13,760
you know it would probably just be

1008
00:38:19,670 --> 00:38:16,960
easier to look at the methane fluxes

1009
00:38:21,829 --> 00:38:19,680
however we thought okay let's make this

1010
00:38:23,990 --> 00:38:21,839
difficult for or would be exoplanet

1011
00:38:26,069 --> 00:38:24,000
astronomers let's assume we have planets

1012
00:38:27,910 --> 00:38:26,079
that for whatever reason have the exact

1013
00:38:29,829 --> 00:38:27,920

same amount of methane as the planets

1014
00:38:32,630 --> 00:38:29,839
that have a biotic methane flux for

1015
00:38:34,230 --> 00:38:32,640
whatever reason you know maybe it just

1016
00:38:36,790 --> 00:38:34,240
has a lot of methane left over from the

1017
00:38:38,150 --> 00:38:36,800
primordial formation of the atmosphere

1018
00:38:42,550 --> 00:38:38,160
maybe there's spectral contamination

1019
00:38:47,589 --> 00:38:45,670
and that's where our tool really shines

1020
00:38:49,430 --> 00:38:47,599
on the left you have

1021
00:38:53,030 --> 00:38:49,440
the

1022
00:38:53,990 --> 00:38:53,040
ahead of myself that's why my slides are

1023
00:38:56,710 --> 00:38:54,000
messed up

1024
00:39:00,630 --> 00:38:58,630
sneak peek but anyways

1025
00:39:03,750 --> 00:39:00,640
this is just a demonstration of what i

1026
00:39:05,510 --> 00:39:03,760
meant by two distributions

1027
00:39:07,670 --> 00:39:05,520
the one on the left is

1028
00:39:10,790 --> 00:39:07,680
basically the same distribution low ks

1029
00:39:12,150 --> 00:39:10,800
value high p value not significant one

1030
00:39:13,510 --> 00:39:12,160
on the right two very different

1031
00:39:14,470 --> 00:39:13,520
distributions

1032
00:39:17,270 --> 00:39:14,480
um

1033
00:39:19,910 --> 00:39:17,280
high ks value low p value

1034
00:39:22,390 --> 00:39:19,920
so anyways right methanogens

1035
00:39:25,670 --> 00:39:22,400
first set we did here we go um like i

1036
00:39:28,230 --> 00:39:25,680
said biotic flux abiotic flux

1037
00:39:30,390 --> 00:39:28,240
methane concentration the atmosphere is

1038
00:39:32,470 --> 00:39:30,400

really high when you have life it's much

1039
00:39:35,270 --> 00:39:32,480
lower when you don't have life

1040
00:39:37,510 --> 00:39:35,280
not too surprising um

1041
00:39:39,750 --> 00:39:37,520
very high ks values for network

1042
00:39:41,270 --> 00:39:39,760
measurement distributions as well but

1043
00:39:44,710 --> 00:39:41,280
you know again you could just look at

1044
00:39:48,790 --> 00:39:46,470
this is the tough case i was talking

1045
00:39:50,310 --> 00:39:48,800
about and as you can see here

1046
00:39:51,990 --> 00:39:50,320
knowing the methane flux doesn't

1047
00:39:54,870 --> 00:39:52,000
actually really help you all that much

1048
00:39:58,230 --> 00:39:54,880
it yields a very low ks value and a very

1049
00:39:59,829 --> 00:39:58,240
high p value so it's probably not that

1050
00:40:01,750 --> 00:39:59,839
statistically distinguishable from each

1051
00:40:02,710 --> 00:40:01,760
other you would be hard-pressed to be

1052
00:40:04,150 --> 00:40:02,720
able to

1053
00:40:06,630 --> 00:40:04,160
tease apart these worlds whether or not

1054
00:40:08,710 --> 00:40:06,640
they have biology just based off of the

1055
00:40:11,990 --> 00:40:08,720
methane concentration in the atmosphere

1056
00:40:14,230 --> 00:40:12,000
however if you look at the ks values for

1057
00:40:15,990 --> 00:40:14,240
the network measurements they're

1058
00:40:18,550 --> 00:40:16,000
much higher in some cases

1059
00:40:20,790 --> 00:40:18,560
you know almost double that of the

1060
00:40:22,230 --> 00:40:20,800
ks value for the methane concentration

1061
00:40:24,550 --> 00:40:22,240
alone

1062
00:40:26,710 --> 00:40:24,560
so this is really encouraging and the p

1063
00:40:28,790 --> 00:40:26,720

values are also very low so this is

1064
00:40:31,510 --> 00:40:28,800
likely statistically significant

1065
00:40:34,309 --> 00:40:31,520
um so that was really heartening to see

1066
00:40:36,630 --> 00:40:34,319
that we can potentially be able to

1067
00:40:38,630 --> 00:40:36,640
distinguish between these planets

1068
00:40:39,829 --> 00:40:38,640
based off of network measurements even

1069
00:40:40,950 --> 00:40:39,839
when we wouldn't necessarily be able to

1070
00:40:43,670 --> 00:40:40,960
tell based off of the methane

1071
00:40:45,829 --> 00:40:43,680
concentration alone

1072
00:40:48,470 --> 00:40:45,839
what are our next steps having proven

1073
00:40:50,390 --> 00:40:48,480
that this potentially works well first

1074
00:40:52,470 --> 00:40:50,400
off we want to do

1075
00:40:53,990 --> 00:40:52,480
um some applications of machine learning

1076
00:40:56,790 --> 00:40:54,000
which we also did for the hot jupiters

1077
00:40:58,630 --> 00:40:56,800
project essentially seeing if including

1078
00:41:01,190 --> 00:40:58,640
these network measurements

1079
00:41:03,190 --> 00:41:01,200
in training predictability algorithms

1080
00:41:05,910 --> 00:41:03,200
makes it easier for

1081
00:41:07,510 --> 00:41:05,920
those algorithms or to be more accurate

1082
00:41:09,430 --> 00:41:07,520
in predicting whether or not a given

1083
00:41:11,109 --> 00:41:09,440
planet has life or not based off of the

1084
00:41:12,710 --> 00:41:11,119
values we feed it

1085
00:41:15,670 --> 00:41:12,720
um the other project that is currently

1086
00:41:19,030 --> 00:41:15,680
ongoing as we speak is looking at um

1087
00:41:20,550 --> 00:41:19,040
abiotic o2 production and

1088
00:41:24,630 --> 00:41:20,560

using some of the work from harman at

1089
00:41:26,710 --> 00:41:24,640
all 2015 um and versus photosynthesis

1090
00:41:28,390 --> 00:41:26,720
sort of in the early proteozoic when the

1091
00:41:30,309 --> 00:41:28,400
great oxidation event was just starting

1092
00:41:31,829 --> 00:41:30,319
because that's also a situation where

1093
00:41:35,030 --> 00:41:31,839
you can have very similar levels of

1094
00:41:37,109 --> 00:41:35,040
oxygen despite one planet being

1095
00:41:39,109 --> 00:41:37,119
inhabited and the other planet not

1096
00:41:40,870 --> 00:41:39,119
and then finally to actually see if we

1097
00:41:43,349 --> 00:41:40,880
can use this for

1098
00:41:45,910 --> 00:41:43,359
practical applications an incoming grad

1099
00:41:47,030 --> 00:41:45,920
student in my lab estelgen n is working

1100
00:41:48,790 --> 00:41:47,040
on

1101
00:41:50,790 --> 00:41:48,800
generating spectra from the atmospheres

1102
00:41:52,470 --> 00:41:50,800
we've modeled using tar rex and then

1103
00:41:54,470 --> 00:41:52,480
seeing if there's any correlations

1104
00:41:57,829 --> 00:41:54,480
between the spectral

1105
00:42:00,150 --> 00:41:57,839
lines and the actual network properties

1106
00:42:01,910 --> 00:42:00,160
including some that we may not

1107
00:42:03,910 --> 00:42:01,920
intuitively associate with each other

1108
00:42:05,589 --> 00:42:03,920
which i'm really excited to see

1109
00:42:07,670 --> 00:42:05,599
um so yeah there's gonna be a lot of

1110
00:42:09,510 --> 00:42:07,680
cool stuff coming up in the next year

1111
00:42:11,190 --> 00:42:09,520
um yeah and if you have any questions

1112
00:42:13,270 --> 00:42:11,200
and also if you're interested in what

1113
00:42:15,109 --> 00:42:13,280

i'm doing i'm gonna be getting my phd in

1114
00:42:17,990 --> 00:42:15,119
the next nine months and i would love to

1115
00:42:32,630 --> 00:42:18,000
have a job so just let me know

1116
00:42:36,630 --> 00:42:34,710
hi martha grover from georgia tech nice

1117
00:42:37,910 --> 00:42:36,640
to see you in person tessa oh thank you

1118
00:42:42,630 --> 00:42:37,920
and thank you for the really interesting

1119
00:42:46,390 --> 00:42:44,309
maybe maybe you explain this but i just

1120
00:42:47,670 --> 00:42:46,400
wanted to make make sure i understood or

1121
00:42:50,069 --> 00:42:47,680
uh uh

1122
00:42:52,150 --> 00:42:50,079
how about the p-values and the

1123
00:42:56,069 --> 00:42:52,160
uncertainty i would i would think from

1124
00:42:58,470 --> 00:42:56,079
measuring um concentrations directly and

1125
00:42:59,670 --> 00:42:58,480
then fitting the kinetic model or the

1126
00:43:02,230 --> 00:42:59,680
reaction model that there would be a lot

1127
00:43:04,630 --> 00:43:02,240
of uncertainty and is the is that

1128
00:43:06,710 --> 00:43:04,640
uncertainty taken into account when

1129
00:43:07,990 --> 00:43:06,720
you're distinguishing distributions or

1130
00:43:10,390 --> 00:43:08,000
yes

1131
00:43:12,150 --> 00:43:10,400
learn more about the uncertainty not for

1132
00:43:14,390 --> 00:43:12,160
the set i showed because these are

1133
00:43:15,829 --> 00:43:14,400
literally just stuff that came out like

1134
00:43:17,670 --> 00:43:15,839
of our models last week for the hot

1135
00:43:19,670 --> 00:43:17,680
jupiters though we had like a whole

1136
00:43:22,550 --> 00:43:19,680
range of uncertainties in the physical

1137
00:43:23,990 --> 00:43:22,560
initial physical conditions and even

1138
00:43:25,990 --> 00:43:24,000

for example temperature with

1139
00:43:27,670 --> 00:43:26,000
uncertainties up to plus or minus 500

1140
00:43:29,430 --> 00:43:27,680
kelvin we were still still able to

1141
00:43:31,589 --> 00:43:29,440
distinguish using network measurements

1142
00:43:34,309 --> 00:43:31,599
i'm going to see if that's also true for

1143
00:43:37,430 --> 00:43:34,319
these planets i'm hoping it's the case

1144
00:43:41,270 --> 00:43:39,430
hello uh

1145
00:43:42,150 --> 00:43:41,280
i'll step a little bit away thank you

1146
00:43:44,069 --> 00:43:42,160
for

1147
00:43:47,910 --> 00:43:44,079
great great talk um very very

1148
00:43:49,270 --> 00:43:47,920
interesting work um i'm i'm i'm very

1149
00:43:51,670 --> 00:43:49,280
very interested in

1150
00:43:53,829 --> 00:43:51,680
how you can distinguish between

1151
00:43:55,030 --> 00:43:53,839
networks and network topologies or

1152
00:43:57,430 --> 00:43:55,040
whether your technique can distinguish

1153
00:43:59,270 --> 00:43:57,440
between networks and network topologies

1154
00:44:01,030 --> 00:43:59,280
that are complex but still achieve a

1155
00:44:02,710 --> 00:44:01,040
sort of equilibrium versus something

1156
00:44:04,630 --> 00:44:02,720
that's relatively simple

1157
00:44:06,470 --> 00:44:04,640
but may not achieve in equilibrium where

1158
00:44:07,910 --> 00:44:06,480
the simplicity might come to our sort of

1159
00:44:09,750 --> 00:44:07,920
ignorance like i can kind of imagine

1160
00:44:11,670 --> 00:44:09,760
throwing a bunch of carbon and nitrogen

1161
00:44:13,349 --> 00:44:11,680
into a furnace and burning it up and you

1162
00:44:14,630 --> 00:44:13,359
can get a really complicated network

1163
00:44:16,630 --> 00:44:14,640

that's actually exactly what happens

1164
00:44:19,030 --> 00:44:16,640
with a lot of the hot jupiter networks

1165
00:44:21,109 --> 00:44:19,040
um that is actually another challenge we

1166
00:44:22,309 --> 00:44:21,119
are planning on doing um

1167
00:44:23,750 --> 00:44:22,319
something i've been talking about

1168
00:44:25,750 --> 00:44:23,760
recently with sean domicle goldman is

1169
00:44:27,510 --> 00:44:25,760
like looking at titan especially if you

1170
00:44:29,030 --> 00:44:27,520
start factoring in ionization you get

1171
00:44:30,950 --> 00:44:29,040
you can get like really high levels of

1172
00:44:33,190 --> 00:44:30,960
complexity um

1173
00:44:35,270 --> 00:44:33,200
we are hoping that

1174
00:44:36,870 --> 00:44:35,280
the overall topology if there's biology

1175
00:44:40,790 --> 00:44:36,880
involved is going to be different enough

1176
00:44:42,710 --> 00:44:40,800
but that is an open question okay thanks

1177
00:44:44,069 --> 00:44:42,720
uh i think secret will have to take the

1178
00:44:45,589 --> 00:44:44,079
question during the break so thank you

1179
00:44:50,550 --> 00:44:45,599
um but one more round of applause for

1180
00:44:55,910 --> 00:44:53,750
and our next talk is from thea kazakus

1181
00:45:04,550 --> 00:44:55,920
who's gonna talk about ozone as a proxy

1182
00:45:08,470 --> 00:45:07,190
do i just click forward here

1183
00:45:11,270 --> 00:45:08,480
cool

1184
00:45:12,470 --> 00:45:11,280
all right can everyone hear me okay

1185
00:45:14,390 --> 00:45:12,480
great

1186
00:45:16,309 --> 00:45:14,400
thank you all for coming either because

1187
00:45:18,309 --> 00:45:16,319
you intended to come or because you've

1188
00:45:19,750 --> 00:45:18,319

become frozen into your seat and you can

1189
00:45:21,510 --> 00:45:19,760
no longer leave

1190
00:45:23,030 --> 00:45:21,520
i'll say sorry i've been awkwardly

1191
00:45:24,790 --> 00:45:23,040
standing out there because i was worried

1192
00:45:26,630 --> 00:45:24,800
if i stayed in this room the whole time

1193
00:45:28,390 --> 00:45:26,640
i'd be chattering so hard you couldn't

1194
00:45:29,750 --> 00:45:28,400
hear me shout out to the people standing

1195
00:45:33,109 --> 00:45:29,760
out there

1196
00:45:35,190 --> 00:45:33,119
thanks ravi um anyway so i'm theo

1197
00:45:36,790 --> 00:45:35,200
kozakis i'm a postdoc at the technical

1198
00:45:38,390 --> 00:45:36,800
university of denmark

1199
00:45:40,309 --> 00:45:38,400
and today i'm going to talk to you all

1200
00:45:44,550 --> 00:45:40,319
about a question that i'm really excited

1201
00:45:48,390 --> 00:45:44,560
about which is is ozone o3 a reliable

1202
00:45:50,069 --> 00:45:48,400
proxy for molecular oxygen o2

1203
00:45:51,829 --> 00:45:50,079
jeez i am a little cold so sorry if i'm

1204
00:45:53,910 --> 00:45:51,839
chattering a little

1205
00:45:56,630 --> 00:45:53,920
alright so you might have heard the joke

1206
00:45:59,829 --> 00:45:56,640
that if a paper or talk title is a

1207
00:46:02,550 --> 00:45:59,839
question that the answer is no and i'm

1208
00:46:04,230 --> 00:46:02,560
happy to report that's not the case here

1209
00:46:06,150 --> 00:46:04,240
the answer is

1210
00:46:07,829 --> 00:46:06,160
it's complicated

1211
00:46:10,550 --> 00:46:07,839
so um

1212
00:46:12,309 --> 00:46:10,560
ozone the photochemical product of o2

1213
00:46:14,470 --> 00:46:12,319

they don't have a straightforward

1214
00:46:16,630 --> 00:46:14,480
relationship it's complicated but i do

1215
00:46:18,710 --> 00:46:16,640
believe that with the proper modeling we

1216
00:46:20,630 --> 00:46:18,720
can understand that relationship and

1217
00:46:22,150 --> 00:46:20,640
work with it

1218
00:46:23,829 --> 00:46:22,160
so now that i've given you the really

1219
00:46:26,150 --> 00:46:23,839
short answer let me give you a bit of a

1220
00:46:27,430 --> 00:46:26,160
longer answer and we should start off

1221
00:46:29,510 --> 00:46:27,440
with um

1222
00:46:31,430 --> 00:46:29,520
why do we want to use ozone as a proxy

1223
00:46:33,910 --> 00:46:31,440
for o2

1224
00:46:35,510 --> 00:46:33,920
a big part of this is that o2 paired

1225
00:46:37,910 --> 00:46:35,520
with a reducing gas is a really

1226
00:46:39,510 --> 00:46:37,920
promising biosignature pair so we're

1227
00:46:40,790 --> 00:46:39,520
going to want to look for these gases in

1228
00:46:44,069 --> 00:46:40,800
the atmospheres of terrestrial

1229
00:46:45,829 --> 00:46:44,079
exoplanets however there are scenarios

1230
00:46:48,630 --> 00:46:45,839
where o2 is either very difficult to

1231
00:46:50,630 --> 00:46:48,640
detect or not possible to detect and in

1232
00:46:54,069 --> 00:46:50,640
these scenarios people have suggested

1233
00:46:57,750 --> 00:46:54,079
using ozone photochemical product of o2

1234
00:46:59,990 --> 00:46:57,760
as a proxy instead

1235
00:47:02,150 --> 00:47:00,000
so just to give a couple of examples of

1236
00:47:04,470 --> 00:47:02,160
where ozone might be the better bet here

1237
00:47:06,870 --> 00:47:04,480
uh for example you have the mid infrared

1238
00:47:08,390 --> 00:47:06,880

so there's several missions proposed to

1239
00:47:09,510 --> 00:47:08,400
look for bio signatures in the mid

1240
00:47:11,750 --> 00:47:09,520
infrared

1241
00:47:15,270 --> 00:47:11,760
and there are no significant 02 features

1242
00:47:17,829 --> 00:47:15,280
yeah life mission daniel sorry

1243
00:47:19,750 --> 00:47:17,839
um so there's no significant o2 features

1244
00:47:22,150 --> 00:47:19,760
in the mid-infrared so these missions

1245
00:47:24,390 --> 00:47:22,160
will rely on ozone

1246
00:47:26,630 --> 00:47:24,400
also ozone is detectable at trace

1247
00:47:29,670 --> 00:47:26,640
amounts which means if you do have a

1248
00:47:32,150 --> 00:47:29,680
planet with low o2 ozone might be the

1249
00:47:34,549 --> 00:47:32,160
better bet there as well so for instance

1250
00:47:36,069 --> 00:47:34,559
the protozoa earth after the great

1251
00:47:38,470 --> 00:47:36,079
oxidation event we had oxygenic

1252
00:47:40,470 --> 00:47:38,480
photosynthesis but it took a while for

1253
00:47:42,790 --> 00:47:40,480
o2 to build up to the relatively high

1254
00:47:45,109 --> 00:47:42,800
levels we have today so a planet like

1255
00:47:47,190 --> 00:47:45,119
that ozone might be the biosignature we

1256
00:47:49,510 --> 00:47:47,200
want to look for

1257
00:47:50,549 --> 00:47:49,520
so let me tell you about how ozone is

1258
00:47:54,069 --> 00:47:50,559
created

1259
00:47:55,910 --> 00:47:54,079
we call the chapman mechanisms and

1260
00:47:58,630 --> 00:47:55,920
basically what happens is you have an o2

1261
00:48:01,109 --> 00:47:58,640
molecule and it's hit by a uv photon the

1262
00:48:03,670 --> 00:48:01,119
uv photon has to be less than 242

1263
00:48:05,670 --> 00:48:03,680

nanometers in order to break the strong

1264
00:48:08,549 --> 00:48:05,680
double o2 bond

1265
00:48:10,950 --> 00:48:08,559
it then creates oxygen atoms and those

1266
00:48:13,349 --> 00:48:10,960
oxygen atoms can then recombine with

1267
00:48:15,190 --> 00:48:13,359
molecular o2 with the help of a

1268
00:48:16,150 --> 00:48:15,200
background molecule to carry away excess

1269
00:48:18,470 --> 00:48:16,160
energy

1270
00:48:20,710 --> 00:48:18,480
to create ozone

1271
00:48:23,190 --> 00:48:20,720
so note that this ozone formation

1272
00:48:25,270 --> 00:48:23,200
reaction is a three-body reaction

1273
00:48:29,109 --> 00:48:25,280
not to put in spoilers but this is

1274
00:48:30,470 --> 00:48:29,119
foreshadowing for three slides from now

1275
00:48:33,190 --> 00:48:30,480
also you might be looking at these

1276
00:48:35,190 --> 00:48:33,200
reactions and thinking that the ozone o2

1277
00:48:36,470 --> 00:48:35,200
relationship is straightforward so i

1278
00:48:37,829 --> 00:48:36,480
just want to put in the disclaimer right

1279
00:48:39,829 --> 00:48:37,839
away that we've known that they have a

1280
00:48:41,589 --> 00:48:39,839
non-linear relationship for

1281
00:48:44,069 --> 00:48:41,599
a really long time now

1282
00:48:46,390 --> 00:48:44,079
and that because of the uv dependence on

1283
00:48:47,990 --> 00:48:46,400
ozone formation the ozone o2

1284
00:48:51,030 --> 00:48:48,000
relationship is going to change

1285
00:48:52,309 --> 00:48:51,040
depending on the host star

1286
00:48:54,150 --> 00:48:52,319
and because of that it's really

1287
00:48:56,630 --> 00:48:54,160
important to do photo chemistry modeling

1288
00:48:58,790 --> 00:48:56,640

if you want to think about ozone so um

1289
00:49:00,549 --> 00:48:58,800
so that's what i did so i use atmos

1290
00:49:02,630 --> 00:49:00,559
which is a coupled 1d climate

1291
00:49:05,190 --> 00:49:02,640
photochemistry code to model the

1292
00:49:07,750 --> 00:49:05,200
atmospheres of terrestrial planets and

1293
00:49:09,829 --> 00:49:07,760
then i used picasso a radiative transfer

1294
00:49:11,910 --> 00:49:09,839
code to create planetary emission

1295
00:49:13,670 --> 00:49:11,920
spectra for these model atmospheres to

1296
00:49:15,430 --> 00:49:13,680
get an idea of what ozone emission

1297
00:49:17,670 --> 00:49:15,440
features would look like

1298
00:49:19,829 --> 00:49:17,680
and for all of these planets i used

1299
00:49:23,670 --> 00:49:19,839
modern earth initial conditions

1300
00:49:26,950 --> 00:49:23,680
but i changed the o2 abundance from 0.01

1301
00:49:29,750 --> 00:49:26,960
to 150 percent our present atmospheric

1302
00:49:31,670 --> 00:49:29,760
level and that's the pal abbreviation

1303
00:49:33,430 --> 00:49:31,680
you're going to see here a lot and also

1304
00:49:36,309 --> 00:49:33,440
for reference our present atmospheric

1305
00:49:38,630 --> 00:49:36,319
level of o2 so 21 of our atmosphere

1306
00:49:40,630 --> 00:49:38,640
right now

1307
00:49:44,309 --> 00:49:40,640
so let's start with the results for the

1308
00:49:47,430 --> 00:49:44,319
earth sun case so here i have ozone on

1309
00:49:50,390 --> 00:49:47,440
the y-axis o2 on the x-axis

1310
00:49:52,069 --> 00:49:50,400
and then these uh

1311
00:49:54,069 --> 00:49:52,079
vertical lines here just pointing out

1312
00:49:56,390 --> 00:49:54,079
some cases of interest so you have 100

1313
00:49:59,030 --> 00:49:56,400

the present atmospheric level o2 so

1314
00:49:59,990 --> 00:49:59,040
modern earth and then 10 1 and 0.1

1315
00:50:01,750 --> 00:50:00,000
percent

1316
00:50:03,430 --> 00:50:01,760
and right away you could see that i

1317
00:50:06,950 --> 00:50:03,440
didn't lie the relationship is

1318
00:50:08,950 --> 00:50:06,960
complicated um there's a sort of

1319
00:50:11,270 --> 00:50:08,960
similar levels of ozone for both the

1320
00:50:13,430 --> 00:50:11,280
modern earth case and if you reduced

1321
00:50:15,270 --> 00:50:13,440
earth oxygen content to only 10 percent

1322
00:50:17,990 --> 00:50:15,280
of its present value

1323
00:50:19,270 --> 00:50:18,000
and peak ozone abundance occurs at about

1324
00:50:21,670 --> 00:50:19,280
25

1325
00:50:23,430 --> 00:50:21,680
our present atmospheric level of o2

1326
00:50:25,190 --> 00:50:23,440
so that might seem a bit strange but

1327
00:50:27,670 --> 00:50:25,200
fortunately there's a relatively simple

1328
00:50:30,069 --> 00:50:27,680
explanation for this it all boils down

1329
00:50:32,150 --> 00:50:30,079
to the fact that when there's less o2

1330
00:50:34,390 --> 00:50:32,160
ozone is going to form in a deeper layer

1331
00:50:36,549 --> 00:50:34,400
of the atmosphere and i'll explain this

1332
00:50:38,390 --> 00:50:36,559
by showing these two model atmospheres

1333
00:50:39,990 --> 00:50:38,400
here and they're both going to have the

1334
00:50:41,990 --> 00:50:40,000
same background gases and all i'm

1335
00:50:43,750 --> 00:50:42,000
changing is o2 and one's going to be

1336
00:50:46,069 --> 00:50:43,760
like modern earth and the other is going

1337
00:50:47,190 --> 00:50:46,079
to be half of the o2 we have on a modern

1338
00:50:50,870 --> 00:50:47,200

earth

1339
00:50:53,109 --> 00:50:50,880
molecules and these arrows are

1340
00:50:56,870 --> 00:50:53,119
representing uv photons coming in

1341
00:50:58,870 --> 00:50:56,880
breaking apart o2 and forming ozone

1342
00:51:00,950 --> 00:50:58,880
if we look at the comparison case with

1343
00:51:02,790 --> 00:51:00,960
half the amount of o2 put in those

1344
00:51:04,870 --> 00:51:02,800
arrows you could see that just because

1345
00:51:07,109 --> 00:51:04,880
there's less o2 in the atmosphere

1346
00:51:09,430 --> 00:51:07,119
the uv photons can get deeper so ozone

1347
00:51:11,510 --> 00:51:09,440
forms deeper in the atmosphere and the

1348
00:51:14,230 --> 00:51:11,520
reason why this matters is because ozone

1349
00:51:16,549 --> 00:51:14,240
is created with a three-body reaction

1350
00:51:18,630 --> 00:51:16,559
and three-body reactions are faster if

1351
00:51:20,470 --> 00:51:18,640
they're happening in a denser region of

1352
00:51:23,030 --> 00:51:20,480
the atmosphere

1353
00:51:25,349 --> 00:51:23,040
so that's why when you decrease o2

1354
00:51:27,510 --> 00:51:25,359
levels at first from modern earth levels

1355
00:51:30,309 --> 00:51:27,520
you do have more efficient ozone

1356
00:51:32,309 --> 00:51:30,319
production and for some o2 values that

1357
00:51:36,470 --> 00:51:32,319
sort of overcomes the fact that you're

1358
00:51:39,349 --> 00:51:36,480
taking away the source o2 to form ozone

1359
00:51:40,950 --> 00:51:39,359
all right let's look at the o2 ozone

1360
00:51:42,470 --> 00:51:40,960
relationship for other types of stars

1361
00:51:43,670 --> 00:51:42,480
because you know so a lot of stars in

1362
00:51:45,349 --> 00:51:43,680
the universe and we want to look for

1363
00:51:47,510 --> 00:51:45,359

life around all of them

1364
00:51:49,349 --> 00:51:47,520
so here are the uv spectra of the hosts

1365
00:51:51,349 --> 00:51:49,359
that i model plants around

1366
00:51:54,069 --> 00:51:51,359
if you are not an astronomer and you're

1367
00:51:55,710 --> 00:51:54,079
not familiar with our um

1368
00:51:57,829 --> 00:51:55,720
interesting spectral type

1369
00:51:59,510 --> 00:51:57,839
classifications just know when you look

1370
00:52:01,190 --> 00:51:59,520
at the sludge and when you go from top

1371
00:52:03,510 --> 00:52:01,200
to bottom you're sort of going from the

1372
00:52:05,589 --> 00:52:03,520
hotter stars with more uv down to cooler

1373
00:52:07,349 --> 00:52:05,599
stars with less uv it's just a simple

1374
00:52:10,069 --> 00:52:07,359
thing

1375
00:52:12,230 --> 00:52:10,079
so let's look again at this ozone o2

1376
00:52:13,990 --> 00:52:12,240
diagram there is the sun which we looked

1377
00:52:16,069 --> 00:52:14,000
at the last slide now i'm going to add

1378
00:52:17,910 --> 00:52:16,079
on the g 0 star

1379
00:52:19,910 --> 00:52:17,920
and the k2 star so those are the two

1380
00:52:21,910 --> 00:52:19,920
other hottest hosts that i looked at and

1381
00:52:22,630 --> 00:52:21,920
just looking at them quickly you could

1382
00:52:24,390 --> 00:52:22,640
see

1383
00:52:26,309 --> 00:52:24,400
the ozone abundance is different for

1384
00:52:28,470 --> 00:52:26,319
them but they follow sort of that same

1385
00:52:30,069 --> 00:52:28,480
trend there because when there's less o2

1386
00:52:31,750 --> 00:52:30,079
ozone forms deeper in the atmosphere

1387
00:52:33,750 --> 00:52:31,760
it's more efficient

1388
00:52:35,910 --> 00:52:33,760

but let's look at the two coolest host

1389
00:52:37,829 --> 00:52:35,920
stars i looked at so we have

1390
00:52:39,910 --> 00:52:37,839
a k5

1391
00:52:41,510 --> 00:52:39,920
and an m5 and right away you could see

1392
00:52:43,750 --> 00:52:41,520
that um those are different

1393
00:52:46,230 --> 00:52:43,760
relationships those are different trends

1394
00:52:49,190 --> 00:52:46,240
and if you take away o2 in these cases

1395
00:52:50,870 --> 00:52:49,200
you always get a decrease in ozone and

1396
00:52:54,309 --> 00:52:50,880
the reason for this is just that there's

1397
00:52:56,710 --> 00:52:54,319
less uv light reaching these planets

1398
00:52:59,349 --> 00:52:56,720
so if we return again to this diagram

1399
00:53:00,790 --> 00:52:59,359
that i showed a couple of slides earlier

1400
00:53:03,030 --> 00:53:00,800
if you want to look at a planet with

1401
00:53:05,589 --> 00:53:03,040
less uv we can sort of approximate that

1402
00:53:08,390 --> 00:53:05,599
by just deleting a couple of arrows and

1403
00:53:09,589 --> 00:53:08,400
you can see that basically the uv light

1404
00:53:11,270 --> 00:53:09,599
doesn't get that deep in those

1405
00:53:13,430 --> 00:53:11,280
atmospheres so the ozone layer doesn't

1406
00:53:15,349 --> 00:53:13,440
move down as enough as much as the

1407
00:53:18,230 --> 00:53:15,359
hotter stars so you don't have that

1408
00:53:19,430 --> 00:53:18,240
really efficient ozone production

1409
00:53:21,829 --> 00:53:19,440
and that's why if we return to this

1410
00:53:25,109 --> 00:53:21,839
diagram again the trends are different

1411
00:53:26,710 --> 00:53:25,119
depending on the host star so again

1412
00:53:28,630 --> 00:53:26,720
photochemistry modeling is going to be

1413
00:53:30,870 --> 00:53:28,640

really important if we want to use ozone

1414
00:53:32,549 --> 00:53:30,880
as a proxy for o2

1415
00:53:34,470 --> 00:53:32,559
and i also want to show you some of the

1416
00:53:35,750 --> 00:53:34,480
emission features that i simulated for

1417
00:53:38,230 --> 00:53:35,760
these models

1418
00:53:41,270 --> 00:53:38,240
so here for earth around the sun here's

1419
00:53:43,349 --> 00:53:41,280
the 9.6 micron ozone feature and right

1420
00:53:45,349 --> 00:53:43,359
now i'm showing it for the point one

1421
00:53:46,309 --> 00:53:45,359
percent present atmospheric level of o2

1422
00:53:48,230 --> 00:53:46,319
case

1423
00:53:49,990 --> 00:53:48,240
and let's increase the o2 see what

1424
00:53:51,910 --> 00:53:50,000
happens so here's one percent our

1425
00:53:53,589 --> 00:53:51,920
present level that feature is deeper

1426
00:53:56,630 --> 00:53:53,599
that makes sense

1427
00:53:57,990 --> 00:53:56,640
10 percent that's uh sort of overlapping

1428
00:53:59,030 --> 00:53:58,000
with the one percent case which is

1429
00:54:00,950 --> 00:53:59,040
interesting because there's

1430
00:54:03,270 --> 00:54:00,960
significantly more ozone in the ten

1431
00:54:05,030 --> 00:54:03,280
percent case in the one percent case

1432
00:54:07,670 --> 00:54:05,040
and a hundred percent which is uh

1433
00:54:09,030 --> 00:54:07,680
shallower than both of those which um

1434
00:54:11,750 --> 00:54:09,040
seems interesting it's a little

1435
00:54:13,430 --> 00:54:11,760
complicated but we can't understand this

1436
00:54:15,990 --> 00:54:13,440
and the reason is that the depth of

1437
00:54:17,510 --> 00:54:16,000
emission features is dependent

1438
00:54:19,910 --> 00:54:17,520

on the temperature difference between

1439
00:54:22,230 --> 00:54:19,920
the emitting and absorbing layers of the

1440
00:54:23,430 --> 00:54:22,240
atmosphere so for ozone that's going to

1441
00:54:25,349 --> 00:54:23,440
be the temperature difference between

1442
00:54:28,309 --> 00:54:25,359
the planetary surface and the

1443
00:54:29,910 --> 00:54:28,319
stratosphere with the ozone layer exists

1444
00:54:31,829 --> 00:54:29,920
so here are the temperature profiles of

1445
00:54:33,990 --> 00:54:31,839
these cases if you look at the black

1446
00:54:35,589 --> 00:54:34,000
line the modern earth case you can see

1447
00:54:37,510 --> 00:54:35,599
there's a huge temperature inversion

1448
00:54:39,190 --> 00:54:37,520
there and that's because most of the

1449
00:54:41,670 --> 00:54:39,200
stratospheric heating on earth is

1450
00:54:44,230 --> 00:54:41,680
through uv absorption of ozone so even

1451
00:54:46,150 --> 00:54:44,240
though this case has a lot of ozone

1452
00:54:47,750 --> 00:54:46,160
as a result the temperature difference

1453
00:54:50,630 --> 00:54:47,760
between the surface of the planet and

1454
00:54:52,390 --> 00:54:50,640
the stratosphere is much less than say

1455
00:54:54,390 --> 00:54:52,400
the one percent case where there's

1456
00:54:56,150 --> 00:54:54,400
significantly less ozone but the

1457
00:54:58,230 --> 00:54:56,160
temperature difference there between the

1458
00:54:59,430 --> 00:54:58,240
surface and the stratosphere is much

1459
00:55:01,750 --> 00:54:59,440
greater because it doesn't have the

1460
00:55:03,430 --> 00:55:01,760
ozone stratospheric heating

1461
00:55:05,510 --> 00:55:03,440
so climate modeling is going to be

1462
00:55:07,270 --> 00:55:05,520
really important too for using ozone as

1463
00:55:08,870 --> 00:55:07,280

a biosignature

1464
00:55:11,109 --> 00:55:08,880
and last i just want to show you these

1465
00:55:13,510 --> 00:55:11,119
corresponding emission features around

1466
00:55:16,710 --> 00:55:13,520
an mdorf so that's the coolest star that

1467
00:55:20,069 --> 00:55:16,720
we looked at so here is again the 0.1

1468
00:55:21,589 --> 00:55:20,079
percent present atmospheric level of o2

1469
00:55:25,670 --> 00:55:21,599
1

1470
00:55:26,870 --> 00:55:25,680
um that might have been a little

1471
00:55:28,309 --> 00:55:26,880
underwhelming

1472
00:55:29,270 --> 00:55:28,319
thank you eddie

1473
00:55:30,789 --> 00:55:29,280
um

1474
00:55:32,549 --> 00:55:30,799
so yeah so these features are a little

1475
00:55:34,390 --> 00:55:32,559
more in a way straightforward to what

1476
00:55:36,069 --> 00:55:34,400
you might have intuitively guessed and

1477
00:55:37,589 --> 00:55:36,079
if you look at the temperature profiles

1478
00:55:38,950 --> 00:55:37,599
you can see why you could see that none

1479
00:55:41,109 --> 00:55:38,960
of these cases

1480
00:55:42,549 --> 00:55:41,119
have the stratospheric inversion and

1481
00:55:44,789 --> 00:55:42,559
that's because first of all there's less

1482
00:55:46,630 --> 00:55:44,799
ozone in these cases but also because

1483
00:55:48,069 --> 00:55:46,640
there's less uv

1484
00:55:50,390 --> 00:55:48,079
reaching the atmospheres of these

1485
00:55:52,710 --> 00:55:50,400
planets for ozone to absorb and it's

1486
00:55:54,309 --> 00:55:52,720
through that uv absorption of ozone the

1487
00:55:56,549 --> 00:55:54,319
stratosphere is heated

1488
00:55:58,549 --> 00:55:56,559

so in a way around cooler stars without

1489
00:56:01,030 --> 00:55:58,559
temperature inversions in the atmosphere

1490
00:56:03,670 --> 00:56:01,040
in a way that gives a simpler emission

1491
00:56:06,710 --> 00:56:03,680
feature but again climate modeling is

1492
00:56:08,230 --> 00:56:06,720
going to be really important here

1493
00:56:10,069 --> 00:56:08,240
all right so i've just thrown a lot of

1494
00:56:12,309 --> 00:56:10,079
information at you and i hope that you

1495
00:56:13,990 --> 00:56:12,319
can agree that the relationship between

1496
00:56:16,549 --> 00:56:14,000
o2 and ozone

1497
00:56:18,470 --> 00:56:16,559
is complicated but that if we do the

1498
00:56:20,390 --> 00:56:18,480
proper modeling we could start to work

1499
00:56:22,870 --> 00:56:20,400
it out so we're going to really have to

1500
00:56:26,150 --> 00:56:22,880
understand the uv spectrum of the host

1501
00:56:29,349 --> 00:56:26,160
star and do the atmospheric modeling

1502
00:56:31,190 --> 00:56:29,359
so if you're interested in this project

1503
00:56:33,990 --> 00:56:31,200
please feel free to pull me aside to

1504
00:56:36,309 --> 00:56:34,000
chat you can email me you could message

1505
00:56:38,470 --> 00:56:36,319
my twitter it's just my name

1506
00:56:50,549 --> 00:56:38,480
or you could ask me a question right now

1507
00:56:55,109 --> 00:56:53,030
i think sean won hey uh sean dominical

1508
00:56:56,870 --> 00:56:55,119
golden nasa goddard space flight center

1509
00:56:58,549 --> 00:56:56,880
um two questions maybe if there's no

1510
00:57:00,950 --> 00:56:58,559
others the first is did you look at the

1511
00:57:03,750 --> 00:57:00,960
ultraviolet uh absorption feature as

1512
00:57:05,190 --> 00:57:03,760
well as the 9.6 micron feature

1513
00:57:07,430 --> 00:57:05,200

sorry i missed the first part did you

1514
00:57:09,670 --> 00:57:07,440
ask if i looked at the uv features

1515
00:57:12,069 --> 00:57:09,680
so not in this current paper but i am

1516
00:57:15,349 --> 00:57:12,079
very interested in it especially since

1517
00:57:19,670 --> 00:57:15,359
the future great observatory so this uh

1518
00:57:21,349 --> 00:57:19,680
luvx or as i call it baby luboir thing

1519
00:57:24,390 --> 00:57:21,359
i know that they specifically want their

1520
00:57:26,710 --> 00:57:24,400
wavelength range to include the uv

1521
00:57:29,109 --> 00:57:26,720
ozone absorption in the hopes that you

1522
00:57:30,630 --> 00:57:29,119
could use ozone to find low levels of o2

1523
00:57:32,710 --> 00:57:30,640
so i haven't looked at that yet but

1524
00:57:34,390 --> 00:57:32,720
that's a future plan because i'm very

1525
00:57:36,789 --> 00:57:34,400
interested in that future as well yeah

1526
00:57:38,789 --> 00:57:36,799
we'd be super interested in that um yeah

1527
00:57:39,990 --> 00:57:38,799
the second question if it's okay

1528
00:57:41,750 --> 00:57:40,000
i'm actually thinking about stephanie's

1529
00:57:43,670 --> 00:57:41,760
work the the woman to your left and

1530
00:57:46,549 --> 00:57:43,680
looking at the seasonality of oxygen

1531
00:57:47,750 --> 00:57:46,559
fluxes it's a good thing um yeah and and

1532
00:57:48,870 --> 00:57:47,760
combining that with like what you're

1533
00:57:50,309 --> 00:57:48,880
doing which is like looking at the

1534
00:57:51,750 --> 00:57:50,319
different start types have you thought

1535
00:57:53,190 --> 00:57:51,760
about that like other plans for that i

1536
00:57:54,789 --> 00:57:53,200
think because i think that would also be

1537
00:57:56,870 --> 00:57:54,799
just fascinating to see

1538
00:57:57,990 --> 00:57:56,880

yeah so i forgot to mention sorry i keep

1539
00:57:59,829 --> 00:57:58,000
hitting the microphone because i'm

1540
00:58:01,829 --> 00:57:59,839
wearing a mask um

1541
00:58:04,230 --> 00:58:01,839
so i forgot to mention this is so going

1542
00:58:06,230 --> 00:58:04,240
to be a series of papers and the

1543
00:58:07,670 --> 00:58:06,240
seasonality is something i'm really

1544
00:58:09,990 --> 00:58:07,680
important in because obviously that's

1545
00:58:11,750 --> 00:58:10,000
going to change the ozone abundance and

1546
00:58:13,990 --> 00:58:11,760
you know day night cycles tidally locked

1547
00:58:16,309 --> 00:58:14,000
planets it's going to change

1548
00:58:18,549 --> 00:58:16,319
for everything so these are definitely

1549
00:58:20,630 --> 00:58:18,559
things on the to-do list that i'm really

1550
00:58:24,950 --> 00:58:20,640
interested in cool looking forward to

1551
00:58:27,990 --> 00:58:26,230
we have time for maybe one more quick

1552
00:58:30,069 --> 00:58:28,000
question and if no one else is going to

1553
00:58:31,270 --> 00:58:30,079
ask it i am so

1554
00:58:32,549 --> 00:58:31,280
um

1555
00:58:35,109 --> 00:58:32,559
no oh

1556
00:58:36,710 --> 00:58:35,119
please hi i'm angela burke from purdue

1557
00:58:40,390 --> 00:58:36,720
university hi i was wondering if you had

1558
00:58:43,270 --> 00:58:40,400
plans to study non-earth-like exoplanets

1559
00:58:45,510 --> 00:58:43,280
yeah that's a good question so right now

1560
00:58:47,990 --> 00:58:45,520
uh so there's so many questions i have

1561
00:58:49,430 --> 00:58:48,000
for the earth-like exoplanets right now

1562
00:58:52,309 --> 00:58:49,440
like i'm working on things where i'm

1563
00:58:54,069 --> 00:58:52,319

changing like methane abundance and

1564
00:58:57,030 --> 00:58:54,079
nitrous oxide abundance because that

1565
00:58:58,630 --> 00:58:57,040
changes ozone and then

1566
00:59:01,030 --> 00:58:58,640
like working on different boundary

1567
00:59:02,950 --> 00:59:01,040
conditions in the models change it so

1568
00:59:04,950 --> 00:59:02,960
right now on my to-do list it is only

1569
00:59:06,789 --> 00:59:04,960
earth-like planets but of course this is

1570
00:59:08,230 --> 00:59:06,799
going to be important in

1571
00:59:10,470 --> 00:59:08,240
all types of planets so i'm not

1572
00:59:12,150 --> 00:59:10,480
currently planning on it but i think

1573
00:59:14,150 --> 00:59:12,160
it's important if that's something you

1574
00:59:15,910 --> 00:59:14,160
want to do you should totally do it

1575
00:59:17,430 --> 00:59:15,920
thank you or if that's something someone

1576
00:59:18,710 --> 00:59:17,440
else wants to do i think it's important

1577
00:59:21,510 --> 00:59:18,720
maybe once i get through all the

1578
00:59:22,630 --> 00:59:21,520
earth-like questions

1579
00:59:29,670 --> 00:59:22,640
yeah

1580
00:59:32,789 --> 00:59:31,430
and uh next up we have ryan felton who's

1581
00:59:35,190 --> 00:59:32,799
going to talk to us about the role of

1582
00:59:46,789 --> 00:59:35,200
atmospheric exchange in pulse positive

1583
00:59:50,710 --> 00:59:47,910
okay

1584
00:59:53,510 --> 00:59:50,720
good morning everyone i'm ryan felton

1585
00:59:55,030 --> 00:59:53,520
i'm uh npp out at nasa ames in beautiful

1586
00:59:57,589 --> 00:59:55,040
sunny california

1587
01:00:00,309 --> 00:59:57,599
and along with my co-authors listed here

1588
01:00:02,870 --> 01:00:00,319

i wanted to uh talk to you about a paper

1589
01:00:04,870 --> 01:00:02,880
we recently published titled the role of

1590
01:00:08,549 --> 01:00:04,880
atmospheric exchange and false positive

1591
01:00:12,470 --> 01:00:10,950
so this work was all first inspired by

1592
01:00:13,510 --> 01:00:12,480
thinking about the titan enceladus

1593
01:00:14,390 --> 01:00:13,520
system

1594
01:00:16,150 --> 01:00:14,400
where essentially you have the

1595
01:00:18,549 --> 01:00:16,160
cryovolcanics on enceladus they're

1596
01:00:20,950 --> 01:00:18,559
spewing out organic volatiles they're

1597
01:00:22,789 --> 01:00:20,960
then entering the saturnian system

1598
01:00:24,549 --> 01:00:22,799
cycling through it and some of it

1599
01:00:26,630 --> 01:00:24,559
actually becoming incorporated into

1600
01:00:28,470 --> 01:00:26,640
titan's atmosphere

1601
01:00:31,750 --> 01:00:28,480
and so we thought

1602
01:00:34,390 --> 01:00:31,760
well could a similar type of interaction

1603
01:00:36,630 --> 01:00:34,400
occur amongst exoplanets and so we

1604
01:00:38,870 --> 01:00:36,640
envisioned this hypothetical here

1605
01:00:40,309 --> 01:00:38,880
where in the trappist-1 system you have

1606
01:00:42,150 --> 01:00:40,319
traps 1d

1607
01:00:44,309 --> 01:00:42,160
losing its atmosphere due to extreme

1608
01:00:46,630 --> 01:00:44,319
stellar activity and that material

1609
01:00:48,549 --> 01:00:46,640
blowing off from trappist-1d

1610
01:00:51,829 --> 01:00:48,559
moving out into space and essentially

1611
01:00:53,829 --> 01:00:51,839
raining down onto trappist-1 e

1612
01:00:56,470 --> 01:00:53,839
so we thought well if you have all this

1613
01:00:58,230 --> 01:00:56,480

extra material entering into

1614
01:01:00,630 --> 01:00:58,240
another atmosphere could you trigger

1615
01:01:02,390 --> 01:01:00,640
some kind of false positive biosignature

1616
01:01:04,150 --> 01:01:02,400
now that all that extra material is

1617
01:01:06,390 --> 01:01:04,160
there

1618
01:01:09,030 --> 01:01:06,400
and so the buyer signature wanted to

1619
01:01:11,190 --> 01:01:09,040
look at is one that's a historically

1620
01:01:14,789 --> 01:01:11,200
strong one it's just considered the

1621
01:01:16,950 --> 01:01:14,799
methane o2 or o3 biosignature where

1622
01:01:18,789 --> 01:01:16,960
essentially you should not really see

1623
01:01:20,630 --> 01:01:18,799
both of these at the same time due to

1624
01:01:21,510 --> 01:01:20,640
the way that they interact

1625
01:01:24,630 --> 01:01:21,520
where

1626
01:01:27,109 --> 01:01:24,640
either it is abundant oxygen environment

1627
01:01:29,750 --> 01:01:27,119
the methane is going to be destroyed or

1628
01:01:31,510 --> 01:01:29,760
in a str uh an abundant

1629
01:01:35,510 --> 01:01:31,520
methane environment

1630
01:01:36,870 --> 01:01:35,520
the o2 will rapidly be lost to reducing

1631
01:01:38,309 --> 01:01:36,880
sinks

1632
01:01:39,990 --> 01:01:38,319
so the only time that you should see the

1633
01:01:40,950 --> 01:01:40,000
two of these at the same time is really

1634
01:01:43,030 --> 01:01:40,960
if there's something else that's

1635
01:01:44,789 --> 01:01:43,040
replenishing it and our understanding is

1636
01:01:49,270 --> 01:01:44,799
that that mechanism would need to be

1637
01:01:53,670 --> 01:01:50,470
and so again

1638
01:01:55,990 --> 01:01:53,680

could external material influx amongst

1639
01:01:58,470 --> 01:01:56,000
exoplanets cause a false positive and to

1640
01:02:00,710 --> 01:01:58,480
begin answering that question we turn to

1641
01:02:02,230 --> 01:02:00,720
the trappist-1 system specifically

1642
01:02:05,670 --> 01:02:02,240
trappist-1e

1643
01:02:08,069 --> 01:02:05,680
we took in our a narcan earth simulation

1644
01:02:09,829 --> 01:02:08,079
and started essentially making it a

1645
01:02:12,549 --> 01:02:09,839
trappist-1 e1

1646
01:02:13,910 --> 01:02:12,559
using the 1d photochemical climate model

1647
01:02:15,990 --> 01:02:13,920
atmos

1648
01:02:18,069 --> 01:02:16,000
and we applied

1649
01:02:19,990 --> 01:02:18,079
our keen earth surface pressure but then

1650
01:02:22,069 --> 01:02:20,000
essentially everything else was trapped

1651
01:02:23,990 --> 01:02:22,079
when ebay so the planetary parameters

1652
01:02:27,670 --> 01:02:24,000
and stellar installation for that system

1653
01:02:32,549 --> 01:02:29,829
and we needed to bound the problem so to

1654
01:02:34,870 --> 01:02:32,559
begin we had methane surface fluxes this

1655
01:02:37,349 --> 01:02:34,880
methane vent coming out of the surface

1656
01:02:39,910 --> 01:02:37,359
and we bended based on these three

1657
01:02:41,510 --> 01:02:39,920
categories here either abiotic ambiguous

1658
01:02:44,549 --> 01:02:41,520
or biotic and these bindings are

1659
01:02:49,190 --> 01:02:44,559
essentially just based on literature um

1660
01:02:53,029 --> 01:02:51,109
and then we want to have two fluxes so

1661
01:02:54,630 --> 01:02:53,039
this is the material that's coming into

1662
01:02:56,470 --> 01:02:54,640
the external material coming into the

1663
01:02:58,230 --> 01:02:56,480

top of the atmosphere so the first one

1664
01:03:00,390 --> 01:02:58,240
is oxygen

1665
01:03:02,470 --> 01:03:00,400
and we said lower and upper bound so the

1666
01:03:05,349 --> 01:03:02,480
lower limits are really just based on

1667
01:03:07,750 --> 01:03:05,359
titan titan research uh and uh cassini

1668
01:03:09,990 --> 01:03:07,760
oregon's results and the upper limit is

1669
01:03:11,430 --> 01:03:10,000
based on simulations of proximus and b

1670
01:03:14,230 --> 01:03:11,440
where it's essentially due to cellular

1671
01:03:17,670 --> 01:03:14,240
activity is having uh ionized atomic

1672
01:03:19,750 --> 01:03:17,680
oxygen stripped off of it and uh

1673
01:03:22,710 --> 01:03:19,760
the flux or the molecules per centimeter

1674
01:03:25,510 --> 01:03:22,720
squared per second for that was on this

1675
01:03:27,270 --> 01:03:25,520
range of about 10 to the 10.

1676
01:03:29,430 --> 01:03:27,280
and then another flux that we wanted to

1677
01:03:30,710 --> 01:03:29,440
incorporate here to test this was water

1678
01:03:33,510 --> 01:03:30,720
so now you can just think of a water

1679
01:03:35,109 --> 01:03:33,520
hose this spigot you turn it on and it's

1680
01:03:37,430 --> 01:03:35,119
spewing water out onto the top of the

1681
01:03:39,029 --> 01:03:37,440
atmosphere and again uh we turned it

1682
01:03:40,390 --> 01:03:39,039
tightened to establish the lower limit

1683
01:03:42,069 --> 01:03:40,400
for that flux

1684
01:03:44,470 --> 01:03:42,079
and the upper limit is really based on

1685
01:03:46,710 --> 01:03:44,480
kind of just the back of the envelope

1686
01:03:48,390 --> 01:03:46,720
calculation for water loss on earth and

1687
01:03:52,150 --> 01:03:48,400
then converting that to the appropriate

1688
01:03:56,150 --> 01:03:53,670

and so first i would just want to show

1689
01:03:59,270 --> 01:03:56,160
you some of our photochemical results

1690
01:04:01,670 --> 01:03:59,280
what you see here is methane and ozone

1691
01:04:05,109 --> 01:04:01,680
column density on the y-axis as a

1692
01:04:07,990 --> 01:04:05,119
function of the incoming water flux

1693
01:04:10,309 --> 01:04:08,000
and then the boundaries that i discussed

1694
01:04:12,069 --> 01:04:10,319
are you can see here in orange and black

1695
01:04:13,910 --> 01:04:12,079
are the vertical dashed lines the left

1696
01:04:16,230 --> 01:04:13,920
and right

1697
01:04:18,390 --> 01:04:16,240
and then the region to

1698
01:04:19,670 --> 01:04:18,400
the far right past that black line

1699
01:04:21,589 --> 01:04:19,680
essentially what we considered the

1700
01:04:23,270 --> 01:04:21,599
physically implausible region so this is

1701
01:04:26,230 --> 01:04:23,280
not these are not fluxes that really

1702
01:04:28,150 --> 01:04:26,240
should be occurring in nature

1703
01:04:30,470 --> 01:04:28,160
and the big takeaway here is you can see

1704
01:04:31,910 --> 01:04:30,480
that as you're moving from left to right

1705
01:04:33,750 --> 01:04:31,920
as you're turning up the dial on the

1706
01:04:36,390 --> 01:04:33,760
amount of water coming out

1707
01:04:38,710 --> 01:04:36,400
the atmosphere is gradually starting to

1708
01:04:41,349 --> 01:04:38,720
respond to that

1709
01:04:42,950 --> 01:04:41,359
and the same thing now just with oxygen

1710
01:04:45,190 --> 01:04:42,960
again we have our limits on the left and

1711
01:04:49,589 --> 01:04:45,200
right and then that in physically

1712
01:04:53,270 --> 01:04:51,190
and so with our simulations or

1713
01:04:55,510 --> 01:04:53,280

photochemical simulations in place we

1714
01:04:58,069 --> 01:04:55,520
needed to the next turn to

1715
01:04:59,270 --> 01:04:58,079
actual observations what could we see

1716
01:05:01,589 --> 01:04:59,280
it didn't do that we turned into

1717
01:05:03,270 --> 01:05:01,599
planetary spectrogenerator or psg we

1718
01:05:05,270 --> 01:05:03,280
also incorporated

1719
01:05:08,069 --> 01:05:05,280
uh water and water ice clouds so we

1720
01:05:10,309 --> 01:05:08,079
weren't just painting on an albedo we

1721
01:05:13,910 --> 01:05:10,319
could actually have a little bit of more

1722
01:05:18,390 --> 01:05:16,309
and within psg we had four instruments

1723
01:05:19,829 --> 01:05:18,400
five sorry four telescopes five

1724
01:05:22,230 --> 01:05:19,839
instruments

1725
01:05:25,190 --> 01:05:22,240
and james webb of course because it's

1726
01:05:27,109 --> 01:05:25,200
now launched and it was actually um

1727
01:05:28,789 --> 01:05:27,119
it was interesting we were between uh

1728
01:05:30,309 --> 01:05:28,799
when we started this had not launched

1729
01:05:31,430 --> 01:05:30,319
and then while we were in review it

1730
01:05:33,190 --> 01:05:31,440
launched

1731
01:05:35,270 --> 01:05:33,200
uh and then the other telescopes are

1732
01:05:36,710 --> 01:05:35,280
based on the master 2020 decadal mission

1733
01:05:41,990 --> 01:05:36,720
concepts

1734
01:05:44,390 --> 01:05:42,950
and so

1735
01:05:46,630 --> 01:05:44,400
let's get to

1736
01:05:49,270 --> 01:05:46,640
some of the results here for this is for

1737
01:05:51,910 --> 01:05:49,280
the psg results

1738
01:05:54,549 --> 01:05:51,920

and so you these are signal to noise for

1739
01:05:57,190 --> 01:05:54,559
ratios versus observatories and we're

1740
01:05:58,950 --> 01:05:57,200
looking for a minimum of uh five sigma

1741
01:06:01,990 --> 01:05:58,960
or five snr

1742
01:06:03,670 --> 01:06:02,000
as a considered to be a reliable signal

1743
01:06:05,510 --> 01:06:03,680
and so what we have here is when we're

1744
01:06:07,109 --> 01:06:05,520
looking for methane signals so remember

1745
01:06:08,470 --> 01:06:07,119
there's at least two where we're looking

1746
01:06:10,789 --> 01:06:08,480
for two to three

1747
01:06:11,589 --> 01:06:10,799
biosignatures or two to three gases and

1748
01:06:13,270 --> 01:06:11,599
so

1749
01:06:17,029 --> 01:06:13,280
you see here that

1750
01:06:19,589 --> 01:06:17,039
the only telescopes that have any snr's

1751
01:06:21,990 --> 01:06:19,599
for the methane for when oxygen is

1752
01:06:24,150 --> 01:06:22,000
flowing into the top of the atmosphere

1753
01:06:26,470 --> 01:06:24,160
or origins in louisville

1754
01:06:28,630 --> 01:06:26,480
and then the color codes here break down

1755
01:06:32,230 --> 01:06:28,640
by what you can see on the far right so

1756
01:06:33,750 --> 01:06:32,240
blue is 5 yellow is 10 and gray is 20.

1757
01:06:35,109 --> 01:06:33,760
and that's really just based on the fact

1758
01:06:37,510 --> 01:06:35,119
that james webb

1759
01:06:39,029 --> 01:06:37,520
had such a successful launch and so it's

1760
01:06:41,589 --> 01:06:39,039
estimated that it will have a 20-year

1761
01:06:43,829 --> 01:06:41,599
lifetime so we extended the

1762
01:06:46,549 --> 01:06:43,839
mission lifetimes and in turn the

1763
01:06:48,789 --> 01:06:46,559

transits for our all of our telescope

1764
01:06:49,910 --> 01:06:48,799
simulations

1765
01:06:52,069 --> 01:06:49,920
and one thing to note that was

1766
01:06:55,349 --> 01:06:52,079
interesting we did apply

1767
01:06:57,270 --> 01:06:55,359
a 10 ppm estimated noise floor for james

1768
01:06:58,950 --> 01:06:57,280
webb and you can see here that for near

1769
01:07:00,390 --> 01:06:58,960
spec prism we actually hit the noise for

1770
01:07:03,270 --> 01:07:00,400
essentially immediately

1771
01:07:08,309 --> 01:07:03,280
and so any further transits did not

1772
01:07:13,190 --> 01:07:10,309
and this is for cloudy and then for

1773
01:07:14,950 --> 01:07:13,200
clear sky i'll just put these together

1774
01:07:16,710 --> 01:07:14,960
and really and so

1775
01:07:20,390 --> 01:07:16,720
the solid

1776
01:07:22,470 --> 01:07:20,400
is the cloudy clear uh clear is the dash

1777
01:07:24,710 --> 01:07:22,480
diagonal and as you would imagine in a

1778
01:07:29,190 --> 01:07:24,720
clear sky the observation circuit the

1779
01:07:32,309 --> 01:07:30,630
and then an example of one of our

1780
01:07:33,510 --> 01:07:32,319
strongest methane signals and i say

1781
01:07:34,950 --> 01:07:33,520
strongest here even though it's cloudy

1782
01:07:36,870 --> 01:07:34,960
just because that would also potentially

1783
01:07:39,270 --> 01:07:36,880
be the more realistic

1784
01:07:42,549 --> 01:07:39,280
was for lou 4a you can see the sigma

1785
01:07:43,990 --> 01:07:42,559
here of well over five sigma and the

1786
01:07:46,069 --> 01:07:44,000
feature we're looking at is the one at

1787
01:07:48,549 --> 01:07:46,079
two point thirty three microns with a

1788
01:07:49,829 --> 01:07:48,559

vertical dashed line on the far right

1789
01:07:51,029 --> 01:07:49,839
and other features are really just

1790
01:07:52,309 --> 01:07:51,039
highlighted to kind of show you what

1791
01:07:55,750 --> 01:07:52,319
else is out there and also just how

1792
01:07:57,589 --> 01:07:55,760
heavily blended these spectra can be

1793
01:07:58,950 --> 01:07:57,599
even though you do see things there

1794
01:08:00,630 --> 01:07:58,960
where there is another methane and

1795
01:08:02,710 --> 01:08:00,640
there's co2 they're also blended with

1796
01:08:04,710 --> 01:08:02,720
other gases

1797
01:08:05,670 --> 01:08:04,720
and the ability to break them out it may

1798
01:08:07,430 --> 01:08:05,680
not be

1799
01:08:09,589 --> 01:08:07,440
would it's got to be harder than you

1800
01:08:11,270 --> 01:08:09,599
would imagine

1801
01:08:13,510 --> 01:08:11,280
so that's what you can see here in the

1802
01:08:15,430 --> 01:08:13,520
transmits where the

1803
01:08:19,990 --> 01:08:15,440
overlay of the other gas is based on the

1804
01:08:24,070 --> 01:08:21,910
and so now that was one guess though

1805
01:08:26,390 --> 01:08:24,080
remember we're looking at the methane

1806
01:08:28,870 --> 01:08:26,400
and no 203 biosignature combination

1807
01:08:33,590 --> 01:08:28,880
trying to see that and so i'll tell you

1808
01:08:34,470 --> 01:08:33,600
no you actually do not find o2 or o3

1809
01:08:36,149 --> 01:08:34,480
at

1810
01:08:39,110 --> 01:08:36,159
any appreciable

1811
01:08:41,430 --> 01:08:39,120
snr levels for the boundaries that we

1812
01:08:43,269 --> 01:08:41,440
established when the within this project

1813
01:08:44,149 --> 01:08:43,279

and those boundaries again are all based

1814
01:08:45,749 --> 01:08:44,159
on

1815
01:08:47,749 --> 01:08:45,759
um

1816
01:08:50,709 --> 01:08:47,759
either stellar activity or tying

1817
01:08:53,269 --> 01:08:50,719
essentially physical limits that

1818
01:08:56,870 --> 01:08:53,279
we already have understandings for and

1819
01:08:58,470 --> 01:08:56,880
so all of these snr's were either less

1820
01:09:01,269 --> 01:08:58,480
than one

1821
01:09:03,349 --> 01:09:01,279
or they were so for louvre a i believe

1822
01:09:04,630 --> 01:09:03,359
there was one oxygen signal but it was

1823
01:09:06,309 --> 01:09:04,640
so heavily

1824
01:09:08,149 --> 01:09:06,319
covered up by the noise which is well

1825
01:09:09,829 --> 01:09:08,159
over 500 ppm that you were just never

1826
01:09:11,669 --> 01:09:09,839
going to actually be able to resolve

1827
01:09:14,470 --> 01:09:11,679
this

1828
01:09:16,149 --> 01:09:14,480
that

1829
01:09:17,349 --> 01:09:16,159
when we're looking at the traps one

1830
01:09:21,269 --> 01:09:17,359
system

1831
01:09:24,789 --> 01:09:21,279
with uh the upcoming james webb cycles

1832
01:09:28,070 --> 01:09:24,799
the g the guaranteed and general cycles

1833
01:09:29,910 --> 01:09:28,080
um we should not be worrying about

1834
01:09:31,030 --> 01:09:29,920
coming across this potential false

1835
01:09:32,470 --> 01:09:31,040
positive

1836
01:09:34,149 --> 01:09:32,480
now i also wondered though okay well how

1837
01:09:36,550 --> 01:09:34,159
much do we actually actually push this

1838
01:09:38,070 --> 01:09:36,560

to see something

1839
01:09:39,990 --> 01:09:38,080
and you do have to push it past the

1840
01:09:41,829 --> 01:09:40,000
physical bounds

1841
01:09:43,990 --> 01:09:41,839
that's what we see here so if you look

1842
01:09:46,390 --> 01:09:44,000
at the bottom right or sorry at the

1843
01:09:48,149 --> 01:09:46,400
bottom middle the water and oxygen

1844
01:09:50,470 --> 01:09:48,159
toa are top of the atmosphere of flux

1845
01:09:53,269 --> 01:09:50,480
they're 10 to the 12. so this is now

1846
01:09:55,350 --> 01:09:53,279
two orders of magnitude above the limit

1847
01:09:57,270 --> 01:09:55,360
that we impose into so essentially

1848
01:10:00,149 --> 01:09:57,280
towards the magnitude outside of a

1849
01:10:01,350 --> 01:10:00,159
realistic scenario

1850
01:10:05,189 --> 01:10:01,360
and

1851
01:10:08,709 --> 01:10:05,199
origins is the only one that shows a

1852
01:10:10,709 --> 01:10:08,719
snr a simulated snr of five or higher

1853
01:10:11,669 --> 01:10:10,719
and it's only in the 20-year lifetime

1854
01:10:13,750 --> 01:10:11,679
but

1855
01:10:18,229 --> 01:10:13,760
this is again within an implausively

1856
01:10:21,270 --> 01:10:19,189
and so

1857
01:10:23,189 --> 01:10:21,280
to conclude as i was saying we do not

1858
01:10:24,310 --> 01:10:23,199
need to be concerned about this false

1859
01:10:25,590 --> 01:10:24,320
positive

1860
01:10:26,950 --> 01:10:25,600
for

1861
01:10:29,270 --> 01:10:26,960
uh at least the traps one system

1862
01:10:30,709 --> 01:10:29,280
especially for em dwarfs

1863
01:10:32,229 --> 01:10:30,719

uh you really need to be at least two

1864
01:10:35,270 --> 01:10:32,239
orders of magnitude above what would be

1865
01:10:37,030 --> 01:10:35,280
physically implausible and no we

1866
01:10:38,070 --> 01:10:37,040
we will say that we did not consider

1867
01:10:40,550 --> 01:10:38,080
other

1868
01:10:43,110 --> 01:10:40,560
potential uh biosignature combinations

1869
01:10:44,709 --> 01:10:43,120
like methane and co2

1870
01:10:47,270 --> 01:10:44,719
and

1871
01:10:49,669 --> 01:10:47,280
there's no space observations or sorry

1872
01:10:53,350 --> 01:10:49,679
we only did space observatory so there's

1873
01:10:58,229 --> 01:10:54,790
and if you're interested in any

1874
01:11:09,110 --> 01:10:58,239
potential collaboration just come say hi

1875
01:11:13,189 --> 01:11:10,830
that was very nice talk thank you very

1876
01:11:14,229 --> 01:11:13,199
much um katya machima from university of

1877
01:11:16,790 --> 01:11:14,239
florida

1878
01:11:18,630 --> 01:11:16,800
um you were quoting as an example of the

1879
01:11:21,030 --> 01:11:18,640
analog for

1880
01:11:24,070 --> 01:11:21,040
the work and the interaction possible

1881
01:11:26,470 --> 01:11:24,080
interaction between titan and celadas

1882
01:11:28,229 --> 01:11:26,480
those analogues are very far in the

1883
01:11:30,790 --> 01:11:28,239
solar system they're kind of in the

1884
01:11:32,709 --> 01:11:30,800
regime where the um the radiation from

1885
01:11:34,990 --> 01:11:32,719
the sun is not strong enough to destroy

1886
01:11:37,830 --> 01:11:35,000
those molecules in the

1887
01:11:39,590 --> 01:11:37,840
interplanetary uh distance how about in

1888
01:11:43,030 --> 01:11:39,600

the condition for the trappist one those

1889
01:11:45,590 --> 01:11:43,040
are very close to the hosting star

1890
01:11:48,470 --> 01:11:45,600
um how do you model the survivability

1891
01:11:49,350 --> 01:11:48,480
how these molecules survive outside in

1892
01:11:52,310 --> 01:11:49,360
the

1893
01:11:53,510 --> 01:11:52,320
host planet yeah so we thought about

1894
01:11:55,830 --> 01:11:53,520
this essentially we took this

1895
01:11:57,510 --> 01:11:55,840
stoichiometric argument that anything

1896
01:11:59,350 --> 01:11:57,520
that would be broken up we essentially

1897
01:12:00,630 --> 01:11:59,360
applied a one-to-one ratio so anything

1898
01:12:02,790 --> 01:12:00,640
that would

1899
01:12:06,229 --> 01:12:02,800
get out of the atmosphere be blown off

1900
01:12:08,870 --> 01:12:06,239
at that first planet like trips one dnr

1901
01:12:10,870 --> 01:12:08,880
simul in the picture we just took that

1902
01:12:12,550 --> 01:12:10,880
we went with the stoichiometric argument

1903
01:12:15,270 --> 01:12:12,560
that anything that

1904
01:12:16,870 --> 01:12:15,280
is left and broken up would come back

1905
01:12:19,110 --> 01:12:16,880
together in some way when it entered at

1906
01:12:27,110 --> 01:12:19,120
least that was the best way to

1907
01:12:35,350 --> 01:12:28,229
all right there are no more questions

1908
01:12:38,149 --> 01:12:36,550
and at this time

1909
01:12:42,310 --> 01:12:38,159
hand it over stephanie and i'm gonna

1910
01:12:47,430 --> 01:12:44,790
all right our final talk of the session

1911
01:12:49,350 --> 01:12:47,440
comes from felipe gomez who will be

1912
01:13:04,630 --> 01:12:49,360
talking to us about

1913
01:13:04,640 --> 01:13:08,149

hi hello can you hear me

1914
01:13:11,910 --> 01:13:10,070
we can hear you but we can't see your

1915
01:13:16,070 --> 01:13:11,920
slides yet

1916
01:13:19,590 --> 01:13:16,080
okay i'm going to do sir because

1917
01:13:23,750 --> 01:13:19,600
we have some problems uh

1918
01:13:24,950 --> 01:13:23,760
yeah right now i'm trying to

1919
01:13:29,189 --> 01:13:24,960
get into

1920
01:13:31,350 --> 01:13:29,199
my presentation which is right here

1921
01:13:33,110 --> 01:13:31,360
can you see those lights right now

1922
01:13:35,350 --> 01:13:33,120
we can see them now

1923
01:13:37,590 --> 01:13:35,360
okay thank you uh this is uh felipe

1924
01:13:40,390 --> 01:13:37,600
gomez from central of australia in

1925
01:13:41,350 --> 01:13:40,400
biology astrology center in madrid in

1926
01:13:42,149 --> 01:13:41,360
spain

1927
01:13:45,270 --> 01:13:42,159
and

1928
01:13:47,669 --> 01:13:45,280
i am presenting our work extra foot

1929
01:13:50,229 --> 01:13:47,679
photosynthetic photosynthetic activity

1930
01:13:52,790 --> 01:13:50,239
thickness in exoplanetary systems

1931
01:13:54,790 --> 01:13:52,800
this uh this works an attempt to know

1932
01:13:58,229 --> 01:13:54,800
how the origin of photosynthesis could

1933
01:14:00,390 --> 01:13:58,239
be on our planet and by extrapolation

1934
01:14:02,950 --> 01:14:00,400
if it could be possible that this kind

1935
01:14:03,750 --> 01:14:02,960
of photosystems like the ones that we

1936
01:14:06,310 --> 01:14:03,760
have

1937
01:14:07,350 --> 01:14:06,320
planeted would work in other solar

1938
01:14:10,709 --> 01:14:07,360

systems

1939
01:14:12,630 --> 01:14:10,719
uh in the disaster we would present

1940
01:14:14,630 --> 01:14:12,640
not only the evolution of the

1941
01:14:16,790 --> 01:14:14,640
first probably

1942
01:14:18,550 --> 01:14:16,800
for the pigments on earth if not the

1943
01:14:20,310 --> 01:14:18,560
real fitness of the

1944
01:14:22,790 --> 01:14:20,320
this

1945
01:14:24,870 --> 01:14:22,800
theoretical for the bigness for the

1946
01:14:26,870 --> 01:14:24,880
pigments and at the same time the

1947
01:14:28,870 --> 01:14:26,880
regular ones that we have colored right

1948
01:14:31,669 --> 01:14:28,880
now since the very beginning of the

1949
01:14:34,070 --> 01:14:31,679
human being the different cultures

1950
01:14:35,830 --> 01:14:34,080
cannot serve the sky and many questions

1951
01:14:37,830 --> 01:14:35,840
have been asked

1952
01:14:40,870 --> 01:14:37,840
are we alone in the universe are there

1953
01:14:43,430 --> 01:14:40,880
other girls with possibilities of life

1954
01:14:45,110 --> 01:14:43,440
philosophers artists scientists have

1955
01:14:47,830 --> 01:14:45,120
have contributed from their point of

1956
01:14:50,790 --> 01:14:47,840
view to the advantage the advancement of

1957
01:14:53,189 --> 01:14:50,800
this knowledge and of course the the the

1958
01:14:55,830 --> 01:14:53,199
question about how could they resemble

1959
01:14:57,669 --> 01:14:55,840
other planetary bodies in the case of

1960
01:14:59,590 --> 01:14:57,679
any kind of photosynthetic processing

1961
01:15:00,709 --> 01:14:59,600
this would take place

1962
01:15:04,149 --> 01:15:00,719
take place

1963
01:15:06,229 --> 01:15:04,159

with uh with the technology uh sorry

1964
01:15:08,229 --> 01:15:06,239
with the with the technology that we

1965
01:15:10,709 --> 01:15:08,239
have nowadays the drop of water of

1966
01:15:13,030 --> 01:15:10,719
knowledge in the measurable oxygen of

1967
01:15:15,510 --> 01:15:13,040
ignorance could be a little bigger

1968
01:15:17,510 --> 01:15:15,520
bringing light to the great darkness

1969
01:15:20,070 --> 01:15:17,520
that has surrounded these issues in the

1970
01:15:23,110 --> 01:15:20,080
past 50 years ago

1971
01:15:26,390 --> 01:15:23,120
the bodyguard is slight so the projected

1972
01:15:29,030 --> 01:15:26,400
prop took a picture of earth that carl

1973
01:15:30,630 --> 01:15:29,040
sagan called the pale blue dot

1974
01:15:32,870 --> 01:15:30,640
if this probe had carried that

1975
01:15:35,910 --> 01:15:32,880
spectrometer on board it would have

1976
01:15:39,110 --> 01:15:35,920
identified a discontinuity between red

1977
01:15:40,870 --> 01:15:39,120
and infrared it is what we know as the

1978
01:15:44,870 --> 01:15:40,880
age in red

1979
01:15:47,510 --> 01:15:44,880
and it's due to the vegetation on earth

1980
01:15:50,149 --> 01:15:47,520
responsible responsibly if is a

1981
01:15:52,709 --> 01:15:50,159
photosynthesis the process by which

1982
01:15:55,750 --> 01:15:52,719
plants obtain energy and nutrients from

1983
01:15:58,310 --> 01:15:55,760
co2 in the atmosphere by water and

1984
01:16:00,310 --> 01:15:58,320
sunlight photosynthetic pigments such as

1985
01:16:02,709 --> 01:16:00,320
chlorophylls and bacteria chlorophylls

1986
01:16:05,830 --> 01:16:02,719
which are the basic devices of this

1987
01:16:08,390 --> 01:16:05,840
process assort blue and red wavelength

1988
01:16:11,030 --> 01:16:08,400

which is what makes vegetation green

1989
01:16:12,870 --> 01:16:11,040
the range of the spectrum that we

1990
01:16:15,110 --> 01:16:12,880
identify in green is the part of the

1991
01:16:17,270 --> 01:16:15,120
radiation that plants reflect because

1992
01:16:18,390 --> 01:16:17,280
it's not used in the photosynthetic

1993
01:16:19,590 --> 01:16:18,400
processes

1994
01:16:23,830 --> 01:16:19,600
so

1995
01:16:25,510 --> 01:16:23,840
uh we asked ourselves again the question

1996
01:16:28,149 --> 01:16:25,520
that our ancestors already asked

1997
01:16:30,070 --> 01:16:28,159
themselves would photosynthesis be

1998
01:16:32,630 --> 01:16:30,080
possible on other planets what kind of

1999
01:16:34,630 --> 01:16:32,640
atmosphere would be necessary and what

2000
01:16:36,310 --> 01:16:34,640
distance between the planet in question

2001
01:16:39,030 --> 01:16:36,320
and the corresponding star would there

2002
01:16:41,750 --> 01:16:39,040
be and not only that god color for

2003
01:16:44,229 --> 01:16:41,760
example has a very simple question what

2004
01:16:45,510 --> 01:16:44,239
color could have the plants in another

2005
01:16:47,189 --> 01:16:45,520
planet

2006
01:16:49,430 --> 01:16:47,199
to others

2007
01:16:52,550 --> 01:16:49,440
uh this issue we have created a group of

2008
01:16:54,229 --> 01:16:52,560
scientists at the astrobiology center

2009
01:16:56,550 --> 01:16:54,239
in madrid made of

2010
01:16:59,030 --> 01:16:56,560
of chemicals astrophysics

2011
01:17:01,669 --> 01:16:59,040
biologists

2012
01:17:03,590 --> 01:17:01,679
electronic technicians belonging to the

2013
01:17:04,950 --> 01:17:03,600

different departments

2014
01:17:08,709 --> 01:17:04,960
astrophysics

2015
01:17:09,590 --> 01:17:08,719
planetology and habitability at that cup

2016
01:17:11,669 --> 01:17:09,600
but

2017
01:17:13,510 --> 01:17:11,679
this work is limited to certain types of

2018
01:17:16,630 --> 01:17:13,520
spark of stars

2019
01:17:18,390 --> 01:17:16,640
atmospheres and photosystems that is we

2020
01:17:20,470 --> 01:17:18,400
limit the three main parameters

2021
01:17:22,470 --> 01:17:20,480
considering them under the darwinian

2022
01:17:24,790 --> 01:17:22,480
principle of evolution

2023
01:17:28,070 --> 01:17:24,800
and that determined that possibility

2024
01:17:29,990 --> 01:17:28,080
only those photosystems whose spectra

2025
01:17:32,149 --> 01:17:30,000
overlap the radiation spectrum of the

2026
01:17:34,070 --> 01:17:32,159
corresponding star will survive taking

2027
01:17:36,390 --> 01:17:34,080
into account the filter that the

2028
01:17:38,709 --> 01:17:36,400
corresponding atmosphere is supposed to

2029
01:17:40,790 --> 01:17:38,719
allow only that spectrum trends that

2030
01:17:44,229 --> 01:17:40,800
will be photosynthetically active to

2031
01:17:46,149 --> 01:17:44,239
reach the surface of the planet

2032
01:17:47,669 --> 01:17:46,159
but in this study we are going to go a

2033
01:17:50,229 --> 01:17:47,679
little further

2034
01:17:53,110 --> 01:17:50,239
and we are not only going to consider

2035
01:17:54,950 --> 01:17:53,120
the photo pigments currently functioning

2036
01:17:56,709 --> 01:17:54,960
in nature such as chlorophylls and

2037
01:17:58,590 --> 01:17:56,719
bacteriochlorophylls

2038
01:18:00,950 --> 01:17:58,600

but we are also going to use

2039
01:18:03,830 --> 01:18:00,960
computational chemistry software to

2040
01:18:05,669 --> 01:18:03,840
design theoretical pigments that could

2041
01:18:06,550 --> 01:18:05,679
have been the origin of the current

2042
01:18:09,189 --> 01:18:06,560
words

2043
01:18:11,510 --> 01:18:09,199
now to do this we will follow the

2044
01:18:14,709 --> 01:18:11,520
principles of simplicity and

2045
01:18:17,510 --> 01:18:14,719
dynamic advantage that allow us to guess

2046
01:18:19,830 --> 01:18:17,520
which could be those first pigments that

2047
01:18:22,149 --> 01:18:19,840
after evolving gave rise to those

2048
01:18:25,830 --> 01:18:22,159
currently used in

2049
01:18:27,270 --> 01:18:25,840
by photosynthetic organisms

2050
01:18:29,750 --> 01:18:27,280
why do

2051
01:18:30,790 --> 01:18:29,760
we not consider photosynthetic organisms

2052
01:18:34,070 --> 01:18:30,800
as such

2053
01:18:36,790 --> 01:18:34,080
mainly due to the complexity of of the

2054
01:18:38,390 --> 01:18:36,800
photosynthetic systems if it would

2055
01:18:40,790 --> 01:18:38,400
already be difficult to reduce the

2056
01:18:42,709 --> 01:18:40,800
origin and thermodynamic evolution of

2057
01:18:45,910 --> 01:18:42,719
this protein complexes associated with

2058
01:18:47,189 --> 01:18:45,920
pigments on planet earth you can imagine

2059
01:18:49,910 --> 01:18:47,199
applying

2060
01:18:52,149 --> 01:18:49,920
these ferrites to exoplanets and at the

2061
01:18:54,790 --> 01:18:52,159
same time are those pigments which are

2062
01:18:56,790 --> 01:18:54,800
finally absorbing the light radiation to

2063
01:18:58,550 --> 01:18:56,800

rub photosynthesis this is the reason

2064
01:19:00,790 --> 01:18:58,560
why we

2065
01:19:04,630 --> 01:19:00,800
consider only the photo pigments

2066
01:19:06,709 --> 01:19:04,640
included in the photosynthesis processes

2067
01:19:09,110 --> 01:19:06,719
on the other hand we have the second

2068
01:19:11,189 --> 01:19:09,120
parameter the atmosphere factor there

2069
01:19:14,630 --> 01:19:11,199
are different types of atmospheres from

2070
01:19:18,070 --> 01:19:14,640
oxidizing to highly reducing atmospheres

2071
01:19:21,030 --> 01:19:18,080
these atmospheres function as filters of

2072
01:19:23,030 --> 01:19:21,040
solar radiation

2073
01:19:24,870 --> 01:19:23,040
allowing only a fraction of the total

2074
01:19:27,110 --> 01:19:24,880
relative of the star to reach the

2075
01:19:29,350 --> 01:19:27,120
surface of the planet in question we

2076
01:19:32,229 --> 01:19:29,360
have calculated the transmittance using

2077
01:19:34,950 --> 01:19:32,239
the free nasa planetary spectrum

2078
01:19:37,590 --> 01:19:34,960
generator software software

2079
01:19:40,470 --> 01:19:37,600
finally we have uh

2080
01:19:42,790 --> 01:19:40,480
to have in mind to consider only rocky

2081
01:19:44,870 --> 01:19:42,800
planets located in the habitable zone of

2082
01:19:48,229 --> 01:19:44,880
stars between

2083
01:19:50,630 --> 01:19:48,239
types a and l that will be neither very

2084
01:19:52,950 --> 01:19:50,640
cold nor very hot and we have calculated

2085
01:19:58,229 --> 01:19:52,960
their spectrum in the habitable zone

2086
01:20:02,830 --> 01:20:00,390
we have crossed all these parameters

2087
01:20:05,510 --> 01:20:02,840
taking into account those pigments whose

2088
01:20:07,830 --> 01:20:05,520

spectra overlap the stellar radiation

2089
01:20:10,229 --> 01:20:07,840
that reaches the surface of the planet

2090
01:20:12,870 --> 01:20:10,239
and we have quantified this overlap with

2091
01:20:15,270 --> 01:20:12,880
a metric that we have called a spectral

2092
01:20:17,350 --> 01:20:15,280
attrition rate

2093
01:20:20,070 --> 01:20:17,360
and that quantifies the number of

2094
01:20:22,629 --> 01:20:20,080
absorbed photons per molecule and that

2095
01:20:24,229 --> 01:20:22,639
yields an amount of energy and this is

2096
01:20:27,990 --> 01:20:24,239
the three parameters that can be

2097
01:20:30,550 --> 01:20:28,000
possible to see in the slide right now

2098
01:20:33,270 --> 01:20:30,560
but let's see how it works with an

2099
01:20:34,629 --> 01:20:33,280
example if we combine the emission

2100
01:20:36,229 --> 01:20:34,639
spectrum

2101
01:20:36,950 --> 01:20:36,239
of the sun

2102
01:20:39,030 --> 01:20:36,960
top

2103
01:20:41,270 --> 01:20:39,040
left of the image

2104
01:20:42,470 --> 01:20:41,280
with the transmittance of the earth's

2105
01:20:43,990 --> 01:20:42,480
atmosphere

2106
01:20:48,149 --> 01:20:44,000
and the attraction spectrum of

2107
01:20:50,470 --> 01:20:48,159
chlorophyll a on the right we obtain it

2108
01:20:51,750 --> 01:20:50,480
it's a spectrum at social rate from

2109
01:20:56,470 --> 01:20:51,760
which

2110
01:21:01,270 --> 01:20:58,470
but

2111
01:21:03,750 --> 01:21:01,280
what makes us different from other

2112
01:21:06,470 --> 01:21:03,760
previous studies in our case we will

2113
01:21:09,189 --> 01:21:06,480

follow an incremental and iterative life

2114
01:21:12,790 --> 01:21:09,199
cycle in which we will add more and more

2115
01:21:15,350 --> 01:21:12,800
type of stars binary systems

2116
01:21:18,149 --> 01:21:15,360
types of atmospheres and photosynthetic

2117
01:21:20,629 --> 01:21:18,159
pigments in the long term we will use

2118
01:21:24,310 --> 01:21:20,639
different convections using big data

2119
01:21:26,790 --> 01:21:24,320
platforms and we will also

2120
01:21:28,870 --> 01:21:26,800
develop

2121
01:21:30,790 --> 01:21:28,880
the earth have

2122
01:21:33,430 --> 01:21:30,800
technical capabilities that allow us to

2123
01:21:36,149 --> 01:21:33,440
iterate this result to design the

2124
01:21:38,390 --> 01:21:36,159
corresponding search of exoplanets in

2125
01:21:41,510 --> 01:21:38,400
the near future missions to detect this

2126
01:21:44,390 --> 01:21:41,520
type of systems all based on our own

2127
01:21:45,830 --> 01:21:44,400
calculations

2128
01:21:48,070 --> 01:21:45,840
but we won't

2129
01:21:49,110 --> 01:21:48,080
have to wait that long we already have

2130
01:21:51,350 --> 01:21:49,120
results

2131
01:21:53,510 --> 01:21:51,360
we have proposed a possible road of

2132
01:21:55,510 --> 01:21:53,520
chemical and thermodynamically favorable

2133
01:21:56,709 --> 01:21:55,520
molecular revolution towards the

2134
01:21:59,270 --> 01:21:56,719
appearance

2135
01:22:02,070 --> 01:21:59,280
of more complex pigments and evolve it

2136
01:22:03,110 --> 01:22:02,080
through cycle adding reactions

2137
01:22:05,030 --> 01:22:03,120
whose

2138
01:22:07,590 --> 01:22:05,040

intermediate strength function as

2139
01:22:10,310 --> 01:22:07,600
pigments at at least

2140
01:22:13,270 --> 01:22:10,320
of a physical point of view in the slide

2141
01:22:15,990 --> 01:22:13,280
you already have right now these uh

2142
01:22:19,189 --> 01:22:16,000
adding life cycles and the

2143
01:22:22,149 --> 01:22:19,199
thermodynamic thermodynamically

2144
01:22:25,189 --> 01:22:22,159
favorable reactions in which from the

2145
01:22:27,590 --> 01:22:25,199
very top left in which the the the

2146
01:22:29,430 --> 01:22:27,600
precursors we think in the atmosphere in

2147
01:22:32,229 --> 01:22:29,440
water cycle

2148
01:22:35,590 --> 01:22:32,239
can uh finally rendered

2149
01:22:39,910 --> 01:22:35,600
a molecule of thought zero photo is the

2150
01:22:40,709 --> 01:22:39,920
previous uh origin of what we thought is

2151
01:22:47,510 --> 01:22:40,719
the

2152
01:22:49,669 --> 01:22:47,520
earth

2153
01:22:52,470 --> 01:22:49,679
it has been simulated

2154
01:22:55,030 --> 01:22:52,480
what happens to the photosynthetic

2155
01:22:57,990 --> 01:22:55,040
capacity of different photo pigments if

2156
01:22:59,910 --> 01:22:58,000
we take our earth as the beginning using

2157
01:23:02,149 --> 01:22:59,920
different temperatures

2158
01:23:05,590 --> 01:23:02,159
but always place at a distance from the

2159
01:23:08,709 --> 01:23:05,600
start our sun in which liquid water of

2160
01:23:11,430 --> 01:23:08,719
the surface of the earth is possible

2161
01:23:14,950 --> 01:23:11,440
a planet and we have found interesting

2162
01:23:18,790 --> 01:23:16,629
now you can see for example the

2163
01:23:21,350 --> 01:23:18,800

photosynthetic capacity

2164
01:23:23,350 --> 01:23:21,360
in stars between types a and g would be

2165
01:23:25,669 --> 01:23:23,360
similar if the atmosphere of the planet

2166
01:23:29,669 --> 01:23:25,679
absorbs an excess of uv radiation from

2167
01:23:31,590 --> 01:23:29,679
type a stars or that for example

2168
01:23:32,870 --> 01:23:31,600
just on the on the

2169
01:23:35,270 --> 01:23:32,880
right

2170
01:23:37,830 --> 01:23:35,280
bacteriochlorophyll b is capable of

2171
01:23:41,189 --> 01:23:37,840
developing its function in a planetary

2172
01:23:44,470 --> 01:23:41,199
system in within the environment of an

2173
01:23:49,910 --> 01:23:47,590
exophore has clear idea and development

2174
01:23:51,830 --> 01:23:49,920
behind it perhaps it's a romantic idea

2175
01:23:54,709 --> 01:23:51,840
that is taking us to the extent of the

2176
01:23:57,830 --> 01:23:54,719
scientific spirit because who of some of

2177
01:24:00,310 --> 01:23:57,840
us present here now has not imagined

2178
01:24:02,709 --> 01:24:00,320
what other worlds could be like it is an

2179
01:24:05,990 --> 01:24:02,719
ambitious but realistic project situated

2180
01:24:09,270 --> 01:24:06,000
in that could be a new era of astrology

2181
01:24:13,350 --> 01:24:11,350
of the exo-fort project we want to go

2182
01:24:15,430 --> 01:24:13,360
far we want to participate in this new

2183
01:24:17,830 --> 01:24:15,440
era of explanatory

2184
01:24:21,110 --> 01:24:17,840
research and establish a new line of

2185
01:24:24,149 --> 01:24:21,120
research that allow us to know the real

2186
01:24:27,110 --> 01:24:24,159
possibilities of systems that could host

2187
01:24:29,430 --> 01:24:27,120
some form of metabolism based on use of

2188
01:24:31,110 --> 01:24:29,440

the radiation coming from the star but

2189
01:24:33,910 --> 01:24:31,120
this work has stylized about this

2190
01:24:37,350 --> 01:24:33,920
disciplinary team that allow us to have

2191
01:24:39,110 --> 01:24:37,360
unnecessary research for it

2192
01:24:41,270 --> 01:24:39,120
that's all thank you and of course

2193
01:24:53,990 --> 01:24:41,280
collaborations are welcome if anybody is

2194
01:24:54,000 --> 01:25:08,709
any questions for felipe

2195
01:25:14,870 --> 01:25:12,070
philly very eric mamajek jpl um what did

2196
01:25:16,310 --> 01:25:14,880
you assume for the

2197
01:25:17,910 --> 01:25:16,320
absorption

2198
01:25:19,189 --> 01:25:17,920
by the planetary

2199
01:25:21,030 --> 01:25:19,199
atmosphere

2200
01:25:22,390 --> 01:25:21,040
you should the stellar scds you should

2201
01:25:23,590 --> 01:25:22,400
the chlorophyll

2202
01:25:25,510 --> 01:25:23,600
absorption

2203
01:25:27,910 --> 01:25:25,520
but they must be incredibly different

2204
01:25:29,430 --> 01:25:27,920
photochemistries and

2205
01:25:30,470 --> 01:25:29,440
there could be a bewildering array of

2206
01:25:32,229 --> 01:25:30,480
different

2207
01:25:36,229 --> 01:25:32,239
planetary atmosphere compositions so

2208
01:25:40,470 --> 01:25:38,070
okay thank you for your question i

2209
01:25:42,709 --> 01:25:40,480
assume for the for absorption the

2210
01:25:44,870 --> 01:25:42,719
filtering process of the atmosphere this

2211
01:25:46,709 --> 01:25:44,880
means if an atmosphere with different

2212
01:25:47,990 --> 01:25:46,719
chemistries of course and we have to

2213
01:25:49,910 --> 01:25:48,000

take into account the different

2214
01:25:52,070 --> 01:25:49,920
chemistry that could be run in these

2215
01:25:54,470 --> 01:25:52,080
conditions

2216
01:25:56,470 --> 01:25:54,480
the atmosphere filter the the the for

2217
01:26:00,470 --> 01:25:56,480
example in our case on earth the sun

2218
01:26:02,390 --> 01:26:00,480
radiation this means that only a very uh

2219
01:26:04,470 --> 01:26:02,400
a small part of the radiation of the

2220
01:26:05,669 --> 01:26:04,480
total atmosphere reach the surface of

2221
01:26:08,629 --> 01:26:05,679
the planet

2222
01:26:11,430 --> 01:26:08,639
this is what we consider to filter to to

2223
01:26:14,070 --> 01:26:11,440
to to reach the surface of course at the

2224
01:26:16,310 --> 01:26:14,080
second step we consider as well any kind

2225
01:26:21,430 --> 01:26:16,320
of possible reaction that would could

2226
01:26:21,440 --> 01:26:25,990
any other questions

2227
01:26:29,030 --> 01:26:28,310
all right let's speak felipe and all of

2228
01:26:31,270 --> 01:26:29,040
our

2229
01:26:35,430 --> 01:26:31,280
speakers again

2230
01:26:38,709 --> 01:26:36,390
that you

2231
01:26:41,510 --> 01:26:38,719
our session for this morning we will

2232
01:26:43,510 --> 01:26:41,520
reconvene after lunch but we will not be

2233
01:26:46,550 --> 01:26:43,520
in this room we will be upstairs on the

2234
01:26:48,870 --> 01:26:46,560
third floor and then we have uh posters