

NEXSS & NFOLD

STANDARDS OF EVIDENCE FOR LIFE
DETECTION COMMUNITY WORKSHOP

DR. VICTORIA MEADOWS
PHOSPHINE ON VENUS: AN OVERVIEW



1
00:00:03,909 --> 00:00:02,629
hi everyone i'm vicki meadows i'm a

2
00:00:05,670 --> 00:00:03,919
professor of astronomy

3
00:00:07,269 --> 00:00:05,680
at the university of washington and the

4
00:00:08,470 --> 00:00:07,279
director of the astrobiology program

5
00:00:10,070 --> 00:00:08,480
there

6
00:00:11,910 --> 00:00:10,080
um and in this presentation i'm going to

7
00:00:13,430 --> 00:00:11,920
provide an overview of the claimed

8
00:00:15,270 --> 00:00:13,440
discovery of phosphine

9
00:00:16,630 --> 00:00:15,280
a potential biosignature in the venus

10
00:00:17,830 --> 00:00:16,640
atmosphere

11
00:00:19,590 --> 00:00:17,840
and also look at the subsequent

12
00:00:21,269 --> 00:00:19,600
community response to attempt to

13
00:00:22,950 --> 00:00:21,279

validate and increase our confidence in

14

00:00:26,710 --> 00:00:22,960

this discovery

15

00:00:28,950 --> 00:00:26,720

september 2020 and so it's fairly recent

16

00:00:30,950 --> 00:00:28,960

but it's provided a great example of how

17

00:00:32,950 --> 00:00:30,960

we as a community respond to a bicycle

18

00:00:34,709 --> 00:00:32,960

detection claim

19

00:00:36,790 --> 00:00:34,719

it's also an interesting test case for

20

00:00:39,590 --> 00:00:36,800

exoplanet biasing detection

21

00:00:41,430 --> 00:00:39,600

which will also necessarily be done via

22

00:00:43,190 --> 00:00:41,440

spectroscopy

23

00:00:44,229 --> 00:00:43,200

and whether or not you are convinced

24

00:00:45,750 --> 00:00:44,239

that there is phosphine in the

25

00:00:46,709 --> 00:00:45,760

atmosphere of venus and that is a sign

26

00:00:48,389 --> 00:00:46,719

of life

27

00:00:50,389 --> 00:00:48,399

the process of trying to verify the

28

00:00:51,670 --> 00:00:50,399

phosphene detection and interpretation

29

00:00:54,150 --> 00:00:51,680

is an important one

30

00:00:55,670 --> 00:00:54,160

that can help us think more deeply about

31

00:00:59,990 --> 00:00:55,680

how we might develop standards of

32

00:01:03,510 --> 00:01:01,910

so the phosphate and venus story starts

33

00:01:07,350 --> 00:01:03,520

with this paper

34

00:01:10,149 --> 00:01:07,360

led by jane grieves and team which

35

00:01:12,630 --> 00:01:10,159

showed detection of a line in the

36

00:01:14,550 --> 00:01:12,640

millimeter wave attributed to phosphine

37

00:01:15,670 --> 00:01:14,560

taken from both the james maxwell

38

00:01:17,590 --> 00:01:15,680

telescope and

39

00:01:20,630 --> 00:01:17,600

the atacama large millimeter array

40

00:01:22,710 --> 00:01:20,640

telescope on two separate occasions

41

00:01:25,270 --> 00:01:22,720

um in the paper not only the discovery

42

00:01:28,390 --> 00:01:25,280

of line is shown but also an exhaustive

43

00:01:30,069 --> 00:01:28,400

study of different ways that the

44

00:01:31,429 --> 00:01:30,079

phosphine might potentially be

45

00:01:33,749 --> 00:01:31,439

abiotically produced

46

00:01:34,950 --> 00:01:33,759

in the venus's atmosphere cloud surface

47

00:01:37,109 --> 00:01:34,960

subsurface

48

00:01:37,990 --> 00:01:37,119

or from lightning volcanic or immediate

49

00:01:40,630 --> 00:01:38,000

delivery

50

00:01:41,510 --> 00:01:40,640

is undertaken um and the conclusion is

51
00:01:43,030 --> 00:01:41,520
that there is no

52
00:01:45,590 --> 00:01:43,040
obvious way that phosphine could be

53
00:01:47,350 --> 00:01:45,600
produced via these processes

54
00:01:49,270 --> 00:01:47,360
so phosphine is believed then to

55
00:01:50,389 --> 00:01:49,280
originate from unknown photochemistry or

56
00:01:52,310 --> 00:01:50,399
geochemistry

57
00:01:53,670 --> 00:01:52,320
or by analogy with biological production

58
00:01:58,630 --> 00:01:53,680
of phosphine of earth

59
00:02:02,789 --> 00:02:01,590
so these are the discovery data the jcmt

60
00:02:04,950 --> 00:02:02,799
data is shown here

61
00:02:07,429 --> 00:02:04,960
in the second panel with the fit that

62
00:02:10,150 --> 00:02:07,439
shows 20 parts per billion of phosphine

63
00:02:11,830 --> 00:02:10,160

retrieved over here the armor narrow

64

00:02:12,550 --> 00:02:11,840

band shows an even more significant

65

00:02:19,510 --> 00:02:12,560

detection

66

00:02:21,510 --> 00:02:19,520

frequency note that the armor data were

67

00:02:22,949 --> 00:02:21,520

not used for abundance determinations

68

00:02:24,869 --> 00:02:22,959

because they were taken with an

69

00:02:26,790 --> 00:02:24,879

interferometric telescope the armor is

70

00:02:28,630 --> 00:02:26,800

an interferometric array

71

00:02:30,470 --> 00:02:28,640

um and that suffers from something

72

00:02:32,390 --> 00:02:30,480

called line dilution which makes the

73

00:02:34,070 --> 00:02:32,400

array actually less sensitive to things

74

00:02:35,270 --> 00:02:34,080

that are evenly spatially distributed

75

00:02:37,990 --> 00:02:35,280

across the disk

76
00:02:38,949 --> 00:02:38,000
and so the jcmt being a single dish uh

77
00:02:42,390 --> 00:02:38,959
was the

78
00:02:43,830 --> 00:02:42,400
observation um used to measure the

79
00:02:45,350 --> 00:02:43,840
actual abundance in this

80
00:02:47,350 --> 00:02:45,360
case here 20 parts per billion of

81
00:02:49,030 --> 00:02:47,360
phosphine and radiative and

82
00:02:49,990 --> 00:02:49,040
photochemical calculations suggested

83
00:02:51,830 --> 00:02:50,000
that this absorption

84
00:02:54,309 --> 00:02:51,840
actually came from within the clouds of

85
00:02:59,830 --> 00:02:56,790
but there is a complication because even

86
00:03:00,710 --> 00:02:59,840
though phosphine does absorb at 266.94

87
00:03:03,910 --> 00:03:00,720
gigahertz

88
00:03:06,070 --> 00:03:03,920

so does sulfur dioxide and so at the

89

00:03:07,270 --> 00:03:06,080

position at which the line was observed

90

00:03:09,509 --> 00:03:07,280

there was the potential for

91

00:03:11,110 --> 00:03:09,519

contamination from sulfur dioxide which

92

00:03:13,830 --> 00:03:11,120

is the third most common gas

93

00:03:16,229 --> 00:03:13,840

in the greenhouse in the in the venous

94

00:03:18,470 --> 00:03:16,239

atmosphere

95

00:03:19,589 --> 00:03:18,480

so the observers um knowing this set up

96

00:03:21,589 --> 00:03:19,599

a contamination

97

00:03:24,229 --> 00:03:21,599

test where they observed a sulfur

98

00:03:25,190 --> 00:03:24,239

dioxide reference line at 267.54

99

00:03:28,390 --> 00:03:25,200

gigahertz

100

00:03:28,949 --> 00:03:28,400

which is a clean so2 line um at that

101
00:03:31,430 --> 00:03:28,959
position

102
00:03:33,430 --> 00:03:31,440
they observed no sign of absorption so

103
00:03:34,869 --> 00:03:33,440
they failed to detect so2 at the

104
00:03:36,630 --> 00:03:34,879
reference position

105
00:03:39,509 --> 00:03:36,640
they then used that to set an upper

106
00:03:42,309 --> 00:03:39,519
limit on how much so2 could be there

107
00:03:44,070 --> 00:03:42,319
they then modeled the amount of so2 in

108
00:03:45,670 --> 00:03:44,080
that upper limit in this case 10 parts

109
00:03:48,949 --> 00:03:45,680
per billion of so2

110
00:03:50,550 --> 00:03:48,959
at the discovery wavelength and show

111
00:03:52,390 --> 00:03:50,560
that the so2 component

112
00:03:53,990 --> 00:03:52,400
would be extremely small and that the

113
00:03:56,229 --> 00:03:54,000

remainder of the absorption

114

00:04:00,550 --> 00:03:56,239

at the discovery wavelength would be due

115

00:04:02,550 --> 00:04:00,560

in fact to phosphine so obviously this

116

00:04:03,990 --> 00:04:02,560

was an extremely exciting discovery

117

00:04:05,750 --> 00:04:04,000

which caused a lot of interest

118

00:04:08,470 --> 00:04:05,760

especially in the community

119

00:04:09,030 --> 00:04:08,480

um about the potential for life on venus

120

00:04:10,869 --> 00:04:09,040

um

121

00:04:15,350 --> 00:04:10,879

and you know whether or not alien life

122

00:04:16,949 --> 00:04:15,360

was there

123

00:04:18,710 --> 00:04:16,959

so given the importance of this

124

00:04:19,189 --> 00:04:18,720

discovery and the obvious public

125

00:04:21,189 --> 00:04:19,199

interest

126

00:04:23,670 --> 00:04:21,199

um in this question um the scientific

127

00:04:25,590 --> 00:04:23,680

community responded to this discovery

128

00:04:27,030 --> 00:04:25,600

by seeking answer to the following five

129

00:04:28,790 --> 00:04:27,040

questions

130

00:04:31,590 --> 00:04:28,800

first of all can the detection of a

131

00:04:33,350 --> 00:04:31,600

feature at 266.94 gigahertz be

132

00:04:35,430 --> 00:04:33,360

verified by others not just by the

133

00:04:37,110 --> 00:04:35,440

discovery team

134

00:04:38,629 --> 00:04:37,120

are there other features indicative of

135

00:04:40,629 --> 00:04:38,639

phosphine elsewhere in the venus

136

00:04:43,670 --> 00:04:40,639

spectrum because the gold standard

137

00:04:46,710 --> 00:04:43,680

for the detection of a molecule

138

00:04:48,230 --> 00:04:46,720

is not just um being able to observe

139

00:04:49,590 --> 00:04:48,240

with multiple instruments in a different

140

00:04:51,189 --> 00:04:49,600

epochs which was done

141

00:04:52,950 --> 00:04:51,199

but also being able to show that

142

00:04:55,270 --> 00:04:52,960

multiple lines or bands of the same

143

00:04:56,870 --> 00:04:55,280

molecule are present in the spectrum

144

00:04:58,070 --> 00:04:56,880

or was there evidence of phosphine in

145

00:04:59,590 --> 00:04:58,080

other measurements of the venous

146

00:05:01,270 --> 00:04:59,600

atmosphere

147

00:05:03,510 --> 00:05:01,280

is the feature due to phosphine or some

148

00:05:04,870 --> 00:05:03,520

other explanation more likely

149

00:05:06,550 --> 00:05:04,880

are there ways that phosphine could be

150

00:05:07,749 --> 00:05:06,560

made abiotically in the venous

151
00:05:09,430 --> 00:05:07,759
atmosphere

152
00:05:11,189 --> 00:05:09,440
and is it likely that life exists in

153
00:05:12,950 --> 00:05:11,199
this environment and in fact produces

154
00:05:14,830 --> 00:05:12,960
phosphine

155
00:05:18,629 --> 00:05:14,840
so kind of detection of a feature at

156
00:05:20,469 --> 00:05:18,639
266.94 gigahertz be verified by others

157
00:05:22,070 --> 00:05:20,479
so the great thing about this discovery

158
00:05:23,990 --> 00:05:22,080
was that the armored data were released

159
00:05:25,670 --> 00:05:24,000
right on publication of the paper

160
00:05:28,710 --> 00:05:25,680
which allowed several other teams to

161
00:05:30,310 --> 00:05:28,720
very rapidly check the data

162
00:05:32,710 --> 00:05:30,320
so the first team that published on this

163
00:05:35,350 --> 00:05:32,720

was led by ignac snellen

164

00:05:37,029 --> 00:05:35,360

and their conclusion was that the 266.94

165

00:05:39,990 --> 00:05:37,039

gigahertz on the line was in fact

166

00:05:42,150 --> 00:05:40,000

not detected and their argument was that

167

00:05:44,550 --> 00:05:42,160

in fact a 12th order polynomial that was

168

00:05:45,909 --> 00:05:44,560

used to fit the rather ripply continuum

169

00:05:49,350 --> 00:05:45,919

of the data

170

00:05:51,749 --> 00:05:49,360

had in fact given invalid prominence to

171

00:05:53,670 --> 00:05:51,759

essentially a noise feature making it

172

00:05:56,870 --> 00:05:53,680

appear as if it was an absorption

173

00:05:58,950 --> 00:05:56,880

um an absorption line

174

00:06:00,950 --> 00:05:58,960

so using the twelfth order polynomial

175

00:06:02,309 --> 00:06:00,960

they were able to reproduce the results

176

00:06:03,830 --> 00:06:02,319

that greaves it all got but when they

177

00:06:07,110 --> 00:06:03,840

used a more modest third i'll

178

00:06:10,309 --> 00:06:07,120

order polynomial to fit the data the

179

00:06:11,749 --> 00:06:10,319

detection at the phosphine uh frequency

180

00:06:15,909 --> 00:06:11,759

not only dropped to only

181

00:06:17,670 --> 00:06:15,919

two sigma but also other lines um

182

00:06:21,350 --> 00:06:17,680

uh yeah it was not and that was not

183

00:06:22,950 --> 00:06:21,360

considered statistically significant

184

00:06:24,469 --> 00:06:22,960

in another paper following on from that

185

00:06:27,350 --> 00:06:24,479

but the inaudible

186

00:06:30,150 --> 00:06:27,360

um they claimed also that they could not

187

00:06:32,230 --> 00:06:30,160

reproduce the detection of the 266.94

188

00:06:34,070 --> 00:06:32,240

gigahertz on the line

189

00:06:37,029 --> 00:06:34,080

and again this is because the polynomial

190

00:06:39,189 --> 00:06:37,039

fit may have artificially produced

191

00:06:43,590 --> 00:06:39,199

essentially an absorption band um at

192

00:06:47,270 --> 00:06:46,550

so while this was going on um the armor

193

00:06:48,790 --> 00:06:47,280

team

194

00:06:50,469 --> 00:06:48,800

at the telescope discovered that the

195

00:06:52,469 --> 00:06:50,479

data had in fact not been

196

00:06:53,990 --> 00:06:52,479

calibrated as well as it could have been

197

00:06:57,189 --> 00:06:54,000

and so they re

198

00:07:00,230 --> 00:06:57,199

released the data with a new calibration

199

00:07:02,710 --> 00:07:00,240

so grieves it al on re-analyzing the

200

00:07:04,790 --> 00:07:02,720

updated calibration for the data um

201
00:07:06,629 --> 00:07:04,800
showed that in fact indeed the phosphine

202
00:07:08,309 --> 00:07:06,639
was not detected at the significance

203
00:07:08,790 --> 00:07:08,319
that was seen in the original discovery

204
00:07:11,270 --> 00:07:08,800
data

205
00:07:11,990 --> 00:07:11,280
with the with the incorrect calibration

206
00:07:13,990 --> 00:07:12,000
um but they

207
00:07:16,390 --> 00:07:14,000
they claimed that phosphine was still in

208
00:07:18,710 --> 00:07:16,400
fact seen at the the frequency

209
00:07:20,309 --> 00:07:18,720
um that was expected but that now

210
00:07:21,909 --> 00:07:20,319
instead of 20 parts per billion it was

211
00:07:24,070 --> 00:07:21,919
much more likely to be

212
00:07:25,589 --> 00:07:24,080
at least one part per billion of

213
00:07:27,670 --> 00:07:25,599

phosphine

214

00:07:29,510 --> 00:07:27,680

um they argue this is reconcilable with

215

00:07:31,430 --> 00:07:29,520

the 20 parts per billion of phosphine

216

00:07:33,589 --> 00:07:31,440

seen in the jcmt

217

00:07:34,710 --> 00:07:33,599

which was not subject to a recalibration

218

00:07:36,150 --> 00:07:34,720

recall

219

00:07:37,909 --> 00:07:36,160

and said that that was potentially due

220

00:07:41,350 --> 00:07:37,919

to temporal variability

221

00:07:43,909 --> 00:07:41,360

in phosphine in the venous atmosphere

222

00:07:45,990 --> 00:07:43,919

a team led by alex aikens then also

223

00:07:47,350 --> 00:07:46,000

looked again at this recalibrated data

224

00:07:48,629 --> 00:07:47,360

so not the original stuff but the

225

00:07:53,270 --> 00:07:48,639

recalibrated data

226
00:07:56,150 --> 00:07:53,280
but they were again unable to reproduce

227
00:07:56,869 --> 00:07:56,160
a an absorption line at the correct

228
00:08:00,230 --> 00:07:56,879
frequency

229
00:08:02,309 --> 00:08:00,240
even in the recalibrated data

230
00:08:03,670 --> 00:08:02,319
they went on however to explain that

231
00:08:05,749 --> 00:08:03,680
maybe that was because

232
00:08:07,589 --> 00:08:05,759
of line dilution that had occurred

233
00:08:10,390 --> 00:08:07,599
because of the observing configuration

234
00:08:11,670 --> 00:08:10,400
of the armor array so even with all of

235
00:08:13,350 --> 00:08:11,680
the baselines in the

236
00:08:14,790 --> 00:08:13,360
armor array you can get something like a

237
00:08:17,430 --> 00:08:14,800
90 dilution

238
00:08:18,309 --> 00:08:17,440

of an extended absorption which is what

239

00:08:20,390 --> 00:08:18,319

you would have

240

00:08:23,589 --> 00:08:20,400

if the gas was evenly distributed across

241

00:08:26,710 --> 00:08:23,599

the venous disc which is quite large

242

00:08:28,950 --> 00:08:26,720

but removal of the smaller than 33 meter

243

00:08:31,670 --> 00:08:28,960

baseline

244

00:08:33,829 --> 00:08:31,680

array configuration produced a very high

245

00:08:36,709 --> 00:08:33,839

dilution so 95 to 97

246

00:08:37,750 --> 00:08:36,719

dilution meaning that it was it was

247

00:08:40,310 --> 00:08:37,760

suppressing

248

00:08:42,149 --> 00:08:40,320

um the signal coming from the gas in the

249

00:08:42,949 --> 00:08:42,159

venous atmosphere by a factor of 20 to

250

00:08:45,829 --> 00:08:42,959

33

251
00:08:47,350 --> 00:08:45,839
for disc or hemispherical averages so

252
00:08:48,470 --> 00:08:47,360
the fact that nothing was detected in

253
00:08:50,389 --> 00:08:48,480
the armored data

254
00:08:53,430 --> 00:08:50,399
could have actually been a function of

255
00:08:55,829 --> 00:08:53,440
the observing array

256
00:08:56,949 --> 00:08:55,839
so um in summary the proper release of

257
00:08:58,470 --> 00:08:56,959
the discovery and subsequent

258
00:09:00,230 --> 00:08:58,480
recalibrated data sets

259
00:09:02,710 --> 00:09:00,240
allowed the community to attempt to

260
00:09:04,310 --> 00:09:02,720
replicate on this detection

261
00:09:05,990 --> 00:09:04,320
however the consensus was that no

262
00:09:07,829 --> 00:09:06,000
significant feature had been seen

263
00:09:09,590 --> 00:09:07,839

in the armor data possibly due to

264

00:09:11,350 --> 00:09:09,600

suppression by the interferometric

265

00:09:13,269 --> 00:09:11,360

technique used on an extended object

266

00:09:15,110 --> 00:09:13,279

like venus

267

00:09:16,790 --> 00:09:15,120

and as an addendum an additional paper

268

00:09:23,350 --> 00:09:16,800

by thompson also questioned the

269

00:09:24,550 --> 00:09:23,360

detection significance of the jcmt data

270

00:09:26,949 --> 00:09:24,560

so the second question that the

271

00:09:28,630 --> 00:09:26,959

community attempted to answer is that

272

00:09:30,310 --> 00:09:28,640

is is there a secondary confirmation of

273

00:09:31,190 --> 00:09:30,320

phosphine being present because if we

274

00:09:33,509 --> 00:09:31,200

can detect

275

00:09:34,949 --> 00:09:33,519

another phosphine line somewhere else in

276

00:09:36,070 --> 00:09:34,959

the in the spectrum

277

00:09:37,670 --> 00:09:36,080

that would greatly enhance our

278

00:09:39,269 --> 00:09:37,680

confidence that phosphine had in fact

279

00:09:41,590 --> 00:09:39,279

been detected

280

00:09:43,190 --> 00:09:41,600

however by re-examining ground-based

281

00:09:44,150 --> 00:09:43,200

spectra that had already been taken in

282

00:09:47,030 --> 00:09:44,160

2015

283

00:09:47,990 --> 00:09:47,040

a team led by theresa anchor as was not

284

00:09:50,389 --> 00:09:48,000

able

285

00:09:51,110 --> 00:09:50,399

to detect phosphine in this data and

286

00:09:53,509 --> 00:09:51,120

came up

287

00:09:55,269 --> 00:09:53,519

with a um an upper limit for phosphine

288

00:09:57,030 --> 00:09:55,279

of about five parts per billion which

289

00:09:59,350 --> 00:09:57,040

was four times less than that claimed

290

00:10:00,630 --> 00:09:59,360

but in the greaves at ljcmt data the 20

291

00:10:03,350 --> 00:10:00,640

part per billion

292

00:10:04,230 --> 00:10:03,360

so no phosphine detected there and it

293

00:10:06,150 --> 00:10:04,240

should be

294

00:10:07,750 --> 00:10:06,160

a factor for at least less than what

295

00:10:10,870 --> 00:10:07,760

we're seeing

296

00:10:12,710 --> 00:10:10,880

um trumpet is owl um reanalyzed

297

00:10:14,949 --> 00:10:12,720

measurements taken by the venus express

298

00:10:15,990 --> 00:10:14,959

mission which is um was in orbit around

299

00:10:18,949 --> 00:10:16,000

venus for its uh

300

00:10:21,190 --> 00:10:18,959

its main mission um and looking at

301
00:10:22,870 --> 00:10:21,200
spectra near 4.1 microns they also

302
00:10:24,230 --> 00:10:22,880
searched for phosphine signatures there

303
00:10:27,509 --> 00:10:24,240
and did not find it

304
00:10:30,389 --> 00:10:27,519
um producing an upper limit on phosphine

305
00:10:33,350 --> 00:10:30,399
of 0.2 to 0.4 parts per billion

306
00:10:33,750 --> 00:10:33,360
in the venus atmosphere and as an aside

307
00:10:46,310 --> 00:10:33,760
a

308
00:10:50,310 --> 00:10:46,320
shows up

309
00:10:51,910 --> 00:10:50,320
in terrestrial atmospheres

310
00:10:54,069 --> 00:10:51,920
so another way of going after a

311
00:10:55,110 --> 00:10:54,079
potential validation of the phosphine

312
00:10:57,190 --> 00:10:55,120
detection

313
00:10:58,710 --> 00:10:57,200

was to re-analyze data taken from the

314

00:11:01,110 --> 00:10:58,720

pioneer venus large pro

315

00:11:03,030 --> 00:11:01,120

neutral mass spectrometer on descent

316

00:11:04,550 --> 00:11:03,040

through the venous clouds

317

00:11:07,490 --> 00:11:04,560

and so in this particular case in a

318

00:11:09,030 --> 00:11:07,500

paper led by um by mogul adele

319

00:11:11,350 --> 00:11:09,040

[Music]

320

00:11:12,870 --> 00:11:11,360

essentially looked at this mass

321

00:11:13,750 --> 00:11:12,880

measurement within the spectrometer

322

00:11:16,230 --> 00:11:13,760

which could

323

00:11:17,829 --> 00:11:16,240

be phosphine or it could also be h₂s

324

00:11:20,870 --> 00:11:17,839

which has the same mass

325

00:11:23,829 --> 00:11:20,880

molecularly so in the original analysis

326

00:11:26,949 --> 00:11:23,839

of these data taken in 1980

327

00:11:29,430 --> 00:11:26,959

the uh the feature was attributed

328

00:11:31,030 --> 00:11:29,440

to nothing but h2s and so that's the fit

329

00:11:33,430 --> 00:11:31,040

of the h2s to the 3d

330

00:11:35,509 --> 00:11:33,440

data points but the authors here argue

331

00:11:37,829 --> 00:11:35,519

that in fact by fitting it with 80

332

00:11:39,350 --> 00:11:37,839

phosphine and 20 hydrogen sulfide you

333

00:11:44,389 --> 00:11:39,360

can get a better fit

334

00:11:47,670 --> 00:11:45,990

however no abundance of phosphate was

335

00:11:48,870 --> 00:11:47,680

calculated and so the value cannot be

336

00:11:50,150 --> 00:11:48,880

compared to other measurements and

337

00:11:51,590 --> 00:11:50,160

detection limits to check for

338

00:11:53,190 --> 00:11:51,600

consistency to see if it's

339

00:11:55,110 --> 00:11:53,200

right in the same ballpark as that which

340

00:11:56,870 --> 00:11:55,120

was observed elsewhere

341

00:11:59,030 --> 00:11:56,880

however when originally attributed to

342

00:12:00,870 --> 00:11:59,040

h₂s the abundance was estimated to be

343

00:12:02,710 --> 00:12:00,880

three plus or minus two parts per

344

00:12:04,389 --> 00:12:02,720

million so a thousand times more than a

345

00:12:08,629 --> 00:12:04,399

part per billion

346

00:12:11,350 --> 00:12:10,230

so in summary several groups attempted

347

00:12:12,790 --> 00:12:11,360

to increase our confidence in the

348

00:12:14,629 --> 00:12:12,800

phosphate detection by searching for

349

00:12:16,069 --> 00:12:14,639

additional signs of phosphine μm in

350

00:12:17,829 --> 00:12:16,079

other data sets

351
00:12:19,350 --> 00:12:17,839
but spectroscopic observations there 4

352
00:12:20,949 --> 00:12:19,360
and 10 microns failed to detect the

353
00:12:23,990 --> 00:12:20,959
phosphine and set an upper limit that

354
00:12:26,629 --> 00:12:24,000
was between 5 to 0.2 parts per billion

355
00:12:28,629 --> 00:12:26,639
and then re-analysis that pioneer venus

356
00:12:30,389 --> 00:12:28,639
neutral mass spectrometer data

357
00:12:32,310 --> 00:12:30,399
was interpreted to include phosphate in

358
00:12:33,509 --> 00:12:32,320
the measurements previously attributed

359
00:12:36,829 --> 00:12:33,519
to h₂s

360
00:12:42,790 --> 00:12:36,839
but the corresponding abundance was not

361
00:12:46,230 --> 00:12:44,550
so the next question we can ask is is

362
00:12:47,750 --> 00:12:46,240
the feature due to phosphine or some

363
00:12:48,710 --> 00:12:47,760

other molecule more likely so if the

364

00:12:51,509 --> 00:12:48,720

phosphine actually

365

00:12:53,190 --> 00:12:51,519

is there and after the previous analyses

366

00:12:54,310 --> 00:12:53,200

it's not entirely clear that it is but

367

00:12:56,069 --> 00:12:54,320

if it is there

368

00:12:57,910 --> 00:12:56,079

um is it due to phosphine or could it be

369

00:12:59,990 --> 00:12:57,920

due to something else

370

00:13:02,230 --> 00:13:00,000

so v in a way that al suggested that in

371

00:13:02,949 --> 00:13:02,240

fact time variable so2 could explain the

372

00:13:05,110 --> 00:13:02,959

data

373

00:13:05,990 --> 00:13:05,120

um and they fit and evenly mixed 100

374

00:13:09,350 --> 00:13:06,000

parts per billion

375

00:13:12,629 --> 00:13:09,360

of so2 in the mesosphere um

376

00:13:15,750 --> 00:13:12,639

and 10 parts per billion uh in the uh

377

00:13:17,990 --> 00:13:15,760

jcmt data sorry in the armor data and

378

00:13:20,470 --> 00:13:18,000

100 in the jcmt data and so that that

379

00:13:22,069 --> 00:13:20,480

could in fact um fit the data

380

00:13:23,990 --> 00:13:22,079

so they invoke temporal variability in

381

00:13:24,710 --> 00:13:24,000

so2 for the different scene and two data

382

00:13:26,550 --> 00:13:24,720

sets

383

00:13:28,230 --> 00:13:26,560

and they use line with arguments to rule

384

00:13:30,069 --> 00:13:28,240

out the line core being formed within

385

00:13:31,670 --> 00:13:30,079

the clouds so the line core is the the

386

00:13:34,550 --> 00:13:31,680

center of the absorption

387

00:13:36,150 --> 00:13:34,560

of the line out here we have the wings

388

00:13:37,750 --> 00:13:36,160

closer to the continuum

389

00:13:39,670 --> 00:13:37,760

but the line core was what was most

390

00:13:41,350 --> 00:13:39,680

prominently seen and the point was that

391

00:13:43,269 --> 00:13:41,360

that line core was sufficiently

392

00:13:45,670 --> 00:13:43,279

narrow and sufficiently prominent in the

393

00:13:48,310 --> 00:13:45,680

core that it was coming potentially from

394

00:13:50,310 --> 00:13:48,320

the upper atmosphere

395

00:13:52,230 --> 00:13:50,320

grieves that island response um and this

396

00:13:53,269 --> 00:13:52,240

was an ongoing discussion that ended up

397

00:13:56,470 --> 00:13:53,279

in the archive

398

00:13:56,949 --> 00:13:56,480

um from nature matters arising um argued

399

00:13:59,509 --> 00:13:56,959

that

400

00:14:01,829 --> 00:13:59,519

the 266.94 gigahertz line could not be

401
00:14:03,910 --> 00:14:01,839
attributed to so2 because the line width

402
00:14:05,189 --> 00:14:03,920
um in their observed detection which is

403
00:14:07,590 --> 00:14:05,199
this thing here

404
00:14:10,310 --> 00:14:07,600
um was larger than that observed for so2

405
00:14:11,990 --> 00:14:10,320
features seen at other wavelengths

406
00:14:13,670 --> 00:14:12,000
and that the required abundance and they

407
00:14:15,110 --> 00:14:13,680
felt they needed to fit it with 150

408
00:14:17,030 --> 00:14:15,120
parts per billion of so2

409
00:14:18,150 --> 00:14:17,040
would be an extreme outlier compared

410
00:14:20,389 --> 00:14:18,160
with other values

411
00:14:23,430 --> 00:14:20,399
of so2 that had been seen in the venus

412
00:14:26,550 --> 00:14:25,350
so in another paper led by andrew

413
00:14:30,069 --> 00:14:26,560

linkowski and

414

00:14:32,710 --> 00:14:30,079

al they used a radiator transfer

415

00:14:33,509 --> 00:14:32,720

model to actually look at where the

416

00:14:35,750 --> 00:14:33,519

absorption

417

00:14:37,189 --> 00:14:35,760

was coming from in the venous atmosphere

418

00:14:39,910 --> 00:14:37,199

and they showed using radius

419

00:14:40,949 --> 00:14:39,920

acobians um that at least in the case

420

00:14:43,509 --> 00:14:40,959

of phosphine

421

00:14:44,470 --> 00:14:43,519

in that lying position um the phosphine

422

00:14:46,470 --> 00:14:44,480

was coming from

423

00:14:48,150 --> 00:14:46,480

above 75 kilometers in the venus

424

00:14:49,189 --> 00:14:48,160

atmosphere so not within the clouds

425

00:14:50,230 --> 00:14:49,199

where it would be protected from

426
00:14:52,150 --> 00:14:50,240
destruction

427
00:14:54,470 --> 00:14:52,160
but up very high in the atmosphere where

428
00:14:56,389 --> 00:14:54,480
it was vulnerable to being destroyed

429
00:14:58,389 --> 00:14:56,399
and in fact to maintain 20 parts per

430
00:15:00,230 --> 00:14:58,399
billion at these altitudes the flux of

431
00:15:02,230 --> 00:15:00,240
phosphine would have to exceed a hundred

432
00:15:03,030 --> 00:15:02,240
times the earth's photosynthetic oxygen

433
00:15:06,550 --> 00:15:03,040
flux

434
00:15:08,310 --> 00:15:06,560
maintain phosphine at these sorts of

435
00:15:11,910 --> 00:15:08,320
altitudes

436
00:15:13,189 --> 00:15:11,920
when cascadel also modeled the jcmt data

437
00:15:15,829 --> 00:15:13,199
but they did it using

438
00:15:17,670 --> 00:15:15,839

a realistic profile for sulfur dioxide

439

00:15:18,310 --> 00:15:17,680

down through the venus atmosphere which

440

00:15:20,069 --> 00:15:18,320

matched

441

00:15:22,389 --> 00:15:20,079

previous spacecraft data so this was a

442

00:15:24,629 --> 00:15:22,399

realistic so2 profile

443

00:15:26,389 --> 00:15:24,639

matched to spacecraft data i mean they

444

00:15:29,350 --> 00:15:26,399

were able to very well fit

445

00:15:30,069 --> 00:15:29,360

on the jcmt data both the widths and the

446

00:15:34,069 --> 00:15:30,079

depth

447

00:15:35,670 --> 00:15:34,079

of the feature using so2 alone

448

00:15:37,590 --> 00:15:35,680

however this fit would have predicted

449

00:15:39,350 --> 00:15:37,600

that that so2 reference line that was

450

00:15:42,550 --> 00:15:39,360

used for contamination

451
00:15:44,389 --> 00:15:42,560
removal would in fact have been

452
00:15:53,189 --> 00:15:44,399
you know 10 times larger than the limit

453
00:15:59,509 --> 00:15:56,470
however um because

454
00:16:01,990 --> 00:15:59,519
of the the possibility of line dilution

455
00:16:02,949 --> 00:16:02,000
and that um the the shorter bass lines

456
00:16:05,189 --> 00:16:02,959
being removed

457
00:16:07,350 --> 00:16:05,199
it's quite possible that any so2 that

458
00:16:09,110 --> 00:16:07,360
was seen at that reference wavelength

459
00:16:10,790 --> 00:16:09,120
was in fact heavily suppressed

460
00:16:12,710 --> 00:16:10,800
and so the fact that it was not seen was

461
00:16:13,749 --> 00:16:12,720
perhaps not a surprise

462
00:16:17,030 --> 00:16:13,759
but it didn't mean that the

463
00:16:19,430 --> 00:16:17,040

contamination test uh was compromised

464

00:16:20,790 --> 00:16:19,440

uh because if you couldn't see the so2

465

00:16:22,629 --> 00:16:20,800

then you couldn't tell how much of it

466

00:16:26,230 --> 00:16:22,639

was there to be able to subtract it off

467

00:16:30,629 --> 00:16:28,870

but it also means that as seen in the in

468

00:16:31,990 --> 00:16:30,639

the linkowski paper that if you fit the

469

00:16:33,829 --> 00:16:32,000

jcmt line

470

00:16:35,189 --> 00:16:33,839

you therefore due to line suppression

471

00:16:38,230 --> 00:16:35,199

don't expect to see an

472

00:16:40,629 --> 00:16:38,240

so2 feature at that particular position

473

00:16:42,389 --> 00:16:40,639

and so the so2 hypothesis could explain

474

00:16:44,310 --> 00:16:42,399

both the jcmt feature

475

00:16:45,749 --> 00:16:44,320

and the lack of a feature in the armor

476

00:16:47,749 --> 00:16:45,759

data

477

00:16:49,829 --> 00:16:47,759

so in summary plausible venus upper

478

00:16:51,590 --> 00:16:49,839

atmospheric so2 was shown to produce a

479

00:16:53,350 --> 00:16:51,600

signal that fit the width and depth of

480

00:16:54,870 --> 00:16:53,360

the jcmt data

481

00:16:57,990 --> 00:16:54,880

line dilution from the armor array

482

00:16:59,990 --> 00:16:58,000

configuration predicted that little

483

00:17:01,910 --> 00:17:00,000

or no signal could be seen in the armor

484

00:17:03,350 --> 00:17:01,920

data as was the case after the

485

00:17:05,909 --> 00:17:03,360

recalibration

486

00:17:08,069 --> 00:17:05,919

in fact of that data and for phosphine

487

00:17:09,750 --> 00:17:08,079

to fit the jcmt data it would have to be

488

00:17:11,429 --> 00:17:09,760

present above the clouds

489

00:17:12,870 --> 00:17:11,439

where the high flux needed to maintain

490

00:17:16,309 --> 00:17:12,880

it against destruction would be

491

00:17:19,429 --> 00:17:17,669

so the next question the community

492

00:17:20,949 --> 00:17:19,439

looked at was can phosphate be formed

493

00:17:23,669 --> 00:17:20,959

abiotically in the venous

494

00:17:25,510 --> 00:17:23,679

environment so in both the discovery

495

00:17:27,750 --> 00:17:25,520

paper and in an extensive companion

496

00:17:30,710 --> 00:17:27,760

paper i'm led by william baines

497

00:17:32,710 --> 00:17:30,720

um the authors argue that phosphine

498

00:17:34,230 --> 00:17:32,720

cannot be produced by any known surface

499

00:17:36,950 --> 00:17:34,240

interior atmosphere lightning or

500

00:17:39,430 --> 00:17:36,960

meteoritic process

501
00:17:40,230 --> 00:17:39,440
and so that made perhaps the life

502
00:17:42,070 --> 00:17:40,240
hypothesis

503
00:17:44,390 --> 00:17:42,080
potentially more likely or some other

504
00:17:46,470 --> 00:17:44,400
process that we're not thinking about

505
00:17:48,070 --> 00:17:46,480
jerome and lunine argued instead that

506
00:17:49,510 --> 00:17:48,080
trace amounts of phosphites could be

507
00:17:51,270 --> 00:17:49,520
formed in the mantle and volcanically

508
00:17:53,909 --> 00:17:51,280
ejected and react with water or sulfuric

509
00:17:55,990 --> 00:17:53,919
acid to form phosphine

510
00:17:57,669 --> 00:17:56,000
mikhail zolotov counter argued that the

511
00:17:59,350 --> 00:17:57,679
measured amount of phosphine was in fact

512
00:18:00,549 --> 00:17:59,360
inconsistent with the known phosphorus

513
00:18:02,230 --> 00:18:00,559

budget for venus

514

00:18:04,310 --> 00:18:02,240

as phosphorus was unlikely to come from

515

00:18:06,150 --> 00:18:04,320

the interior as is the case on earth we

516

00:18:07,190 --> 00:18:06,160

get little unknown phosphine coming from

517

00:18:08,470 --> 00:18:07,200

our interior

518

00:18:09,990 --> 00:18:08,480

and the amount of frosting needed to

519

00:18:12,830 --> 00:18:10,000

explain the data was in fact well in

520

00:18:15,270 --> 00:18:12,840

excess of that expected from meteoritic

521

00:18:16,950 --> 00:18:15,280

sources

522

00:18:18,630 --> 00:18:16,960

another question then is is it likely

523

00:18:21,669 --> 00:18:18,640

that life exists in the environment

524

00:18:23,830 --> 00:18:21,679

and produces phosphine

525

00:18:25,350 --> 00:18:23,840

and so the survival and biological

526

00:18:27,029 --> 00:18:25,360

generation of phosphine has looked

527

00:18:29,110 --> 00:18:27,039

been looked at by a number of authors

528

00:18:31,830 --> 00:18:29,120

over the years the most recent was the

529

00:18:34,070 --> 00:18:31,840

the review by sigrid allen 2020

530

00:18:35,750 --> 00:18:34,080

um which dylan it delineated the

531

00:18:37,909 --> 00:18:35,760

multiple compound difficulties that life

532

00:18:40,630 --> 00:18:37,919

will face in the venus atmosphere

533

00:18:42,310 --> 00:18:40,640

and a very recent paper by holsworthy

534

00:18:44,150 --> 00:18:42,320

which i think the venus clouds likely

535

00:18:46,470 --> 00:18:44,160

have water activities two orders of

536

00:18:47,990 --> 00:18:46,480

magnitude below the level survivable by

537

00:18:50,230 --> 00:18:48,000

earth extremophiles

538

00:18:51,750 --> 00:18:50,240

and so essentially what that means um is

539

00:18:52,630 --> 00:18:51,760

that water is not available for

540

00:18:56,310 --> 00:18:52,640

biological

541

00:18:58,630 --> 00:18:56,320

um reactions within the venus clouds

542

00:18:59,990 --> 00:18:58,640

and the other argument against life

543

00:19:01,830 --> 00:19:00,000

producing the phosphine

544

00:19:03,510 --> 00:19:01,840

is that the because the observed lining

545

00:19:05,750 --> 00:19:03,520

profile for the jcmt showed the

546

00:19:07,350 --> 00:19:05,760

phosphine was high above the cloud tops

547

00:19:09,110 --> 00:19:07,360

then the flux needed to maintain it up

548

00:19:10,470 --> 00:19:09,120

there is biologically improbable because

549

00:19:13,990 --> 00:19:10,480

it would have to exceed

550

00:19:14,549 --> 00:19:14,000

um the uh by many times the oxygenic

551

00:19:19,909 --> 00:19:14,559

flux

552

00:19:21,990 --> 00:19:19,919

from oxygenic photosynthesis on our own

553

00:19:23,110 --> 00:19:22,000

planet so it's perhaps unlikely that a

554

00:19:25,029 --> 00:19:23,120

biosphere

555

00:19:27,510 --> 00:19:25,039

in venous conditions could be that

556

00:19:29,270 --> 00:19:27,520

projective overall

557

00:19:30,950 --> 00:19:29,280

moreover if the absorption really is

558

00:19:32,789 --> 00:19:30,960

coming from high up

559

00:19:34,070 --> 00:19:32,799

then for phosphine you would expect the

560

00:19:36,230 --> 00:19:34,080

vertical distribution

561

00:19:38,150 --> 00:19:36,240

in of the gas in the atmosphere to drop

562

00:19:38,950 --> 00:19:38,160

off extremely rapidly above the clouds

563

00:19:42,070 --> 00:19:38,960

because of the rate

564

00:19:44,150 --> 00:19:42,080

which is destroyed up there but as a

565

00:19:46,230 --> 00:19:44,160

counter perhaps so2 is more likely

566

00:19:47,669 --> 00:19:46,240

because we know that so2 does exist each

567

00:19:48,549 --> 00:19:47,679

dot here is a measurement taken by a

568

00:19:50,549 --> 00:19:48,559

spacecraft

569

00:19:52,470 --> 00:19:50,559

so so2 is known to exist in the

570

00:19:54,390 --> 00:19:52,480

atmosphere above the venous clouds and

571

00:19:55,350 --> 00:19:54,400

in fact to increase with altitude so it

572

00:19:57,110 --> 00:19:55,360

does not

573

00:20:00,150 --> 00:19:57,120

have a problem with being up at these

574

00:20:02,789 --> 00:20:00,160

types of altitudes

575

00:20:04,470 --> 00:20:02,799

so let's then consider looking at what

576

00:20:06,630 --> 00:20:04,480

we've learned about venus and about

577

00:20:08,390 --> 00:20:06,640

trying to verify the venus observations

578

00:20:11,270 --> 00:20:08,400

and think of a possible framework for

579

00:20:12,549 --> 00:20:11,280

standards of evidence for biosignatures

580

00:20:14,789 --> 00:20:12,559

so the first question we have to ask

581

00:20:16,870 --> 00:20:14,799

ourselves is have you detected something

582

00:20:18,390 --> 00:20:16,880

um or are you in fact observing some

583

00:20:19,909 --> 00:20:18,400

kind of instrumental artifact or

584

00:20:21,190 --> 00:20:19,919

something that is has come out in the

585

00:20:23,029 --> 00:20:21,200

processing

586

00:20:24,870 --> 00:20:23,039

have you correctly identified what you

587

00:20:25,510 --> 00:20:24,880

think you've detected can you verify

588

00:20:27,669 --> 00:20:25,520

that this

589

00:20:29,270 --> 00:20:27,679

is in fact indeed um you know the

590

00:20:30,630 --> 00:20:29,280

molecule that you think you have or is

591

00:20:32,310 --> 00:20:30,640

there some sort of contamination that

592

00:20:34,070 --> 00:20:32,320

you haven't ruled out

593

00:20:35,590 --> 00:20:34,080

other abiotic sources for what you think

594

00:20:37,029 --> 00:20:35,600

you've detected but it makes sense for

595

00:20:38,630 --> 00:20:37,039

life to produce this compound or

596

00:20:40,390 --> 00:20:38,640

expression in this environment

597

00:20:41,750 --> 00:20:40,400

and finally other independent lines of

598

00:20:43,590 --> 00:20:41,760

evidence supporting a biological

599

00:20:45,990 --> 00:20:43,600

explanation

600

00:20:46,789 --> 00:20:46,000

so in all of these steps we need some

601
00:20:48,630 --> 00:20:46,799
assessment of

602
00:20:50,310 --> 00:20:48,640
our standards of confidence of each step

603
00:20:52,310 --> 00:20:50,320
which we can hopefully feed into some

604
00:20:54,470 --> 00:20:52,320
sort of statistical assessment

605
00:20:57,430 --> 00:20:54,480
of the probability of life on non-life

606
00:20:59,270 --> 00:20:57,440
producing the observed phenomena

607
00:21:01,190 --> 00:20:59,280
so we think if we think in the framework

608
00:21:03,909 --> 00:21:01,200
of this sort of um

609
00:21:05,350 --> 00:21:03,919
uh sort of standards of evidence and and

610
00:21:07,190 --> 00:21:05,360
confidence scale

611
00:21:08,789 --> 00:21:07,200
then if we look at the initial discovery

612
00:21:10,630 --> 00:21:08,799
um of the claimed evidence of phosphate

613
00:21:12,470 --> 00:21:10,640

in the venous clouds

614

00:21:13,990 --> 00:21:12,480

then it looks quite robust there are

615

00:21:17,990 --> 00:21:14,000

three detections of a high signal

616

00:21:19,270 --> 00:21:18,000

noise feature um at 266.94 gigahertz

617

00:21:20,710 --> 00:21:19,280

and the observations were taken with

618

00:21:21,830 --> 00:21:20,720

multiple telescopes instruments and

619

00:21:23,110 --> 00:21:21,840

epochs

620

00:21:24,950 --> 00:21:23,120

there was apparently little or no

621

00:21:27,590 --> 00:21:24,960

contamination for so₂ and a

622

00:21:29,430 --> 00:21:27,600

contamination test had been set up

623

00:21:30,630 --> 00:21:29,440

and was able to rule out so₂

624

00:21:32,390 --> 00:21:30,640

contamination

625

00:21:34,310 --> 00:21:32,400

so at that point this discovery was at a

626
00:21:36,310 --> 00:21:34,320
preliminary confidence level i think of

627
00:21:37,270 --> 00:21:36,320
about two on our biosignature assessment

628
00:21:38,789 --> 00:21:37,280
framework

629
00:21:40,710 --> 00:21:38,799
it appeared that there was a robust

630
00:21:42,310 --> 00:21:40,720
detection and that it was indeed due to

631
00:21:43,590 --> 00:21:42,320
phosphine because the so2 had been

632
00:21:45,430 --> 00:21:43,600
rolled out

633
00:21:47,029 --> 00:21:45,440
however recalibration of the armor

634
00:21:48,870 --> 00:21:47,039
discovery data and then subsequent work

635
00:21:49,669 --> 00:21:48,880
by the community to attempt to validate

636
00:21:51,510 --> 00:21:49,679
the detection

637
00:21:53,510 --> 00:21:51,520
served to sort of reduce that overall

638
00:21:55,029 --> 00:21:53,520

significance of the detection

639

00:21:56,870 --> 00:21:55,039

so recalibration showed that the

640

00:21:57,990 --> 00:21:56,880

original 15 sigma armor line was an

641

00:21:59,669 --> 00:21:58,000

artifact

642

00:22:01,510 --> 00:21:59,679

several independent groups could not

643

00:22:03,270 --> 00:22:01,520

reproduce the detected line

644

00:22:04,549 --> 00:22:03,280

in the discovery or the recalibrated

645

00:22:06,070 --> 00:22:04,559

data

646

00:22:07,430 --> 00:22:06,080

and attempts to find corroborating

647

00:22:08,789 --> 00:22:07,440

evidence for phosphine and other

648

00:22:11,990 --> 00:22:08,799

spectral wavelengths

649

00:22:13,590 --> 00:22:12,000

fail to detect the phosphine

650

00:22:15,590 --> 00:22:13,600

community members also called in the

651
00:22:19,190 --> 00:22:15,600
question that so2 contamination

652
00:22:21,029 --> 00:22:19,200
test um and explained that ss2 may not

653
00:22:23,750 --> 00:22:21,039
have been seen in the armada due to line

654
00:22:25,110 --> 00:22:23,760
suppression not a lack of so2

655
00:22:28,310 --> 00:22:25,120
and since light suppression would not

656
00:22:31,190 --> 00:22:28,320
have affected the single dish jcmt data

657
00:22:32,549 --> 00:22:31,200
um then you can't assume that there's no

658
00:22:34,310 --> 00:22:32,559
so2 there and if

659
00:22:35,590 --> 00:22:34,320
therefore all of the line is seen by

660
00:22:37,510 --> 00:22:35,600
biphosphine

661
00:22:38,630 --> 00:22:37,520
and in fact radiative transfer models

662
00:22:41,190 --> 00:22:38,640
showed that in fact

663
00:22:43,669 --> 00:22:41,200

typical venus so2 could fit the gcmt

664

00:22:46,310 --> 00:22:43,679

data without the need for phosphine

665

00:22:47,669 --> 00:22:46,320

and if the line core is indeed coming

666

00:22:50,230 --> 00:22:47,679

from above the clouds as several

667

00:22:52,230 --> 00:22:50,240

researchers pointed out

668

00:22:54,149 --> 00:22:52,240

then it's statistically more likely that

669

00:22:55,990 --> 00:22:54,159

that's going to be so2 which we know

670

00:22:57,669 --> 00:22:56,000

persists and increases with altitude

671

00:22:59,430 --> 00:22:57,679

rather than phosphine which has an

672

00:23:02,310 --> 00:22:59,440

incredibly short lifetime come

673

00:23:03,270 --> 00:23:02,320

above the clouds so while additional

674

00:23:04,950 --> 00:23:03,280

work can be done

675

00:23:06,870 --> 00:23:04,960

in understanding possible abiotic

676
00:23:08,390 --> 00:23:06,880
sources for phosphine and the venous

677
00:23:10,630 --> 00:23:08,400
atmosphere and the likelihood that life

678
00:23:12,230 --> 00:23:10,640
can persist and produce phosphine there

679
00:23:14,070 --> 00:23:12,240
i think the highest priority for future

680
00:23:15,830 --> 00:23:14,080
work on this particular issue

681
00:23:17,669 --> 00:23:15,840
is in potentially showing up confidence

682
00:23:20,710 --> 00:23:17,679
levels one and two the detection

683
00:23:22,710 --> 00:23:20,720
and identification so we essentially

684
00:23:26,470 --> 00:23:22,720
have two hypotheses now for what

685
00:23:27,430 --> 00:23:26,480
that absorption is um in the jcmt data

686
00:23:29,270 --> 00:23:27,440
in particular

687
00:23:31,029 --> 00:23:29,280
so we need to distinguish between

688
00:23:33,909 --> 00:23:31,039

interpreting that line as phosphine

689

00:23:35,270 --> 00:23:33,919

or interpreting it as so2 only and so to

690

00:23:36,950 --> 00:23:35,280

do that there are a bunch of different

691

00:23:38,149 --> 00:23:36,960

observations that could be proposed and

692

00:23:41,350 --> 00:23:38,159

these were proposed

693

00:23:41,990 --> 00:23:41,360

largely by alex aikens first of all

694

00:23:43,510 --> 00:23:42,000

single

695

00:23:45,029 --> 00:23:43,520

dish measurements would be much better

696

00:23:48,390 --> 00:23:45,039

than using an array because they do not

697

00:23:50,390 --> 00:23:48,400

suffer from the line dilution

698

00:23:52,310 --> 00:23:50,400

or another way of getting that is using

699

00:23:53,750 --> 00:23:52,320

the atacama compact array with the much

700

00:23:56,470 --> 00:23:53,760

shorter baselines that are much more

701
00:23:58,789 --> 00:23:56,480
sensitive to broadly distributed gases

702
00:24:00,390 --> 00:23:58,799
and then for the the contamination test

703
00:24:02,070 --> 00:24:00,400
which was done really at two different

704
00:24:03,909 --> 00:24:02,080
epochs with two different instruments it

705
00:24:04,549 --> 00:24:03,919
would be better to do that at the same

706
00:24:06,630 --> 00:24:04,559
time

707
00:24:08,710 --> 00:24:06,640
with the same instrument um and so

708
00:24:10,870 --> 00:24:08,720
simultaneous observations of the so2

709
00:24:13,909 --> 00:24:10,880
reference line along with the blended

710
00:24:15,269 --> 00:24:13,919
to 266.94 gigahertz line

711
00:24:16,950 --> 00:24:15,279
would be a much more definitive

712
00:24:18,470 --> 00:24:16,960
contamination test

713
00:24:20,070 --> 00:24:18,480

and these observations should occur when

714

00:24:22,070 --> 00:24:20,080

venus has a smaller angular

715

00:24:23,669 --> 00:24:22,080

apparent angular diameter and is less

716

00:24:26,549 --> 00:24:23,679

resolved by the armor antennas which

717

00:24:30,230 --> 00:24:27,990

so one of the bigger picture takeaways

718

00:24:31,430 --> 00:24:30,240

from all of this well i think this was

719

00:24:33,909 --> 00:24:31,440

really an interesting test run for

720

00:24:35,430 --> 00:24:33,919

future exoplanet biosignature assessment

721

00:24:36,950 --> 00:24:35,440

um and what it showed us is that

722

00:24:39,110 --> 00:24:36,960

understanding the environment

723

00:24:40,950 --> 00:24:39,120

that you're trying to you know determine

724

00:24:43,110 --> 00:24:40,960

the context of this biosecurity in is

725

00:24:44,549 --> 00:24:43,120

absolutely key to searching for life

726

00:24:46,230 --> 00:24:44,559

and it's important to characterize that

727

00:24:47,909 --> 00:24:46,240

environment and if at all possible have

728

00:24:49,350 --> 00:24:47,919

colleagues who can understand what their

729

00:24:50,549 --> 00:24:49,360

environment's like and understand those

730

00:24:52,470 --> 00:24:50,559

data

731

00:24:54,470 --> 00:24:52,480

obviously for an exoplanet observation

732

00:24:56,549 --> 00:24:54,480

it's going to be extremely challenging

733

00:24:57,750 --> 00:24:56,559

um to be able to uh you know have

734

00:24:59,750 --> 00:24:57,760

someone who's an expert on that

735

00:25:01,190 --> 00:24:59,760

particular planet

736

00:25:02,789 --> 00:25:01,200

because we'll really be learning things

737

00:25:04,390 --> 00:25:02,799

in real time but nonetheless it's

738

00:25:05,590 --> 00:25:04,400

definitely worthwhile taking the time to

739

00:25:06,950 --> 00:25:05,600

look at the environment and try to

740

00:25:09,269 --> 00:25:06,960

understand what else could be there that

741

00:25:10,470 --> 00:25:09,279

could be producing your signal

742

00:25:12,149 --> 00:25:10,480

so increasing confidence and

743

00:25:13,350 --> 00:25:12,159

biosignature discovery requires at least

744

00:25:16,070 --> 00:25:13,360

four critical checks

745

00:25:18,070 --> 00:25:16,080

on detection identification the

746

00:25:19,669 --> 00:25:18,080

assessment of likely abiotic formation

747

00:25:21,350 --> 00:25:19,679

and the assessment of the plausibility

748

00:25:22,789 --> 00:25:21,360

that life can generate that product in

749

00:25:24,230 --> 00:25:22,799

its environment

750

00:25:26,390 --> 00:25:24,240

and as we're rolling out abiotic

751

00:25:28,390 --> 00:25:26,400

hypotheses i think it's also good to

752

00:25:29,669 --> 00:25:28,400

remember i think this is a great quote

753

00:25:31,190 --> 00:25:29,679

from charlie cacao

754

00:25:33,350 --> 00:25:31,200

and a very recent paper on that on the

755

00:25:37,110 --> 00:25:33,360

biosignatures that the venus

756

00:25:38,870 --> 00:25:37,120

phosphine discovery is that the biology

757

00:25:40,870 --> 00:25:38,880

hypothesis must be given the same

758

00:25:42,070 --> 00:25:40,880

rigorous examination as other possible

759

00:25:43,990 --> 00:25:42,080

hypotheses

760

00:25:46,470 --> 00:25:44,000

um it should not simply be proposed as a

761

00:25:47,750 --> 00:25:46,480

hypothesis of exclusion

762

00:25:49,029 --> 00:25:47,760

and another question we can ask

763

00:25:51,190 --> 00:25:49,039

ourselves is you know is a more

764

00:25:53,029 --> 00:25:51,200

collaborative community-wide process

765

00:25:54,470 --> 00:25:53,039

i know and you saw the the community

766

00:25:56,149 --> 00:25:54,480

come together in all of this

767

00:25:57,510 --> 00:25:56,159

likely to produce a better outcome for

768

00:25:59,269 --> 00:25:57,520

life detection

769

00:26:00,950 --> 00:25:59,279

and if so what are the best ways to

770

00:26:01,669 --> 00:26:00,960

incentivize that process and so that's

771

00:26:05,669 --> 00:26:01,679

something that we

772

00:26:06,870 --> 00:26:05,679

need to think about so um so that is the

773

00:26:09,510 --> 00:26:06,880

sort of the story of

774

00:26:11,430 --> 00:26:09,520

of phosphine and venus and again how it

775

00:26:13,430 --> 00:26:11,440

sort of leads us to this idea

776

00:26:15,590 --> 00:26:13,440

of sort of levels of confidence and how

777

00:26:17,669 --> 00:26:15,600

we might help shore up

778

00:26:18,630 --> 00:26:17,679

or find alternative explanations for a

779

00:26:21,750 --> 00:26:18,640

potential biasing

780

00:26:24,390 --> 00:26:21,760

detection and also how it behooves us to

781

00:26:27,350 --> 00:26:24,400

think about how we might want to do

782

00:26:29,029 --> 00:26:27,360

um you know life detection uh both

783

00:26:32,310 --> 00:26:29,039

confirmation and reporting

784

00:26:33,750 --> 00:26:32,320

uh overall so um i hope you'll join us

785

00:26:34,870 --> 00:26:33,760

all for the workshop that's coming up in

786

00:26:36,630 --> 00:26:34,880

a couple of weeks

787

00:26:38,070 --> 00:26:36,640

um where we'll get a chance to discuss

788

00:26:39,590 --> 00:26:38,080

both of those issues and