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1
00:00:06,789 --> 00:00:03,189
hi everyone

2
00:00:09,030 --> 00:00:06,799
um so my name is caprice phillips and my

3
00:00:12,390 --> 00:00:09,040
pronouns are she her and hers

4
00:00:14,070 --> 00:00:12,400
um i'm a phd student at the ohio state

5
00:00:16,790 --> 00:00:14,080
university working with dr

6
00:00:17,830 --> 00:00:16,800
g wong and today i'm going to be talking

7
00:00:20,070 --> 00:00:17,840
about

8
00:00:21,750 --> 00:00:20,080
the research that i've been working on

9
00:00:23,910 --> 00:00:21,760
involving detecting potential buyer

10
00:00:25,910 --> 00:00:23,920
signatures in the atmospheres of gas

11
00:00:29,109 --> 00:00:25,920
drawers with the james webb space

12
00:00:32,229 --> 00:00:31,029
before i get started i wanted to

13
00:00:36,150 --> 00:00:32,239

introduce my

14

00:00:37,110 --> 00:00:36,160

collaborators um so um my advisor is dr

15

00:00:40,470 --> 00:00:37,120

ji wong here

16

00:00:41,510 --> 00:00:40,480

at osu then we also have sarah kendrick

17

00:00:43,270 --> 00:00:41,520

the space

18

00:00:45,190 --> 00:00:43,280

telescope science institute who's an

19

00:00:47,750 --> 00:00:45,200

expert with mary

20

00:00:49,750 --> 00:00:47,760

we also have tom green who works at nasa

21

00:00:53,670 --> 00:00:49,760

ames who's a near spec

22

00:00:55,750 --> 00:00:53,680

expert in renew at jpl who does

23

00:00:57,590 --> 00:00:55,760

photochemical modeling and joel schultz

24

00:00:59,590 --> 00:00:57,600

and wendy panero

25

00:01:00,790 --> 00:00:59,600

who are both in the geology department

26

00:01:03,270 --> 00:01:00,800

and helpful

27

00:01:05,109 --> 00:01:03,280

with interior modeling and then jeff

28

00:01:07,350 --> 00:01:05,119

lenty at the space

29

00:01:09,190 --> 00:01:07,360

science telescope institute was also a

30

00:01:10,710 --> 00:01:09,200

new spec instrument so we've assembled a

31

00:01:12,469 --> 00:01:10,720

really great team

32

00:01:14,710 --> 00:01:12,479

of experts with different instruments

33

00:01:16,149 --> 00:01:14,720

with a board jwst

34

00:01:19,590 --> 00:01:16,159

it's been really great working with all

35

00:01:24,230 --> 00:01:22,230

um so gas dwarfs are among the most

36

00:01:26,469 --> 00:01:24,240

abundant type of planet so this is the

37

00:01:27,270 --> 00:01:26,479

type of planet that my research focuses

38

00:01:32,310 --> 00:01:27,280

on

39

00:01:36,230 --> 00:01:32,320

um and so in 2014 buchavi at all

40

00:01:39,350 --> 00:01:36,240

worked on a paper where they broke um

41

00:01:40,069 --> 00:01:39,360

exoplanets up into three categories

42

00:01:43,190 --> 00:01:40,079

based on

43

00:01:45,590 --> 00:01:43,200

solar metallicity and there were those

44

00:01:46,870 --> 00:01:45,600

be um below one point one point seven

45

00:01:50,310 --> 00:01:46,880

earth radii

46

00:01:53,030 --> 00:01:50,320

and above three point four right three

47

00:01:53,350 --> 00:01:53,040

but the ones in between um were dubbed

48

00:01:56,149 --> 00:01:53,360

uh

49

00:01:57,109 --> 00:01:56,159

gas droves which they said were rocky

50

00:01:59,510 --> 00:01:57,119

plant with

51
00:02:00,149 --> 00:01:59,520
planets with rocky cores and hydrogen

52
00:02:03,109 --> 00:02:00,159
helium

53
00:02:04,230 --> 00:02:03,119
envelopes and those include both super

54
00:02:07,190 --> 00:02:04,240
earths

55
00:02:08,630 --> 00:02:07,200
and many neptunes and so this is a

56
00:02:10,869 --> 00:02:08,640
diagram

57
00:02:12,309 --> 00:02:10,879
uh shown here it's a little outdated but

58
00:02:14,869 --> 00:02:12,319
it's the number of planets

59
00:02:16,470 --> 00:02:14,879
um versus the type of planets here and

60
00:02:18,150 --> 00:02:16,480
highlight are super earths and

61
00:02:20,229 --> 00:02:18,160
subneptunes showing that

62
00:02:21,830 --> 00:02:20,239
they're the most common type of

63
00:02:24,630 --> 00:02:21,840

transiting planet

64

00:02:27,270 --> 00:02:24,640

by size which is what my research

65

00:02:30,150 --> 00:02:27,280

focuses on

66

00:02:31,910 --> 00:02:30,160

um so what's interesting um about these

67

00:02:32,630 --> 00:02:31,920

types of planets is that they are not

68

00:02:34,309 --> 00:02:32,640

found

69

00:02:36,070 --> 00:02:34,319

in the solar system we have a very

70

00:02:37,990 --> 00:02:36,080

structured solar system

71

00:02:40,229 --> 00:02:38,000

where we have the inner rocky planets

72

00:02:42,150 --> 00:02:40,239

like mercury venus earth and mars

73

00:02:43,670 --> 00:02:42,160

we have gas giants like jupiter and

74

00:02:46,869 --> 00:02:43,680

saturn and then we also have

75

00:02:49,030 --> 00:02:46,879

ice giants um uranus and neptune and so

76

00:02:50,070 --> 00:02:49,040

gas dwarfs are not found in the solar

77

00:02:52,229 --> 00:02:50,080

system so

78

00:02:54,150 --> 00:02:52,239

it begs the question are they upscaled

79

00:02:55,990 --> 00:02:54,160

versions of the inner rocky planets are

80

00:02:58,309 --> 00:02:56,000

they downscaled versions

81

00:02:59,990 --> 00:02:58,319

of the gas giants for example and it

82

00:03:01,190 --> 00:03:00,000

brings forth questions about like the

83

00:03:05,030 --> 00:03:01,200

information

84

00:03:06,710 --> 00:03:05,040

atmosphere and if their bio signatures

85

00:03:08,470 --> 00:03:06,720

or potential signs of life

86

00:03:12,070 --> 00:03:08,480

are different in these types of planets

87

00:03:15,670 --> 00:03:15,110

um so ammonia is a biosignature so this

88

00:03:20,390 --> 00:03:15,680

was first

89

00:03:23,750 --> 00:03:20,400
proposed by sarah seeger in 2013

90

00:03:24,949 --> 00:03:23,760
and so the idea is that ammonia is a

91

00:03:27,509 --> 00:03:24,959
biosignature

92

00:03:28,949 --> 00:03:27,519
in an atmosphere rich in hydrogen and

93

00:03:30,149 --> 00:03:28,959
nitrogen

94

00:03:31,910 --> 00:03:30,159
the idea is that you might have

95

00:03:33,830 --> 00:03:31,920
microbial life that can break apart the

96

00:03:36,309 --> 00:03:33,840
bonds to produce ammonia

97

00:03:37,830 --> 00:03:36,319
and eventually we have an access to

98

00:03:39,190 --> 00:03:37,840
build up

99

00:03:40,869 --> 00:03:39,200
and the atmospheres are hopefully

100

00:03:43,350 --> 00:03:40,879
detectable levels and

101
00:03:45,350 --> 00:03:43,360
these microbial vibes can capture the

102
00:03:46,550 --> 00:03:45,360
energy release and the excess of ammonia

103
00:03:47,430 --> 00:03:46,560
like i said will build up in the

104
00:03:50,149 --> 00:03:47,440
atmosphere to

105
00:03:51,350 --> 00:03:50,159
potentially detectable levels and

106
00:03:54,149 --> 00:03:51,360
ammonia is a really

107
00:03:55,190 --> 00:03:54,159
cool biosignature in the potential buyer

108
00:03:56,949 --> 00:03:55,200
signature

109
00:03:59,190 --> 00:03:56,959
and the fact that you need really high

110
00:04:01,190 --> 00:03:59,200
temperatures and pressures to produce it

111
00:04:02,550 --> 00:04:01,200
a biotically so that's kind of the idea

112
00:04:04,630 --> 00:04:02,560
if you were to see

113
00:04:06,550 --> 00:04:04,640

potentially um detect among your

114

00:04:09,190 --> 00:04:06,560

atmosphere it could be the first steps

115

00:04:14,309 --> 00:04:09,200

to start to rule out abiotic

116

00:04:16,390 --> 00:04:14,319

processes and different things like that

117

00:04:18,310 --> 00:04:16,400

so my research focuses on if we can

118

00:04:19,830 --> 00:04:18,320

detect ammonia in the atmospheres of

119

00:04:22,230 --> 00:04:19,840

these gastro orbs

120

00:04:24,310 --> 00:04:22,240

so before we can even see whether we can

121

00:04:26,950 --> 00:04:24,320

detect ammonia we first have to

122

00:04:29,830 --> 00:04:26,960

select targets and so we'd use three

123

00:04:30,469 --> 00:04:29,840

main selection criteria and the first

124

00:04:32,070 --> 00:04:30,479

one

125

00:04:34,550 --> 00:04:32,080

we asked like kind of three questions

126

00:04:36,150 --> 00:04:34,560

like can the planet support liquid water

127

00:04:38,070 --> 00:04:36,160

um does the planet have the right

128

00:04:41,350 --> 00:04:38,080

pressure and third it's a planet

129

00:04:43,430 --> 00:04:41,360

um close enough to earth and so we want

130

00:04:44,870 --> 00:04:43,440

um it to have the right pressure between

131

00:04:48,150 --> 00:04:44,880

1.7

132

00:04:50,550 --> 00:04:48,160

and 3.4 earth radii and the uppercut

133

00:04:52,629 --> 00:04:50,560

is to make sure that it doesn't have too

134

00:04:55,510 --> 00:04:52,639

high repressor to produce ammo

135

00:04:55,990 --> 00:04:55,520

ammonia um abiotic it doesn't have a

136

00:04:59,030 --> 00:04:56,000

process

137

00:05:00,950 --> 00:04:59,040

like here on earth and so we want to

138

00:05:02,310 --> 00:05:00,960

make sure that the planet has the right

139

00:05:04,230 --> 00:05:02,320

temperature support

140

00:05:05,670 --> 00:05:04,240

and the water make sure it's not too hot

141

00:05:06,710 --> 00:05:05,680

and then also we want to make sure it's

142

00:05:08,550 --> 00:05:06,720

close enough

143

00:05:10,550 --> 00:05:08,560

um so that we have adequate flux from

144

00:05:14,310 --> 00:05:10,560

the whole star and the planet

145

00:05:16,950 --> 00:05:14,320

so based on this selection criteria

146

00:05:18,230 --> 00:05:16,960

we have a sample of seven targets shown

147

00:05:20,070 --> 00:05:18,240

on the right here

148

00:05:22,230 --> 00:05:20,080

that's the plot of the planet radius

149

00:05:23,990 --> 00:05:22,240

versus the equilibrium temperature

150

00:05:25,830 --> 00:05:24,000

of our seven targets we have targets

151
00:05:29,670 --> 00:05:25,840
like k2 18b

152
00:05:31,590 --> 00:05:29,680
lhs 1140b and a couple of planets in the

153
00:05:33,189 --> 00:05:31,600
toi 270 system

154
00:05:35,110 --> 00:05:33,199
so the targets are shown here in the

155
00:05:36,469 --> 00:05:35,120
color and the ones in the gray dots are

156
00:05:38,550 --> 00:05:36,479
the ones that meet

157
00:05:43,510 --> 00:05:38,560
the first two criteria but are more than

158
00:05:46,870 --> 00:05:46,070
um so we don't have the spectra for

159
00:05:49,830 --> 00:05:46,880
these

160
00:05:51,189 --> 00:05:49,840
um objects yet so what we have to do is

161
00:05:54,870 --> 00:05:51,199
have to simulate

162
00:05:57,350 --> 00:05:54,880
spectra and so what we

163
00:06:00,309 --> 00:05:57,360

we do that using this code called petite

164

00:06:03,189 --> 00:06:00,319

rate trans um developed by paul moliere

165

00:06:04,790 --> 00:06:03,199

in 2019 so it's a really cool program

166

00:06:07,430 --> 00:06:04,800

and that

167

00:06:09,749 --> 00:06:07,440

what you do is that you can insert an

168

00:06:11,189 --> 00:06:09,759

abundance of molecules you can edit the

169

00:06:13,189 --> 00:06:11,199

concentration

170

00:06:14,230 --> 00:06:13,199

of ammonia and different things like

171

00:06:15,590 --> 00:06:14,240

well water

172

00:06:17,350 --> 00:06:15,600

you can add rayleigh scattering

173

00:06:18,070 --> 00:06:17,360

different things like that and so you

174

00:06:20,950 --> 00:06:18,080

can also

175

00:06:21,749 --> 00:06:20,960

input pressure temperature profiles you

176

00:06:23,830 --> 00:06:21,759

can

177

00:06:25,510 --> 00:06:23,840

edit the surface gravity the size of the

178

00:06:27,270 --> 00:06:25,520

planet the temperature of the planet

179

00:06:28,950 --> 00:06:27,280

and where you want the pressure bar to

180

00:06:31,430 --> 00:06:28,960

be set at and if you would like to you

181

00:06:34,550 --> 00:06:31,440

can account for the effects of cloud

182

00:06:37,590 --> 00:06:34,560

decks as well and so on the right here

183

00:06:38,950 --> 00:06:37,600

is kind of is showing the example of the

184

00:06:42,710 --> 00:06:38,960

model outputs

185

00:06:45,430 --> 00:06:42,720

and so on the top here is showing

186

00:06:47,270 --> 00:06:45,440

um some kind of like new infrared like

187

00:06:50,230 --> 00:06:47,280

transmission

188

00:06:52,469 --> 00:06:50,240

spectroscopy of an example planet and on

189

00:06:54,790 --> 00:06:52,479

the bottom here is emission spectroscopy

190

00:06:57,670 --> 00:06:54,800

shown in the mid infrared

191

00:06:59,270 --> 00:06:57,680

to see whether we can detect ammonia

192

00:06:59,830 --> 00:06:59,280

features as well but these are the model

193

00:07:03,670 --> 00:06:59,840

outputs

194

00:07:08,710 --> 00:07:07,189

so um this slide encompasses basically

195

00:07:11,830 --> 00:07:08,720

the structure

196

00:07:15,990 --> 00:07:11,840

um of this research project so

197

00:07:18,070 --> 00:07:16,000

um the first step is um to build the um

198

00:07:19,589 --> 00:07:18,080

after we built the spectra we

199

00:07:21,110 --> 00:07:19,599

determine the amount of ammonia

200

00:07:24,150 --> 00:07:21,120

atmosphere and we start with

201
00:07:27,350 --> 00:07:24,160
a base amount of 4.0 um

202
00:07:28,309 --> 00:07:27,360
ppm in the atmosphere and also that's

203
00:07:30,469 --> 00:07:28,319
step one

204
00:07:31,990 --> 00:07:30,479
and so step two we select an instrument

205
00:07:34,150 --> 00:07:32,000
to test so

206
00:07:35,990 --> 00:07:34,160
there are a lot of ammonia features in

207
00:07:38,309 --> 00:07:36,000
the near infrared there's also

208
00:07:40,230 --> 00:07:38,319
a pretty dominant um ammonia feature in

209
00:07:43,029 --> 00:07:40,240
the mid-infrared and so we

210
00:07:44,070 --> 00:07:43,039
utilize different instruments to test

211
00:07:46,309 --> 00:07:44,080
whether we can detect

212
00:07:47,749 --> 00:07:46,319
these different features and so for the

213
00:07:49,110 --> 00:07:47,759

beginning at the top here we use

214

00:07:50,869 --> 00:07:49,120

the mirror instrument which is the

215

00:07:53,990 --> 00:07:50,879

mid-infrared

216

00:07:56,390 --> 00:07:54,000

instrument above aboard jwst

217

00:07:57,830 --> 00:07:56,400

which can there's around a 10 micron

218

00:08:00,230 --> 00:07:57,840

ammonia feature that we want to see if

219

00:08:02,230 --> 00:08:00,240

we can detect with emission spectroscopy

220

00:08:04,070 --> 00:08:02,240

and so we move on um select the

221

00:08:04,790 --> 00:08:04,080

instrument and then we also we vary the

222

00:08:06,869 --> 00:08:04,800

amount

223

00:08:09,510 --> 00:08:06,879

of hydrogen in the atmosphere and we

224

00:08:12,550 --> 00:08:09,520

either choose a 90

225

00:08:15,110 --> 00:08:12,560

hydrogen dominated atmosphere or 25

226

00:08:16,629 --> 00:08:15,120

hydrogen based atmosphere which changes

227

00:08:17,830 --> 00:08:16,639

the mean molecular weight of the

228

00:08:21,270 --> 00:08:17,840

atmosphere

229

00:08:22,710 --> 00:08:21,280

respectively and after that for many we

230

00:08:23,430 --> 00:08:22,720

want to ask the question if we can

231

00:08:25,110 --> 00:08:23,440

determine

232

00:08:27,029 --> 00:08:25,120

if the ammonia features can be detected

233

00:08:31,110 --> 00:08:27,039

reacts as a contrast

234

00:08:32,709 --> 00:08:31,120

between the um planet and the stars are

235

00:08:34,550 --> 00:08:32,719

greater than equal to 10 to the

236

00:08:36,630 --> 00:08:34,560

minus four which is a sensitivity

237

00:08:38,550 --> 00:08:36,640

threshold for many

238

00:08:40,070 --> 00:08:38,560

and so we kind of go back to step two

239

00:08:41,670 --> 00:08:40,080

with the near spec instrument which

240

00:08:44,230 --> 00:08:41,680

operates in the

241

00:08:45,350 --> 00:08:44,240

excuse me in the near infrared and so we

242

00:08:47,590 --> 00:08:45,360

go back in the x

243

00:08:48,710 --> 00:08:47,600

we vary again the amount of hydrogen in

244

00:08:52,310 --> 00:08:48,720

the atmosphere

245

00:08:53,509 --> 00:08:52,320

and so with a um 90 based hydrogen

246

00:08:56,230 --> 00:08:53,519

atmosphere we also

247

00:08:57,990 --> 00:08:56,240

want to detect we also want to see the

248

00:08:59,829 --> 00:08:58,000

effects that clouds have on the

249

00:09:02,790 --> 00:08:59,839

detectability and so we

250

00:09:04,310 --> 00:09:02,800

do clouds versus no clouds here and then

251
00:09:05,590 --> 00:09:04,320
for nearly with transmission

252
00:09:08,230 --> 00:09:05,600
spectroscopy

253
00:09:09,509 --> 00:09:08,240
we access a signal to noise for these

254
00:09:12,310 --> 00:09:09,519
ammonia features

255
00:09:14,310 --> 00:09:12,320
greater than equal to uh three sigma

256
00:09:18,230 --> 00:09:14,320
determine if that's a

257
00:09:22,070 --> 00:09:20,710
so we found that transmission

258
00:09:24,470 --> 00:09:22,080
spectroscopy is better

259
00:09:26,710 --> 00:09:24,480
suited to detect ammonia features than

260
00:09:29,350 --> 00:09:26,720
emission spectroscopy

261
00:09:30,630 --> 00:09:29,360
um so as i mentioned with transmission

262
00:09:32,470 --> 00:09:30,640
spectroscopy

263
00:09:34,949 --> 00:09:32,480

well we test a variety of instrument

264

00:09:38,790 --> 00:09:34,959

instruments and modes like the new spect

265

00:09:42,550 --> 00:09:38,800

and the nearest instrument is an example

266

00:09:44,070 --> 00:09:42,560

spectrum of toi 270 see here this is our

267

00:09:45,829 --> 00:09:44,080

simulated spectra

268

00:09:47,110 --> 00:09:45,839

from petite and the orange here and the

269

00:09:50,550 --> 00:09:47,120

black dots

270

00:09:52,470 --> 00:09:50,560

are the um simulated uh

271

00:09:54,150 --> 00:09:52,480

observations from jwst from the

272

00:09:55,110 --> 00:09:54,160

respective instruments shown down here

273

00:09:58,870 --> 00:09:55,120

at the bottom

274

00:10:00,389 --> 00:09:58,880

corresponding signal to noise for the

275

00:10:02,470 --> 00:10:00,399

different features

276

00:10:04,470 --> 00:10:02,480

um so if we take one feature among the

277

00:10:08,150 --> 00:10:04,480

future for example the 1.5

278

00:10:09,990 --> 00:10:08,160

among your feature here we see that with

279

00:10:12,230 --> 00:10:10,000

transmission spectroscopy we would get a

280

00:10:13,750 --> 00:10:12,240

signal to noise of 5 sigma which is

281

00:10:16,310 --> 00:10:13,760

great which would mean you would be able

282

00:10:19,910 --> 00:10:16,320

to detect this feature

283

00:10:22,230 --> 00:10:19,920

using that instrument for example um

284

00:10:23,910 --> 00:10:22,240

however when we go over to emission

285

00:10:25,750 --> 00:10:23,920

spectroscopy

286

00:10:28,150 --> 00:10:25,760

with many as i mentioned before there's

287

00:10:30,470 --> 00:10:28,160

a ammonia feature around 10 microns

288

00:10:32,150 --> 00:10:30,480

and we see that most of the targets here

289

00:10:35,829 --> 00:10:32,160
are below that sensitivity

290

00:10:39,030 --> 00:10:35,839
threshold for mary and even our best

291

00:10:42,310 --> 00:10:39,040
target lp79118c

292

00:10:44,069 --> 00:10:42,320
is barely above that

293

00:10:46,949 --> 00:10:44,079
sensitivity threshold so be very

294

00:10:50,230 --> 00:10:46,959
difficult to detect

295

00:10:53,670 --> 00:10:52,710
and so as we did this project we also

296

00:10:55,750 --> 00:10:53,680
wanted to

297

00:10:56,870 --> 00:10:55,760
test the effects that varying the amount

298

00:10:58,389 --> 00:10:56,880
of hydrogen

299

00:11:02,790 --> 00:10:58,399
and the atmosphere has for ammonia

300

00:11:06,630 --> 00:11:02,800
detection and we see that

301
00:11:08,470 --> 00:11:06,640
with a 90 hydrogen-based atmosphere for

302
00:11:11,509 --> 00:11:08,480
that same 1.5

303
00:11:14,389 --> 00:11:11,519
ammonia feature we have almost a double

304
00:11:15,269 --> 00:11:14,399
signal to noise value you go from a five

305
00:11:17,590 --> 00:11:15,279
sigma

306
00:11:20,150 --> 00:11:17,600
to a 25 percent hydrogen-based

307
00:11:23,430 --> 00:11:20,160
atmosphere to a two sigma

308
00:11:25,829 --> 00:11:23,440
detection um so we wanted to explore

309
00:11:28,790 --> 00:11:25,839
those effects and we see that it's

310
00:11:30,389 --> 00:11:28,800
better to have a higher concentration of

311
00:11:32,069 --> 00:11:30,399
hydrogen in the atmosphere to detect

312
00:11:34,069 --> 00:11:32,079
ammonia

313
00:11:36,389 --> 00:11:34,079

another thing we wanted to explore is

314

00:11:39,509 --> 00:11:36,399

the effects of clouds we see that

315

00:11:41,590 --> 00:11:39,519

clouds higher in the atmosphere cloud

316

00:11:43,990 --> 00:11:41,600

decks high in the atmosphere

317

00:11:45,430 --> 00:11:44,000

do kind of mute and fly in the

318

00:11:47,829 --> 00:11:45,440

transmissions

319

00:11:48,790 --> 00:11:47,839

spectra and so that's another effect

320

00:11:50,710 --> 00:11:48,800

that we wanted

321

00:11:53,829 --> 00:11:50,720

to see we tested a variety of cloud

322

00:11:58,069 --> 00:11:56,470

with that i'll just put up my conclusion

323

00:12:00,230 --> 00:11:58,079

slides

324

00:12:02,150 --> 00:12:00,240

and so we see that gastrops are more

325

00:12:03,910 --> 00:12:02,160

massive and common than earth

326

00:12:05,590 --> 00:12:03,920

and our promising sites look for signs

327

00:12:07,750 --> 00:12:05,600

of life and ammonia

328

00:12:09,750 --> 00:12:07,760

is an exotic biosignature unique to

329

00:12:11,910 --> 00:12:09,760

hydrogen-based atmospheres of gas stores

330

00:12:13,509 --> 00:12:11,920

including super earth and many neptunes

331

00:12:15,350 --> 00:12:13,519

and we found that the near spec

332

00:12:17,190 --> 00:12:15,360

instrument is um

333

00:12:18,949 --> 00:12:17,200

better suited to mirror to detect

334

00:12:19,750 --> 00:12:18,959

ammonia than their specularized

335

00:12:21,670 --> 00:12:19,760

instrument

336

00:12:23,750 --> 00:12:21,680

and we exploit the effects of

337

00:12:25,269 --> 00:12:23,760

detectability of ammonia by seeing how

338

00:12:26,150 --> 00:12:25,279

it's affected by the concentration the

339

00:12:28,310 --> 00:12:26,160

atmosphere

340

00:12:29,829 --> 00:12:28,320

the amount of ammonia present in the

341

00:12:33,110 --> 00:12:29,839

presence of clouds