Hayley Bunn

Measuring the Rotational Spectrum of Aminomethanol for Comparison to Radio Telescope Data

```
1
00:00:00,240 --> 00:00:10,900
[Music]

2
00:00:16,100 --> 00:00:13,220
thanks to introduction so as he

3
00:00:19,400 --> 00:00:16,110
mentioned I'm Haley I work with Susanna

4
00:00:21,740 --> 00:00:19,410
would expire at Emory University and a

5
00:00:23,920 --> 00:00:21,750
lab focuses on measuring a rotational

6
00:00:26,270 --> 00:00:23,930
spectrum of complex organic molecules

7
00:00:28,250 --> 00:00:26,280
for the purpose of comparing them to

8
00:00:29,840 --> 00:00:28,260
radio telescope data to start mapping

9
00:00:31,700 --> 00:00:29,850
out the chemical composition of the

10
00:00:33,740 --> 00:00:31,710
interstellar medium and my particular

11
00:00:34,849 --> 00:00:33,750
project is on the moon ethanol at the

12
00:00:38,450 --> 00:00:34,859
moment so I'm going to be talking about

13
00:00:41,509 --> 00:00:38,460
```

that today so we use radio telescope

14
00:00:44,540 --> 00:00:41,519
data to map out as I mentioned the

15
00:00:47,149 --> 00:00:44,550
interstellar medium radio telescopes

16
00:00:49,549 --> 00:00:47,159
such as Alma look in the submillimetre

17
00:00:52,160 --> 00:00:49,559
microwave regime which gives us

18
00:00:54,290 --> 00:00:52,170
rotational spectra of molecules now you

19
00:00:56,239 --> 00:00:54,300
can imagine we have hundreds of

20
00:00:58,069 --> 00:00:56,249
molecules in the interstellar medium and

21
00:00:59,869 --> 00:00:58,079
you have a telescope pointing in a

22
00:01:01,549 --> 00:00:59,879
particular area and it measures

23
00:01:03,799 --> 00:01:01,559
everything in its line of sight so you

24
00:01:05,260 --> 00:01:03,809
can imagine say we have a hundred

25
00:01:07,640 --> 00:01:05,270
different molecules and they're all

26
00:01:10,270 --> 00:01:07,650
overlaid on each other in one big

27
00:01:13,490 --> 00:01:10,280
spectrum so trying to deconvolution

28
00:01:16,040 --> 00:01:13,500
which molecules are actually in that

29
00:01:19,160 --> 00:01:16,050
spectrum is very very difficult and so

30
00:01:21,140 --> 00:01:19,170
we our lab looks at measuring web-based

31
00:01:23,660 --> 00:01:21,150
rotational spectra so that we can

32
00:01:24,800 --> 00:01:23,670
directly compare it to a radio telescope

33
00:01:27,800 --> 00:01:24,810
data so that we can determine

34
00:01:30,470 --> 00:01:27,810
composition so rotational spectroscopy

35
00:01:34,370 --> 00:01:30,480
is in the gas phase that's the only way

36
00:01:36,980 --> 00:01:34,380
that molecules can rotate but gas phase

37
00:01:39,050 --> 00:01:36,990
model story actually reproduce the

38
00:01:42,890 --> 00:01:39,060

abundances that we observe in space in

39
00:01:45,440 --> 00:01:42,900
space the the accepted theory today is

40
00:01:48,260 --> 00:01:45,450
the surface chemistry of a stellar eye

41
00:01:53,350 --> 00:01:48,270
screens so you have a composition of ice

42
00:01:56,000 --> 00:01:53,360
such as water methanol and nh3 ices and

43
00:01:59,030 --> 00:01:56,010
these come in contact with cosmic rays

44
00:02:01,490 --> 00:01:59,040
UV radiation and it starts to dissociate

45
00:02:04,370 --> 00:02:01,500
these more complex species down into

46
00:02:05,690 --> 00:02:04,380
these radical forms upon upon approach

47
00:02:08,630 --> 00:02:05,700
to a say a protozoa

48
00:02:10,249 --> 00:02:08,640
Cora warmer region these radicals can

49
00:02:12,199 --> 00:02:10,259
migrate in the ice and start to

50
00:02:12,870 --> 00:02:12,209
recombine and that's how we form even

51
00:02:16,110 --> 00:02:12,880
more

52
00:02:18,330 --> 00:02:16,120
by excel getting cc's as this ice warms

53
00:02:19,860 --> 00:02:18,340
up even further these complex molecules

54
00:02:22,170 --> 00:02:19,870
can then be dissolved from the surface

55
00:02:24,240 --> 00:02:22,180
of the ice and that's how we detect the

56
00:02:26,040 --> 00:02:24,250
gas phase and so these four molecules

57
00:02:28,260 --> 00:02:26,050
here dimethyl ether a methyl amine

58
00:02:29,850 --> 00:02:28,270
ethanol and ethylene glycol are

59
00:02:32,760 --> 00:02:29,860
predicted to form from these ice

60
00:02:34,110 --> 00:02:32,770
dissociation products and each for all

61
00:02:36,810 --> 00:02:34,120
four of these have actually been

62
00:02:39,030 --> 00:02:36,820
detected in the interstellar medium so

63
00:02:40,890 --> 00:02:39,040

as I mentioned our target molecule at

64
00:02:42,600 --> 00:02:40,900
the moment is a minima which is also

65
00:02:46,080 --> 00:02:42,610
predicted to form from these these

66
00:02:47,100 --> 00:02:46,090
isotherm dissociation products but I'm

67
00:02:49,290 --> 00:02:47,110
going to give you a little bit of a

68
00:02:51,450 --> 00:02:49,300
rundown on rotational spectroscopy as a

69
00:02:52,860 --> 00:02:51,460
whole because that's what I'm mainly

70
00:02:55,460 --> 00:02:52,870
going to be talking about today just so

71
00:02:57,780 --> 00:02:55,470
you kind of understand I'm talking about

72
00:02:59,340 --> 00:02:57,790
so in the gas phase as I mentioned

73
00:03:01,950 --> 00:02:59,350
molecules are actually able to freely

74
00:03:04,080 --> 00:03:01,960
rotate vibrate and translate all at the

75
00:03:05,960 --> 00:03:04,090
same time so we have if you remember

76
00:03:08,310 --> 00:03:05,970
from undergrad if you ever took P chem

77
00:03:10,260 --> 00:03:08,320
there are three main types of molecular

78
00:03:12,380 --> 00:03:10,270
spectroscopy we have the electronic

79
00:03:14,550 --> 00:03:12,390
spectroscopy which kind of gives us

80
00:03:16,710 --> 00:03:14,560
information on what atoms are in our

81
00:03:18,150 --> 00:03:16,720
system we have vibrational spectroscopy

82
00:03:20,460 --> 00:03:18,160
which gives us functional group

83
00:03:22,470 --> 00:03:20,470
information which is kind of telling us

84
00:03:24,960 --> 00:03:22,480
if we have an O H group or a carboxylic

85
00:03:26,910 --> 00:03:24,970
acid or something like that but

86
00:03:29,070 --> 00:03:26,920
rotational spectroscopy really gives us

87
00:03:31,410 --> 00:03:29,080
that structural fingerprint so if we

88
00:03:33,540 --> 00:03:31,420

have two molecules with the same atoms

89
00:03:35,070 --> 00:03:33,550
in them similar rearrangement but

90
00:03:37,230 --> 00:03:35,080
there's just a slight different

91
00:03:39,050 --> 00:03:37,240
conformational change rotational

92
00:03:42,360 --> 00:03:39,060
spectroscopy can tell us the exact

93
00:03:45,240 --> 00:03:42,370
conformation of a molecule so it's very

94
00:03:50,280 --> 00:03:45,250
very useful in that sense so to give you

95
00:03:51,720 --> 00:03:50,290
an eye the reason that we measure these

96
00:03:54,270 --> 00:03:51,730
different types of molecular

97
00:03:56,390 --> 00:03:54,280
spectroscopy so electronic is kind of

98
00:03:58,920 --> 00:03:56,400
from your visible optical region and up

99
00:04:01,410 --> 00:03:58,930
infrared is where we do our vibrational

100
00:04:04,050 --> 00:04:01,420
spectroscopy and then our radio

101
00:04:05,610 --> 00:04:04,060
microwave submillimetre region is where

102
00:04:07,080 --> 00:04:05,620
we do our rotational spectroscopy which

103
00:04:10,290 --> 00:04:07,090
is where telescopes such as Alma

104
00:04:12,090 --> 00:04:10,300
actually measure so a bit of an energy

105
00:04:14,070 --> 00:04:12,100
level diagram here this bottom one here

106
00:04:15,690 --> 00:04:14,080
is the ground electronic state and then

107
00:04:19,470 --> 00:04:15,700
we have an electronics excited state in

108
00:04:21,870 --> 00:04:19,480
this blue arrow here shows an electronic

109
00:04:24,370 --> 00:04:21,880
transition so it's quite a large energy

110
00:04:27,040 --> 00:04:24,380
gap within these electronic

111
00:04:29,380 --> 00:04:27,050
States we have these vibrational levels

112
00:04:31,750 --> 00:04:29,390
and so you can see here this red one is

113
00:04:33,250 --> 00:04:31,760

a vibrational transition and then within

114
00:04:35,590 --> 00:04:33,260
that again we have rotational

115
00:04:37,660 --> 00:04:35,600
transitions so you can very large

116
00:04:39,430 --> 00:04:37,670
magnitude of different rotational

117
00:04:40,960 --> 00:04:39,440
transitions depending on the electronic

118
00:04:43,300 --> 00:04:40,970
state and the vibrational state and so

119
00:04:45,480 --> 00:04:43,310
forth so it can get quite complex so

120
00:04:48,160 --> 00:04:45,490
starting with the simplest model a

121
00:04:50,530 --> 00:04:48,170
diatomic molecule so imagine you have

122
00:04:52,480 --> 00:04:50,540
two different atoms for rotational

123
00:04:54,460 --> 00:04:52,490
spectroscopy and molecule has to have a

124
00:04:57,520 --> 00:04:54,470
dipole moment and kind of think of that

125
00:04:59,710 --> 00:04:57,530
as having a break in symmetry so for a

126
00:05:02,140 --> 00:04:59,720
diatomic molecule you need two very

127
00:05:03,400 --> 00:05:02,150
different atoms if you have a ch2 for

128
00:05:05,980 --> 00:05:03,410
example if your atoms are the same

129
00:05:07,930 --> 00:05:05,990
you're not going to see it and see if

130
00:05:09,550 --> 00:05:07,940
you can imagine there's two axes running

131
00:05:11,650 --> 00:05:09,560
through so this one coming through here

132
00:05:14,200 --> 00:05:11,660
and say there's an axis going straight

133
00:05:17,560 --> 00:05:14,210
through the bond here if your molecule

134
00:05:18,760 --> 00:05:17,570
rotates around the bond axis you're not

135
00:05:21,700 --> 00:05:18,770
going to see anything so nothing's

136
00:05:23,560 --> 00:05:21,710
really changing right but if you drew an

137
00:05:25,720 --> 00:05:23,570
axis through here and your molecule

138
00:05:26,980 --> 00:05:25,730

rotates about the center of mass you're

139
00:05:28,150 --> 00:05:26,990
gonna see and change the dipole moment

140
00:05:31,210 --> 00:05:28,160
because your molecule is actually

141
00:05:33,280 --> 00:05:31,220
changing orientation diatomic molecules

142
00:05:35,050 --> 00:05:33,290
are quite simple in their spectra they

143
00:05:38,320 --> 00:05:35,060
have very even space energy level

144
00:05:40,750 --> 00:05:38,330
spacings we refer to them as two B where

145
00:05:42,820 --> 00:05:40,760
B is just your rotational constant which

146
00:05:44,710 --> 00:05:42,830
is input inversely proportional to your

147
00:05:47,020 --> 00:05:44,720
moment of inertia of your system so you

148
00:05:49,330 --> 00:05:47,030
get quite even spacings of your your

149
00:05:51,850 --> 00:05:49,340
transitions when you get to a more

150
00:05:53,500 --> 00:05:51,860
complex polyatomic system you need three

151
00:05:57,370 --> 00:05:53,510
different axes to define your molecule

152
00:05:59,860 --> 00:05:57,380
and we define molecules based on these

153
00:06:01,660 --> 00:05:59,870
moments of inertia so starting with your

154
00:06:03,280 --> 00:06:01,670
little linear molecule just like with

155
00:06:05,620 --> 00:06:03,290
your day I'll make an ax in a very

156
00:06:06,880 --> 00:06:05,630
similar way you move to a spherical top

157
00:06:09,550 --> 00:06:06,890
to something that is completely

158
00:06:11,350 --> 00:06:09,560
symmetric you can't see that and then

159
00:06:12,310 --> 00:06:11,360
you have your symmetric top which is

160
00:06:15,100 --> 00:06:12,320
where it starts getting a little bit

161
00:06:16,480 --> 00:06:15,110
more complicated so symmetric top is

162
00:06:19,570 --> 00:06:16,490
defined in two different ways

163
00:06:22,360 --> 00:06:19,580

which is just related to which moment of

164
00:06:24,490 --> 00:06:22,370
inertia which axis actually has a unique

165
00:06:26,320 --> 00:06:24,500
moment of inertia from there we move on

166
00:06:28,210 --> 00:06:26,330
to our asymmetric top which is the most

167
00:06:30,580 --> 00:06:28,220
complex situation that we can have for

168
00:06:35,200 --> 00:06:30,590
example just this water molecule with

169
00:06:37,000 --> 00:06:35,210
three atoms three different atoms has is

170
00:06:37,869 --> 00:06:37,010
an asymmetric top and has a very very

171
00:06:40,139 --> 00:06:37,879
complicated

172
00:06:42,159 --> 00:06:40,149
even though it's a very simple molecule

173
00:06:43,899 --> 00:06:42,169
so to give you an idea what they might

174
00:06:46,029 --> 00:06:43,909
look like compared to the diatomic

175
00:06:47,709 --> 00:06:46,039
spectrum I showed you before we get a

176
00:06:51,399 --> 00:06:47,719
very very complex spectrum this is the

177
00:06:53,169 --> 00:06:51,409
spectrum of glycol out and these are the

178
00:06:54,699 --> 00:06:53,179
magnitude of rotational constants that

179
00:06:56,350 --> 00:06:54,709
you need to fit something like an

180
00:06:58,239 --> 00:06:56,360
asymmetric top so as I showed before

181
00:07:00,549 --> 00:06:58,249
with the diatomic molecule you just need

182
00:07:02,109 --> 00:07:00,559
that B rotational constant whereas for

183
00:07:04,119 --> 00:07:02,119
an asymmetric top it gets much more

184
00:07:06,929 --> 00:07:04,129
complicated so we really need these

185
00:07:09,879 --> 00:07:06,939
laboratory-based spectra to try and fit

186
00:07:11,679 --> 00:07:09,889
imagine if you had a hundred of spectra

187
00:07:13,629 --> 00:07:11,689
like these overlaid on top of each other

188
00:07:17,469 --> 00:07:13,639

we need to try and decom believe that so

189
00:07:19,869 --> 00:07:17,479
that's what we do as I mentioned target

190
00:07:21,399 --> 00:07:19,879
molecules and you know methanol it's of

191
00:07:22,869 --> 00:07:21,409
prebiotic importance which is why we're

192
00:07:25,989 --> 00:07:22,879
interested in it specifically it's the

193
00:07:27,759 --> 00:07:25,999
precursor to glycine it's been predicted

194
00:07:30,009 --> 00:07:27,769
to be stable under interstellar

195
00:07:32,079 --> 00:07:30,019
conditions but it's very unstable under

196
00:07:34,089 --> 00:07:32,089
terrestrial conditions so you can't buy

197
00:07:35,949 --> 00:07:34,099
it in a bottle and even when you make it

198
00:07:38,499 --> 00:07:35,959
it dissociates and reacts away so

199
00:07:40,629 --> 00:07:38,509
quickly that we need to measure it

200
00:07:42,579 --> 00:07:40,639
almost exactly as we're making it so

201
00:07:44,079 --> 00:07:42,589
it's a very very different difficult way

202
00:07:46,959 --> 00:07:44,089
to try and make something and detect it

203
00:07:48,249 --> 00:07:46,969
at the same time as I mentioned it's

204
00:07:51,129 --> 00:07:48,259
predicted to form from interstellar

205
00:07:53,049 --> 00:07:51,139
green surface chemistry and there is no

206
00:07:57,009 --> 00:07:53,059
rotational spectrum of this molecule at

207
00:07:58,959 --> 00:07:57,019
all yes so the way that we proposed to

208
00:08:00,639 --> 00:07:58,969
make amino methanol is using a technique

209
00:08:03,309 --> 00:08:00,649
called it o singlet D insertion

210
00:08:05,049 --> 00:08:03,319
chemistry so a thing that we are going

211
00:08:07,089 --> 00:08:05,059
to that on the next slide but it's just

212
00:08:09,369 --> 00:08:07,099
an excited state of atomic oxygen and

213
00:08:12,939 --> 00:08:09,379

it's been shown in the past too readily

214
00:08:15,519 --> 00:08:12,949
insert into HX bonds where H is hydrogen

215
00:08:18,159 --> 00:08:15,529
and then X can be anything from carbon

216
00:08:20,109 --> 00:08:18,169
nitrogen oxygen or another hydrogen it's

217
00:08:21,699 --> 00:08:20,119
been shown that it has some kind of

218
00:08:23,559 --> 00:08:21,709
preference for carbon hydrogen months

219
00:08:26,079 --> 00:08:23,569
but it can absolutely insert into

220
00:08:27,989 --> 00:08:26,089
different ones so we propose to use the

221
00:08:30,639 --> 00:08:27,999
carbon hydrogen insertion of a singlet D

222
00:08:32,589 --> 00:08:30,649
into methyl amine to form amino methanol

223
00:08:35,740 --> 00:08:32,599
on the fly and then measure it as we're

224
00:08:37,990 --> 00:08:35,750
making it so as I mentioned I D is the

225
00:08:40,449 --> 00:08:38,000
first excited state atomic oxygen its

226
00:08:41,800 --> 00:08:40,459
ground state is a triplet P all I really

227
00:08:43,480 --> 00:08:41,810
want you to get away from this is

228
00:08:46,389 --> 00:08:43,490
singlet and triplet so singlet means

229
00:08:48,160 --> 00:08:46,399
your electrons are all paired and then

230
00:08:51,130 --> 00:08:48,170
in a triplet state you have two unpaired

231
00:08:53,769 --> 00:08:51,140
electrons but for reaction to occur

232
00:08:56,319 --> 00:08:53,779
the surfaces of these these molecules of

233
00:08:58,690 --> 00:08:56,329
these atoms have to overlap them the

234
00:08:59,949 --> 00:08:58,700
only way they can overlap is we're not

235
00:09:02,019 --> 00:08:59,959
the only way but what is that they have

236
00:09:04,240 --> 00:09:02,029
to have the same spin in order to

237
00:09:05,920 --> 00:09:04,250
overlap so a carbon hydrogen or

238
00:09:07,870 --> 00:09:05,930

molecular orbital all of our electrons

239
00:09:10,240 --> 00:09:07,880
are paired and so this surface only

240
00:09:12,130 --> 00:09:10,250
overlaps with our singlet D surface it

241
00:09:14,019 --> 00:09:12,140
doesn't overlap with the triplet piece

242
00:09:17,199 --> 00:09:14,029
so we can't have that insertion occur in

243
00:09:19,300 --> 00:09:17,209
the triplet piece state and since spin

244
00:09:22,210 --> 00:09:19,310
flip is forbidden in this action or in

245
00:09:24,730 --> 00:09:22,220
most cases so the way actually happens

246
00:09:26,380 --> 00:09:24,740
is the oxygen actually takes an electron

247
00:09:28,960 --> 00:09:26,390
from the carbon hydrogen highest

248
00:09:31,210 --> 00:09:28,970
occupied molecular orbital which is

249
00:09:32,650 --> 00:09:31,220
actually a bonding orbital so by taking

250
00:09:34,810 --> 00:09:32,660
that electron out of a bonding orbital

251
00:09:36,910 --> 00:09:34,820
you're decreasing that bond order so

252
00:09:40,660 --> 00:09:36,920
that bond breaks it gets weak it breaks

253
00:09:42,160 --> 00:09:40,670
and the oxygen is able to insert so a

254
00:09:44,199 --> 00:09:42,170
little bit on how we actually do that in

255
00:09:46,600 --> 00:09:44,209
the lab so this is a picture of my

256
00:09:48,009 --> 00:09:46,610
chamber we have a vacuum chamber we have

257
00:09:51,069 --> 00:09:48,019
my laser coming in and we have this

258
00:09:52,329 --> 00:09:51,079
silicon tube here I have a above my

259
00:09:54,310 --> 00:09:52,339
chamber I have a reaction mechanism

260
00:09:57,340 --> 00:09:54,320
where it makes all my molecules together

261
00:10:02,199 --> 00:09:57,350
and I mix ozone argon and methylene

262
00:10:03,910 --> 00:10:02,209
together they enter this tube and that's

263
00:10:06,189 --> 00:10:03,920

where they interact with the laser so

264
00:10:08,410 --> 00:10:06,199
the laser is specifically to interact

265
00:10:11,170 --> 00:10:08,420
with the ozone the ozone at 248

266
00:10:13,329 --> 00:10:11,180
nanometers breaks apart into O singlet D

267
00:10:15,220 --> 00:10:13,339
and therefore while in this tube the O

268
00:10:17,590 --> 00:10:15,230
singlet D can insert into methylamine

269
00:10:19,960 --> 00:10:17,600
for Mamina methanol and then we push it

270
00:10:21,340 --> 00:10:19,970
into our vacuum chamber this difference

271
00:10:24,340 --> 00:10:21,350
in pressure gradient causes it to

272
00:10:25,960 --> 00:10:24,350
rapidly expand which prevents further

273
00:10:27,790 --> 00:10:25,970
reactions from occurring and it also

274
00:10:29,920 --> 00:10:27,800
actually results in rotational and

275
00:10:31,630 --> 00:10:29,930
vibrational cooling of the molecules so

276
00:10:33,910 --> 00:10:31,640
that we can prove these low-lying

277
00:10:35,380 --> 00:10:33,920
rotational States and also the

278
00:10:38,620 --> 00:10:35,390
vibrational calling can prevent it from

279
00:10:39,880 --> 00:10:38,630
further dissociating we then improve the

280
00:10:42,310 --> 00:10:39,890
supersonic expansion with our

281
00:10:45,730 --> 00:10:42,320
submillimetre light and then detect the

282
00:10:47,740 --> 00:10:45,740
spectrum from there so in the past this

283
00:10:49,930 --> 00:10:47,750
technique specifically has been shown to

284
00:10:52,780 --> 00:10:49,940
work to produce methanol from a singlet

285
00:10:55,780 --> 00:10:52,790
the insertion into methane and here's

286
00:10:57,310 --> 00:10:55,790
just a few transitions of methanol to

287
00:10:58,110 --> 00:10:57,320
proof that it was actually methanol that

288
00:11:00,790 --> 00:10:58,120

we're making

289
00:11:02,949 --> 00:11:00,800
but methanol is quite stable so we

290
00:11:04,060 --> 00:11:02,959
wanted to show that an unstable species

291
00:11:06,040 --> 00:11:04,070
like immune and ethanol

292
00:11:08,650 --> 00:11:06,050
example can actually format something

293
00:11:10,510 --> 00:11:08,660
that's been obviously observed before so

294
00:11:12,730 --> 00:11:10,520
they form vinyl alcohol using a singlet

295
00:11:16,000 --> 00:11:12,740
D insertion into ethylene and again you

296
00:11:18,040 --> 00:11:16,010
can see that was successful so Nina

297
00:11:19,900 --> 00:11:18,050
methanol looking at the reaction energy

298
00:11:22,090 --> 00:11:19,910
diagram as I mentioned earlier singlet

299
00:11:25,060 --> 00:11:22,100
do you can insert insert into more than

300
00:11:28,420 --> 00:11:25,070
just the carbon hydrogen bond so we did

301
00:11:30,040 --> 00:11:28,430
a reaction profile energy diagram so

302
00:11:33,010 --> 00:11:30,050
that o singlet D inserts into the methyl

303
00:11:36,130 --> 00:11:33,020
amine and gives off a lot of energy and

304
00:11:38,590 --> 00:11:36,140
amino methanol is the most energy stable

305
00:11:40,840 --> 00:11:38,600
molecule it does give up about 152

306
00:11:43,780 --> 00:11:40,850
kilocalories per mole which will become

307
00:11:45,340 --> 00:11:43,790
important later on in my talk but the

308
00:11:49,600 --> 00:11:45,350
fact that it's the lowest energy species

309
00:11:52,980 --> 00:11:49,610
is likely to mean it's the highest the

310
00:11:55,480 --> 00:11:52,990
most prominent molecule in our spectrum

311
00:11:58,450 --> 00:11:55,490
from now use computational chemistry

312
00:11:59,920 --> 00:11:58,460
techniques so we just ran a theoretical

313
00:12:01,750 --> 00:11:59,930

calculation and grabbed out the

314
00:12:03,700 --> 00:12:01,760
rotational constants in the structure of

315
00:12:05,740 --> 00:12:03,710
the molecule the optimal structure and

316
00:12:07,120 --> 00:12:05,750
it gives us an ID so we simulate this

317
00:12:08,890 --> 00:12:07,130
spectrum using these rotational

318
00:12:10,420 --> 00:12:08,900
constants and it gives us an idea of

319
00:12:12,490 --> 00:12:10,430
where to look in our spectrum what sort

320
00:12:14,230 --> 00:12:12,500
of lines we're looking for maybe what

321
00:12:16,270 --> 00:12:14,240
region we should be expecting them to be

322
00:12:17,920 --> 00:12:16,280
in and then once we get the spectrum we

323
00:12:20,860 --> 00:12:17,930
can we can refine it from there you

324
00:12:22,210 --> 00:12:20,870
think this is our start point so

325
00:12:24,430 --> 00:12:22,220
starting with ozone as I mentioned

326
00:12:26,890 --> 00:12:24,440
that's my singlet D precursor here you

327
00:12:30,160 --> 00:12:26,900
can see we're detecting it and how in

328
00:12:32,170 --> 00:12:30,170
our system if I sit my frequency on the

329
00:12:35,010 --> 00:12:32,180
center of this transition here and

330
00:12:37,180 --> 00:12:35,020
monitor over time so the way that we

331
00:12:39,040 --> 00:12:37,190
introduce our molecules into the chamber

332
00:12:40,660 --> 00:12:39,050
is using a pulsed valve so actually

333
00:12:43,000 --> 00:12:40,670
pulses the gas into the chamber

334
00:12:45,520 --> 00:12:43,010
so as the pulsar opens at time zero you

335
00:12:47,140 --> 00:12:45,530
get this influx of ozone into the

336
00:12:49,060 --> 00:12:47,150
chamber which is what this is showing

337
00:12:51,310 --> 00:12:49,070
here and as your pulse valve closes your

338
00:12:52,600 --> 00:12:51,320

signal goes away at about this time here

339
00:12:55,930 --> 00:12:52,610
unfortunately this frequency doesn't

340
00:12:57,610 --> 00:12:55,940
show up the laser RFI but we do get an

341
00:13:00,850 --> 00:12:57,620
ozone signal depletion which is

342
00:13:02,770 --> 00:13:00,860
indicative of forming a single D from

343
00:13:04,300 --> 00:13:02,780
there we started it's been a while since

344
00:13:06,850 --> 00:13:04,310
this chamber had run an experiment like

345
00:13:09,000 --> 00:13:06,860
this so we went back to methanol to make

346
00:13:12,100 --> 00:13:09,010
sure we were still successfully

347
00:13:13,780 --> 00:13:12,110
inserting our singlet D so we introduced

348
00:13:16,450 --> 00:13:13,790
methane into the chamber with the ozone

349
00:13:17,180 --> 00:13:16,460
you can see here after that laser fires

350
00:13:21,559 --> 00:13:17,190
you can see that

351
00:13:24,800 --> 00:13:21,569
by again this is in time we start

352
00:13:27,009 --> 00:13:24,810
getting it influx of methanol signal and

353
00:13:29,480 --> 00:13:27,019
if you measure a multitude of different

354
00:13:32,300 --> 00:13:29,490
methanol transitions we are in fact

355
00:13:33,920 --> 00:13:32,310
making methanol but it's important to

356
00:13:36,350 --> 00:13:33,930
note that we have to use very specific

357
00:13:38,150 --> 00:13:36,360
techniques to train hone in on this

358
00:13:39,980 --> 00:13:38,160
signal because there's so much dead time

359
00:13:42,499 --> 00:13:39,990
when our molecule of interest actually

360
00:13:44,840 --> 00:13:42,509
isn't there so that makes spectral

361
00:13:46,340 --> 00:13:44,850
acquisition quite slow so I remove the

362
00:13:49,220 --> 00:13:46,350
methane from the system and decided to

363
00:13:51,350 --> 00:13:49,230

introduce the methylamine so here's just

364
00:13:52,610 --> 00:13:51,360
a snippet of a band wide scan which is

365
00:13:55,400 --> 00:13:52,620
how far we've come so far

366
00:13:57,740 --> 00:13:55,410
we've gone from about 140 to 200 25

367
00:14:00,259 --> 00:13:57,750
gigahertz he's just sniff it and you can

368
00:14:01,970 --> 00:14:00,269
see a multitude of different transitions

369
00:14:03,439 --> 00:14:01,980
in here and as you zoom in closer

370
00:14:06,259 --> 00:14:03,449
there's even more down in the noise

371
00:14:09,350 --> 00:14:06,269
there but so far all we've been able to

372
00:14:12,559 --> 00:14:09,360
identify is formaldehyde here's just the

373
00:14:15,800 --> 00:14:12,569
time and then the molecular signal with

374
00:14:17,119 --> 00:14:15,810
an amine and hydrogen cyanide we haven't

375
00:14:18,470 --> 00:14:17,129
been able to assign some of the other

376
00:14:21,110 --> 00:14:18,480
wines yet we're still working on that

377
00:14:23,900 --> 00:14:21,120
but these molecules are quite important

378
00:14:26,210 --> 00:14:23,910
because in a paper in 2005 by Feldman

379
00:14:28,790 --> 00:14:26,220
out at our he showed the dissociation

380
00:14:30,530 --> 00:14:28,800
pathways of amino methanol and if you

381
00:14:32,389 --> 00:14:30,540
can surmount a barrier of about 50

382
00:14:33,740 --> 00:14:32,399
kilocalories per mole which as I

383
00:14:35,990 --> 00:14:33,750
mentioned earlier that o singlet D

384
00:14:38,179 --> 00:14:36,000
reaction gives off about 150

385
00:14:40,639 --> 00:14:38,189
kilocalories per mole of energy we do

386
00:14:43,990 --> 00:14:40,649
actually dissociate into the main the

387
00:14:46,490 --> 00:14:44,000
main pathways formaldehyde and nh3 and

388
00:14:48,410 --> 00:14:46,500

methane amine and water so they are

389
00:14:50,720 --> 00:14:48,420
actually the molecules at least these

390
00:14:52,939 --> 00:14:50,730
two that we're seeing in our spectrum so

391
00:14:54,139 --> 00:14:52,949
we believe that we are actually making a

392
00:14:56,780 --> 00:14:54,149
mean a methanol while we haven't

393
00:14:58,970 --> 00:14:56,790
confirmed our detection yet but we think

394
00:15:01,819 --> 00:14:58,980
it's just associating before enters the

395
00:15:03,799 --> 00:15:01,829
chamber so we think maybe our lasers a

396
00:15:05,210 --> 00:15:03,809
little bit too high up that tube so

397
00:15:07,160 --> 00:15:05,220
maybe we're giving it a little bit too

398
00:15:10,280 --> 00:15:07,170
much time to react in the tube before it

399
00:15:11,990 --> 00:15:10,290
enters the expansion and so we're going

400
00:15:14,179 --> 00:15:12,000
to do some chemistry experiments and

401
00:15:16,369 --> 00:15:14,189
laser chemistry and rest of the tree but

402
00:15:19,160 --> 00:15:16,379
often rathalu laser up and down the tube

403
00:15:21,230 --> 00:15:19,170
to see if our chemistry changes from

404
00:15:23,240 --> 00:15:21,240
there obviously once we confirm the

405
00:15:25,460 --> 00:15:23,250
amino methanol detection we want to

406
00:15:29,059 --> 00:15:25,470
provide these rotational constants so

407
00:15:29,900 --> 00:15:29,069
that we can hope the community trying to

408
00:15:33,680 --> 00:15:29,910
TechEd it in the

409
00:15:35,030 --> 00:15:33,690
so medium from telescope observations we

410
00:15:36,820 --> 00:15:35,040
are having a little bit of trouble so

411
00:15:38,720 --> 00:15:36,830
Arizona is obviously very very active

412
00:15:43,010 --> 00:15:38,730
specifically it reacts very strongly

413
00:15:44,510 --> 00:15:43,020

with methylamine and and also we have

414
00:15:46,430 --> 00:15:44,520
like oxygen in the system there's so

415
00:15:48,050 --> 00:15:46,440
many other reactions that can be

416
00:15:51,080 --> 00:15:48,060
occurring and forming molecules in our

417
00:15:52,610 --> 00:15:51,090
system so one way we've thought to

418
00:15:54,860 --> 00:15:52,620
simplify our spectrum to hopefully

419
00:15:57,260 --> 00:15:54,870
detect it rather than react it away is

420
00:15:59,330 --> 00:15:57,270
to trap the ozone on silica beads

421
00:16:02,330 --> 00:15:59,340
because we do have our ozone generator

422
00:16:04,250 --> 00:16:02,340
creates about 1% ozone and o2 mixture

423
00:16:06,440 --> 00:16:04,260
and so if we can trap it on the beads we

424
00:16:09,560 --> 00:16:06,450
can remove that whole plethora of

425
00:16:11,090 --> 00:16:09,570
reactions from there so that's it for

426
00:16:12,320 --> 00:16:11,100
now I want to give a big shout out to

427
00:16:14,840 --> 00:16:12,330
the rest of the whiticus we've accrued

428
00:16:15,500 --> 00:16:14,850
specifically chase who's now my partner

429
00:16:17,240 --> 00:16:15,510
on the project

430
00:16:18,680 --> 00:16:17,250
I want to thank NASA for all the funding

431
00:16:20,640 --> 00:16:18,690
and the previous students who worked on

432
00:16:27,790 --> 00:16:20,650
the project

433
00:16:44,380 --> 00:16:42,230
Ian Mason talk we have a high 12 so what

434
00:16:47,960 --> 00:16:44,390
kind of detector are you using after

435
00:16:49,820 --> 00:16:47,970
step 3 this one yeah that's a hot

436
00:16:52,940 --> 00:16:49,830
electron thermometer it's set in Z so

437
00:16:54,620 --> 00:16:52,950
how much I like all your data happens in

438
00:17:16,750 --> 00:16:54,630

a matter of seconds

439
00:17:29,020 --> 00:17:23,620
for the computational hot wait sorry my

440
00:17:38,799 --> 00:17:29,030
bed for this one the which hydrogen

441
00:17:40,539 --> 00:17:38,809
bonds oh yes that was considered this

442
00:17:42,190 --> 00:17:40,549
calculation was done by a previous

443
00:17:45,520 --> 00:17:42,200
graduate student but I believe he did

444
00:17:47,190 --> 00:17:45,530
consider that but we ran a bunch of

445
00:17:51,190 --> 00:17:47,200
different calculations at different

446
00:17:54,640 --> 00:17:51,200
Theory levels to get the right yeah

447
00:17:58,419 --> 00:17:54,650
right to get the most likely structure

448
00:18:00,159 --> 00:17:58,429
for that but we are we are working on

449
00:18:01,899 --> 00:18:00,169
trying to improve this so we do get

450
00:18:04,390 --> 00:18:01,909
what's called hyperfine splitting in our

451
00:18:06,490 --> 00:18:04,400
spectrum so we're trying to add more

452
00:18:28,460 --> 00:18:06,500
terms to this calculation to try and get

453
00:18:44,270 --> 00:18:36,080
this energy difference oh I see it's

454
00:18:46,840 --> 00:18:44,280
easy um this is a various reaction all