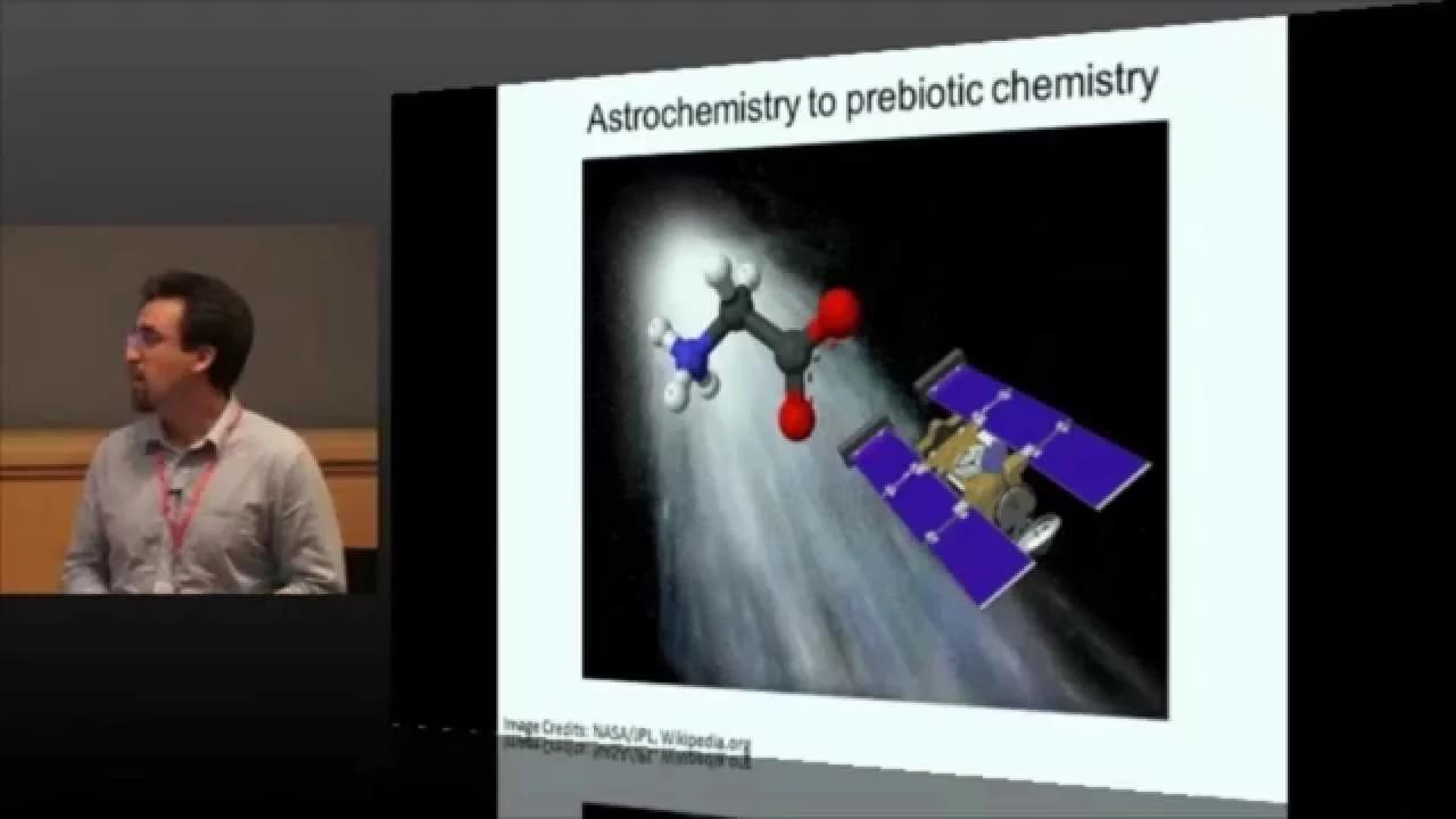
Astrochemistry to prebiotic chemistry
Image Credits: NASA/JPL, Wikipedia.org

1
00:00:10,289 --> 00:00:08,640
all right Thank You Brett and thank you

2
00:00:13,289 --> 00:00:10,299
to the AB grad Con organizers this has

3
00:00:14,730 --> 00:00:13,299
been rfg was a lot of fun and I'm

4
00:00:17,010 --> 00:00:14,740
looking forward to the rest of AB grad

5
00:00:19,440 --> 00:00:17,020
con so I'd like to really talk to you

6
00:00:21,600 --> 00:00:19,450
about complex molecule formation and

7
00:00:23,790 --> 00:00:21,610
terahertz spectroscopy and really this

8
00:00:25,830 --> 00:00:23,800
is all about Astra chemistry so Brett

9
00:00:27,060 --> 00:00:25,840
gave a really great warm up talk so I

10
00:00:28,800 --> 00:00:27,070
think you guys actually have a lot of

11
00:00:32,070 --> 00:00:28,810
the basics actually he stoled a lot of

12
00:00:33,720 --> 00:00:32,080
my thunder so what I'm going to really

13
00:00:36,930 --> 00:00:33,730

tell you about is the importance of

14
00:00:39,450 --> 00:00:36,940
molecules really we think in how life

15
00:00:40,950 --> 00:00:39,460
came to exist on this planet so we've

16
00:00:43,290 --> 00:00:40,960
just heard a bit about protoplanetary

17
00:00:45,750 --> 00:00:43,300
disks so this is a artists cartoon of

18
00:00:48,060 --> 00:00:45,760
one when you go from say a

19
00:00:49,529 --> 00:00:48,070
protoplanetary disc to a solar system we

20
00:00:52,920 --> 00:00:49,539
understand pretty well the role that

21
00:00:55,500 --> 00:00:52,930
molecules play but what was less clear

22
00:00:57,060 --> 00:00:55,510
is if you have a solar system and a

23
00:00:59,369 --> 00:00:57,070
solar system like ours we know we have

24
00:01:00,840 --> 00:00:59,379
life right so really one of the

25
00:01:03,479 --> 00:01:00,850
important questions in Astro chemistry

26
00:01:06,600 --> 00:01:03,489
is how do you go from a solar system to

27
00:01:09,480 --> 00:01:06,610
a solar system with life and really

28
00:01:11,609 --> 00:01:09,490
we're encouraged that we can learn

29
00:01:14,010 --> 00:01:11,619
something from the chemistry of space

30
00:01:15,660 --> 00:01:14,020
that will tell us about life on say a

31
00:01:18,330 --> 00:01:15,670
planet like Earth because of the

32
00:01:21,150 --> 00:01:18,340
Stardust mission and when we you know we

33
00:01:25,980 --> 00:01:21,160
know that now that we've seen glycine in

34
00:01:28,760 --> 00:01:25,990
the cometary tail of the comet that

35
00:01:31,589 --> 00:01:28,770
Stardust sampled and this gives us

36
00:01:33,839 --> 00:01:31,599
really a thought that well okay complex

37
00:01:35,490 --> 00:01:33,849
molecules are forming in space so maybe

38
00:01:37,109 --> 00:01:35,500

one of the important ways that we

39
00:01:38,880 --> 00:01:37,119
actually wind up with the precursors of

40
00:01:42,359 --> 00:01:38,890
life the prebiotic species that we need

41
00:01:43,859 --> 00:01:42,369
are some complex molecule formation in

42
00:01:46,680 --> 00:01:43,869
space that is then subsequently

43
00:01:48,630 --> 00:01:46,690
delivered to a planet and so if we

44
00:01:50,520 --> 00:01:48,640
really want to then understand complex

45
00:01:52,350 --> 00:01:50,530
chemistry in space the place that we

46
00:01:55,770 --> 00:01:52,360
have to think about our icy death

47
00:01:58,199 --> 00:01:55,780
screens if you remember something about

48
00:02:00,870 --> 00:01:58,209
chemistry at some point you might have

49
00:02:03,059 --> 00:02:00,880
or even physics to have three three

50
00:02:05,699 --> 00:02:03,069
different species come together and all

51
00:02:07,139 --> 00:02:05,709
hit each other at the same time it's not

52
00:02:08,760 --> 00:02:07,149
a straightforward process and in the

53
00:02:11,010 --> 00:02:08,770
case of having them hitting each other

54
00:02:13,949 --> 00:02:11,020
and then react that's going to be a very

55
00:02:15,810 --> 00:02:13,959
rare event but if you have say a third

56
00:02:16,920 --> 00:02:15,820
body like a dust grain that's just

57
00:02:18,720 --> 00:02:16,930
floating around you can have some

58
00:02:20,610 --> 00:02:18,730
molecule come down and stick to its

59
00:02:22,530 --> 00:02:20,620
surface now it's there first

60
00:02:24,660 --> 00:02:22,540
amount of time if another molecule comes

61
00:02:26,339 --> 00:02:24,670
down it can diffuse around find it on

62
00:02:30,690 --> 00:02:26,349
this guy who is sitting there first and

63
00:02:31,770 --> 00:02:30,700

react over the course of time you and by

64
00:02:34,440 --> 00:02:31,780
time we're talking about millions of

65
00:02:36,990 --> 00:02:34,450
years in you know a star-forming system

66
00:02:38,910 --> 00:02:37,000
you can build up a layer of ice on the

67
00:02:41,100 --> 00:02:38,920
surface of this dust grain and the

68
00:02:43,190 --> 00:02:41,110
molecules that are on this surface will

69
00:02:45,899 --> 00:02:43,200
affect the the subsequent chemistry and

70
00:02:48,680 --> 00:02:45,909
this is really what we're thinking about

71
00:02:51,420 --> 00:02:48,690
in our lab so we want to investigate

72
00:02:53,369 --> 00:02:51,430
Isis and we're going to take we're not

73
00:02:55,440 --> 00:02:53,379
going to try to actually say we are

74
00:02:57,720 --> 00:02:55,450
gonna make what's in space no we're

75
00:03:00,330 --> 00:02:57,730
gonna go simpler we're going to try and

76
00:03:02,729 --> 00:03:00,340
look at simple things and slowly build

77
00:03:05,009 --> 00:03:02,739
up into a bigger and bigger picture so

78
00:03:06,839 --> 00:03:05,019
that we can understand and try to

79
00:03:09,300 --> 00:03:06,849
disentangle the complex picture that's

80
00:03:12,059 --> 00:03:09,310
happening in space from laboratory

81
00:03:13,259 --> 00:03:12,069
experiments and again this is important

82
00:03:15,030 --> 00:03:13,269
because if you want to make anything

83
00:03:17,610 --> 00:03:15,040
more complicated than as Brett was

84
00:03:19,020 --> 00:03:17,620
saying methyl formate or methanol there

85
00:03:20,640 --> 00:03:19,030
is no way that you can do this in the

86
00:03:22,619 --> 00:03:20,650
gas phase so we really need to look at

87
00:03:24,210 --> 00:03:22,629
Isis so in order for me to take you

88
00:03:26,039 --> 00:03:24,220

there I do have to take you through a

89
00:03:28,800 --> 00:03:26,049
quick diversion to the electromagnetic

90
00:03:30,720 --> 00:03:28,810
spectrum and the region that I'm gonna

91
00:03:32,460 --> 00:03:30,730
be focusing on here is what I call the

92
00:03:35,670 --> 00:03:32,470
terahertz region or it's often known as

93
00:03:37,289 --> 00:03:35,680
the far infrared and the reason is the

94
00:03:39,539 --> 00:03:37,299
far infrared is because you come down

95
00:03:41,550 --> 00:03:39,549
from the visible and the near IR mid IR

96
00:03:44,490 --> 00:03:41,560
you hit the far infrared and it's a

97
00:03:47,190 --> 00:03:44,500
region that really corresponds to low

98
00:03:49,470 --> 00:03:47,200
energy vibrations and solids long range

99
00:03:51,689 --> 00:03:49,480
interactions you need lots of molecules

100
00:03:55,409 --> 00:03:51,699
participating in in order to actually

101
00:03:56,550 --> 00:03:55,419
see these vibrational modes and it's

102
00:03:58,470 --> 00:03:56,560
kind of an interesting region because

103
00:04:00,449 --> 00:03:58,480
historically it's been a difficult place

104
00:04:02,309 --> 00:04:00,459
to actually make making detect photons

105
00:04:03,689 --> 00:04:02,319
and so we're excited to be working here

106
00:04:05,849 --> 00:04:03,699
because there's a lot of new stuff to

107
00:04:07,259 --> 00:04:05,859
learn the reason why it's important for

108
00:04:09,119 --> 00:04:07,269
a stroke a mystery however is that

109
00:04:10,439 --> 00:04:09,129
fundamentally there are things that we

110
00:04:12,270 --> 00:04:10,449
can learn from terahertz spectroscopy

111
00:04:14,610 --> 00:04:12,280
that we'll never be able to learn from

112
00:04:17,279 --> 00:04:14,620
the near infrared so if you take this

113
00:04:19,020 --> 00:04:17,289

nice picture of an edge on disk as taken

114
00:04:22,050 --> 00:04:19,030
by the Hubble Space Telescope you can

115
00:04:23,310 --> 00:04:22,060
see in the middle here it's black and

116
00:04:25,589 --> 00:04:23,320
that's because even though there is a

117
00:04:27,810 --> 00:04:25,599
star at the center of this disk that's

118
00:04:30,540 --> 00:04:27,820
giving off lots of light there's so much

119
00:04:32,430 --> 00:04:30,550
material it's so dense through that

120
00:04:34,409 --> 00:04:32,440
section that we don't see any light

121
00:04:37,830 --> 00:04:34,419
making it to our tell us

122
00:04:39,780 --> 00:04:37,840
so if we actually have all this stuff

123
00:04:41,340 --> 00:04:39,790
there and we want to learn something

124
00:04:42,379 --> 00:04:41,350
about say maybe the colder part of the

125
00:04:45,000 --> 00:04:42,389
disk

126
00:04:47,520 --> 00:04:45,010
we'd like there to be some thermal

127
00:04:50,400 --> 00:04:47,530
excitation of molecules that would then

128
00:04:52,770 --> 00:04:50,410
emit photons we can detect if we want to

129
00:04:54,420 --> 00:04:52,780
look at Isis those need to be cold

130
00:04:56,370 --> 00:04:54,430
temperatures and if you just take a look

131
00:04:58,409 --> 00:04:56,380
at my math here at the bottom if we're

132
00:05:00,090 --> 00:04:58,419
looking or at somewhere in the mid

133
00:05:01,620 --> 00:05:00,100
infrared around you know a thousand wave

134
00:05:03,870 --> 00:05:01,630
numbers in order to have thermal

135
00:05:05,550 --> 00:05:03,880
excitation and actually see emission

136
00:05:07,409 --> 00:05:05,560
from the outer region of the disk the

137
00:05:09,990 --> 00:05:07,419
disk would have to be around 1400 Kelvin

138
00:05:11,820 --> 00:05:10,000

there's not going to be any ice at 1400

139
00:05:13,740 --> 00:05:11,830
Kelvin so we have to go to the terahertz

140
00:05:15,600 --> 00:05:13,750
and that's why there are things we can

141
00:05:19,740 --> 00:05:15,610
learn there that we can't learn anywhere

142
00:05:21,570 --> 00:05:19,750
else so what do I actually do so I have

143
00:05:23,760 --> 00:05:21,580
a vacuum chamber in my laboratory and

144
00:05:25,529 --> 00:05:23,770
inside I have a substrate and I can cool

145
00:05:27,300 --> 00:05:25,539
that substrate all the way down to 10

146
00:05:30,210 --> 00:05:27,310
Kelvin I can control the temperature

147
00:05:32,700 --> 00:05:30,220
between 10 Kelvin at about 300 Kelvin

148
00:05:34,379 --> 00:05:32,710
and I have this little pipe here that is

149
00:05:37,230 --> 00:05:34,389
connected to a dosing line where I'd

150
00:05:38,580 --> 00:05:37,240
have a cylinder or some sample of a

151
00:05:41,730 --> 00:05:38,590
liquid that I'll get in the gas phase

152
00:05:44,190 --> 00:05:41,740
and I can leak a few molecules into the

153
00:05:45,659 --> 00:05:44,200
chamber and those molecules will stick

154
00:05:47,430 --> 00:05:45,669
to the cold surface they'll stick

155
00:05:49,170 --> 00:05:47,440
everywhere but you know as long as they

156
00:05:51,450 --> 00:05:49,180
stick to the surface here which is

157
00:05:54,920 --> 00:05:51,460
actually a silicon substrate I can then

158
00:05:57,839 --> 00:05:54,930
take spectroscopy of them so so I have

159
00:05:59,159 --> 00:05:57,849
terahertz pall source that Brandon is

160
00:06:01,110 --> 00:05:59,169
actually gonna describe in a little more

161
00:06:03,000 --> 00:06:01,120
detail but it's pretty cool because we

162
00:06:05,939 --> 00:06:03,010
actually ionize the air in the

163
00:06:08,490 --> 00:06:05,949

laboratory and make plasma and that's

164
00:06:10,140 --> 00:06:08,500
actually our terahertz source and so the

165
00:06:11,870 --> 00:06:10,150
pulse comes in it interacts with the

166
00:06:14,490 --> 00:06:11,880
sample it gets absorbed by the sample

167
00:06:18,120 --> 00:06:14,500
sample reom it's a pulse that then we

168
00:06:19,800 --> 00:06:18,130
detect in our spectrometer so let me

169
00:06:21,870 --> 00:06:19,810
show you then just some of the spectra

170
00:06:24,779 --> 00:06:21,880
that we've collected and you can see

171
00:06:26,670 --> 00:06:24,789
here this is kind of a almost butterfly

172
00:06:28,710 --> 00:06:26,680
collecting slide but the the purpose of

173
00:06:31,589 --> 00:06:28,720
it is to show you that different

174
00:06:33,300 --> 00:06:31,599
molecules really have distinct spectral

175
00:06:35,129 --> 00:06:33,310
fingerprints in the terahertz region so

176
00:06:37,650 --> 00:06:35,139
we've got more simple molecules like

177
00:06:39,750 --> 00:06:37,660
water water and co2

178
00:06:42,270 --> 00:06:39,760
we've got more complex molecules here

179
00:06:45,779 --> 00:06:42,280
like acetone and methanol and you can

180
00:06:46,750 --> 00:06:45,789
see again these features are very

181
00:06:48,730 --> 00:06:46,760
distinct from

182
00:06:50,770 --> 00:06:48,740
spectrum to the next which gives us hope

183
00:06:52,930 --> 00:06:50,780
that we'll be able to actually identify

184
00:06:56,170 --> 00:06:52,940
different species if they're in a more

185
00:06:57,610 --> 00:06:56,180
complicated ice now what are some of the

186
00:07:01,030 --> 00:06:57,620
useful things that we can learn from

187
00:07:02,140 --> 00:07:01,040
these spectra it's actually oh it would

188
00:07:03,910 --> 00:07:02,150

be great if we could look at a

189
00:07:06,160 --> 00:07:03,920
protoplanetary disc and learn something

190
00:07:09,400 --> 00:07:06,170
about and know with certainty the local

191
00:07:12,010 --> 00:07:09,410
temperature so if you look at our

192
00:07:14,950 --> 00:07:12,020
terahertz spectra this is this is carbon

193
00:07:16,780 --> 00:07:14,960
dioxide ice and I've I've taken spectra

194
00:07:18,430 --> 00:07:16,790
with the ice health at three different

195
00:07:21,430 --> 00:07:18,440
temperatures and you can see in the

196
00:07:22,690 --> 00:07:21,440
inset as I wore as I saw as a cool the

197
00:07:25,180 --> 00:07:22,700
ice down to colder and colder

198
00:07:28,330 --> 00:07:25,190
temperatures the the peak of a spectral

199
00:07:29,950 --> 00:07:28,340
feature actually shifts and this is

200
00:07:31,510 --> 00:07:29,960
great so this means that now if I if I

201
00:07:33,940 --> 00:07:31,520
were to actually see something you know

202
00:07:35,470 --> 00:07:33,950
here versus here I can actually tell you

203
00:07:37,330 --> 00:07:35,480
what the temperature is and you can do

204
00:07:39,480 --> 00:07:37,340
this in the laboratory obviously it'll

205
00:07:42,370 --> 00:07:39,490
be more difficult in space but this is a

206
00:07:44,560 --> 00:07:42,380
potentially and interesting result so

207
00:07:46,810 --> 00:07:44,570
what are these vibrations and I just

208
00:07:49,720 --> 00:07:46,820
really you know have to show you some

209
00:07:51,250 --> 00:07:49,730
some cartoons from some DFT calculations

210
00:07:53,650 --> 00:07:51,260
where we've simulated the spectra of

211
00:07:55,270 --> 00:07:53,660
these of these features and you can see

212
00:07:58,270 --> 00:07:55,280
here that they really are collective

213
00:08:00,520 --> 00:07:58,280

motions these are entire planes of of

214
00:08:01,930 --> 00:08:00,530
co2 molecules in this solid that are

215
00:08:03,700 --> 00:08:01,940
sliding against each other or in the

216
00:08:05,710 --> 00:08:03,710
case of the second mode that you saw in

217
00:08:08,140 --> 00:08:05,720
the spectrum kind of moving with respect

218
00:08:12,310 --> 00:08:08,150
to one another so really think of these

219
00:08:15,520 --> 00:08:12,320
as as phonon modes as large long range

220
00:08:17,920 --> 00:08:15,530
interactions that really require very

221
00:08:19,720 --> 00:08:17,930
little energy to tweak but and as a

222
00:08:23,230 --> 00:08:19,730
result they're very very sensitive to

223
00:08:25,000 --> 00:08:23,240
the structure of the material which

224
00:08:26,680 --> 00:08:25,010
means they're sensitive to the structure

225
00:08:28,780 --> 00:08:26,690
that we're going to see really

226
00:08:30,970 --> 00:08:28,790
interesting differences when we talk

227
00:08:32,890 --> 00:08:30,980
about mixtures and that's what I have on

228
00:08:35,050 --> 00:08:32,900
this slide you can see we start off with

229
00:08:36,940 --> 00:08:35,060
water and I'm going with increasing the

230
00:08:39,400 --> 00:08:36,950
methanol concentration as I go down the

231
00:08:40,930 --> 00:08:39,410
slide until I have pure methanol and you

232
00:08:43,390 --> 00:08:40,940
can see I start with with features

233
00:08:44,740 --> 00:08:43,400
either the very characteristic features

234
00:08:46,510 --> 00:08:44,750
here of water this feature really

235
00:08:49,180 --> 00:08:46,520
actually corresponds to the sort of

236
00:08:52,690 --> 00:08:49,190
bilayer of a water ice stretching like

237
00:08:55,390 --> 00:08:52,700
this and and as I as I add methanol this

238
00:08:56,800 --> 00:08:55,400

feature slowly goes away when I have a

239
00:08:59,920 --> 00:08:56,810
sort of one-to-one mixture I really have

240
00:09:01,750 --> 00:08:59,930
this big almost amorphous blob

241
00:09:03,220 --> 00:09:01,760
as I add more methanol we start to see

242
00:09:04,780 --> 00:09:03,230
maybe these aren't maybe these are the

243
00:09:08,079 --> 00:09:04,790
methanol features growing in here and

244
00:09:09,880 --> 00:09:08,089
then pure methanol is very clear and and

245
00:09:17,040 --> 00:09:09,890
this is the same spectrum like I had on

246
00:09:20,290 --> 00:09:17,050
the first light so so one of the really

247
00:09:21,610 --> 00:09:20,300
bringing this to one more thing that we

248
00:09:23,740 --> 00:09:21,620
really think is interesting about the

249
00:09:25,540 --> 00:09:23,750
chemistry of say a place like a

250
00:09:28,300 --> 00:09:25,550
protoplanetary disk terahertz

251
00:09:30,699 --> 00:09:28,310
spectroscopy really seems to give us the

252
00:09:33,340 --> 00:09:30,709
chance to say something maybe about the

253
00:09:36,250 --> 00:09:33,350
thermal history of an ice and so what do

254
00:09:38,139 --> 00:09:36,260
I mean by that well everything I've

255
00:09:40,840 --> 00:09:38,149
shown you so far as a crystalline solid

256
00:09:42,490 --> 00:09:40,850
so that means when I when I showed you I

257
00:09:44,590 --> 00:09:42,500
was depositing my ice and I had that

258
00:09:46,180 --> 00:09:44,600
substrate that I could change the

259
00:09:48,699 --> 00:09:46,190
temperature I actually kept that

260
00:09:50,410 --> 00:09:48,709
substrate warmer and the idea is when

261
00:09:51,970 --> 00:09:50,420
when the substrate is warmer when the

262
00:09:53,920 --> 00:09:51,980
molecules leak into the chamber and they

263
00:09:56,410 --> 00:09:53,930

hit the substrate they have enough

264
00:09:59,620 --> 00:09:56,420
energy to relax and find sort of their

265
00:10:00,880 --> 00:09:59,630
lowest energy position and in that case

266
00:10:04,480 --> 00:10:00,890
we're actually going to wind up with a

267
00:10:06,430 --> 00:10:04,490
nice ordered crystal structure if I

268
00:10:08,980 --> 00:10:06,440
actually instead of doing that I

269
00:10:10,810 --> 00:10:08,990
actually kept my substrate colder

270
00:10:12,160 --> 00:10:10,820
I would actually wind up with an

271
00:10:14,650 --> 00:10:12,170
amorphous solid because when the

272
00:10:16,750 --> 00:10:14,660
molecules come in and stick they don't

273
00:10:19,030 --> 00:10:16,760
have enough energy to reorient they

274
00:10:21,310 --> 00:10:19,040
can't actually find their lowest energy

275
00:10:23,530 --> 00:10:21,320
equilibrium position relative to all of

276
00:10:25,180 --> 00:10:23,540
the other molecules in the solid so we

277
00:10:27,010 --> 00:10:25,190
wind up with this big amorphous blob and

278
00:10:29,140 --> 00:10:27,020
if you look again you know this this is

279
00:10:31,390 --> 00:10:29,150
water and there's this feature here that

280
00:10:32,980 --> 00:10:31,400
kind of you know maybe if you squint I

281
00:10:35,440 --> 00:10:32,990
mean it looks like this but it's bigger

282
00:10:39,010 --> 00:10:35,450
and broader and doesn't have as clean of

283
00:10:40,960 --> 00:10:39,020
features so we compare you know this

284
00:10:42,340 --> 00:10:40,970
spectrum taking at 10 Kelvin here with

285
00:10:43,780 --> 00:10:42,350
this spectrum take it at 10 Kelvin here

286
00:10:46,150 --> 00:10:43,790
there's an obvious there's an obvious

287
00:10:48,160 --> 00:10:46,160
difference okay but that's not a thermal

288
00:10:51,550 --> 00:10:48,170

history effect because I've just these

289
00:10:54,850 --> 00:10:51,560
are two separate ices but if I take this

290
00:10:57,310 --> 00:10:54,860
ice and I warm it up so you think if I

291
00:10:59,290 --> 00:10:57,320
warm something up all the way up to this

292
00:11:02,350 --> 00:10:59,300
say that the state same temperature at

293
00:11:03,970 --> 00:11:02,360
which I deposited the first ice it would

294
00:11:05,889 --> 00:11:03,980
have enough energy to reorient and

295
00:11:07,780 --> 00:11:05,899
become a crystalline solid in my

296
00:11:09,819 --> 00:11:07,790
spectrum should look just like this but

297
00:11:12,160 --> 00:11:09,829
as you can see from this top spectrum

298
00:11:13,310 --> 00:11:12,170
that's not the case so there is a

299
00:11:15,110 --> 00:11:13,320
feature that that looks

300
00:11:17,180 --> 00:11:15,120
like this but it's actually shifted

301
00:11:18,470 --> 00:11:17,190
relative to this peak and you know

302
00:11:21,680 --> 00:11:18,480
there's a lot more structure here than

303
00:11:23,360 --> 00:11:21,690
there is here so one of the things you

304
00:11:25,460 --> 00:11:23,370
can imagine happening is hey you are in

305
00:11:27,500 --> 00:11:25,470
a protoplanetary disk and some dust

306
00:11:29,450 --> 00:11:27,510
grain with some ice on it goes from you

307
00:11:31,130 --> 00:11:29,460
know colder spot to a warmer spot back

308
00:11:32,300 --> 00:11:31,140
to a colder spot you might actually be

309
00:11:35,600 --> 00:11:32,310
able to learn something about the

310
00:11:38,000 --> 00:11:35,610
history of that dust grain and thus the

311
00:11:40,670 --> 00:11:38,010
chemistry of what's going on in the disk

312
00:11:42,410 --> 00:11:40,680
and so with that the take home thoughts

313
00:11:44,750 --> 00:11:42,420

are really that you know terahertz

314
00:11:47,720 --> 00:11:44,760
spectroscopy is really sensitive to both

315
00:11:49,670 --> 00:11:47,730
the structure and a temperature of Isis

316
00:11:52,970 --> 00:11:49,680
we can just distinguish them with their

317
00:11:54,500 --> 00:11:52,980
thermal history and when we think that

318
00:11:56,360 --> 00:11:54,510
this is a this is going to be a useful

319
00:11:58,100 --> 00:11:56,370
tool to understanding complex molecule

320
00:11:59,840 --> 00:11:58,110
formation and to bring it all back to

321
00:12:01,190 --> 00:11:59,850
astrobiology if we can understand

322
00:12:02,870 --> 00:12:01,200
complex molecule formation

323
00:12:04,970 --> 00:12:02,880
maybe we can understand how we wind up

324
00:12:07,640 --> 00:12:04,980
with life on this planet and with that

325
00:12:09,320 --> 00:12:07,650
I'd like to say my lab mates and my

326
00:12:11,060 --> 00:12:09,330
advisor at all the people for funding

327
00:12:17,070 --> 00:12:11,070
and everybody for their attention thank

328
00:12:36,040 --> 00:12:31,930
questions for Marco Marco thanks for the

329
00:12:38,020 --> 00:12:36,050
talk so in one slice you show the ratio

330
00:12:42,190 --> 00:12:38,030
different ratio of the water and the

331
00:12:45,520 --> 00:12:42,200
methyl whatever the two organics so I'm

332
00:12:48,280 --> 00:12:45,530
just wondering if you can predict that

333
00:12:51,130 --> 00:12:48,290
when you get spectrum together I don't

334
00:12:52,840 --> 00:12:51,140
know if it is proportional four and if

335
00:12:56,650 --> 00:12:52,850
you can predict the ratio of the water

336
00:12:58,930 --> 00:12:56,660
to the organics are you saying could I

337
00:13:03,400 --> 00:12:58,940
could I predict what the spectrum looks

338
00:13:05,380 --> 00:13:03,410

like I would say that we we could maybe

339
00:13:07,660 --> 00:13:05,390
try although I think the theory these

340
00:13:10,150 --> 00:13:07,670
are kind of hard theoretical problems

341
00:13:14,920 --> 00:13:10,160
because they they do really require a

342
00:13:16,960 --> 00:13:14,930
picture that involves say what the what

343
00:13:20,440 --> 00:13:16,970
the unit cell structure looks like of

344
00:13:23,290 --> 00:13:20,450
say a crystalline material and if it's

345
00:13:25,300 --> 00:13:23,300
not crystalline it gets even harder so I

346
00:13:27,250 --> 00:13:25,310
would say it's possible but it's it's

347
00:13:34,840 --> 00:13:27,260
definitely a hard fioretto problem it's

348
00:13:37,750 --> 00:13:34,850
it's not one that we've looked at oh oh

349
00:13:39,550 --> 00:13:37,760
I see what you're saying okay sure the

350
00:13:41,080 --> 00:13:39,560
answer is yes and but what you'd have to

351
00:13:42,720 --> 00:13:41,090
do is you we'd have to do you know we'd

352
00:13:44,830 --> 00:13:42,730
have to have built up a library of

353
00:13:47,260 --> 00:13:44,840
spectra so they're taking spectra at

354
00:13:49,810 --> 00:13:47,270
different ratios and then we we would be

355
00:13:50,950 --> 00:13:49,820
able to figure out then say if we had a

356
00:13:53,080 --> 00:13:50,960
blank spectrum we didn't know what the

357
00:13:57,450 --> 00:13:53,090
ratio was we could compare it to our

358
00:13:59,470 --> 00:13:57,460
laboratory database and go from there