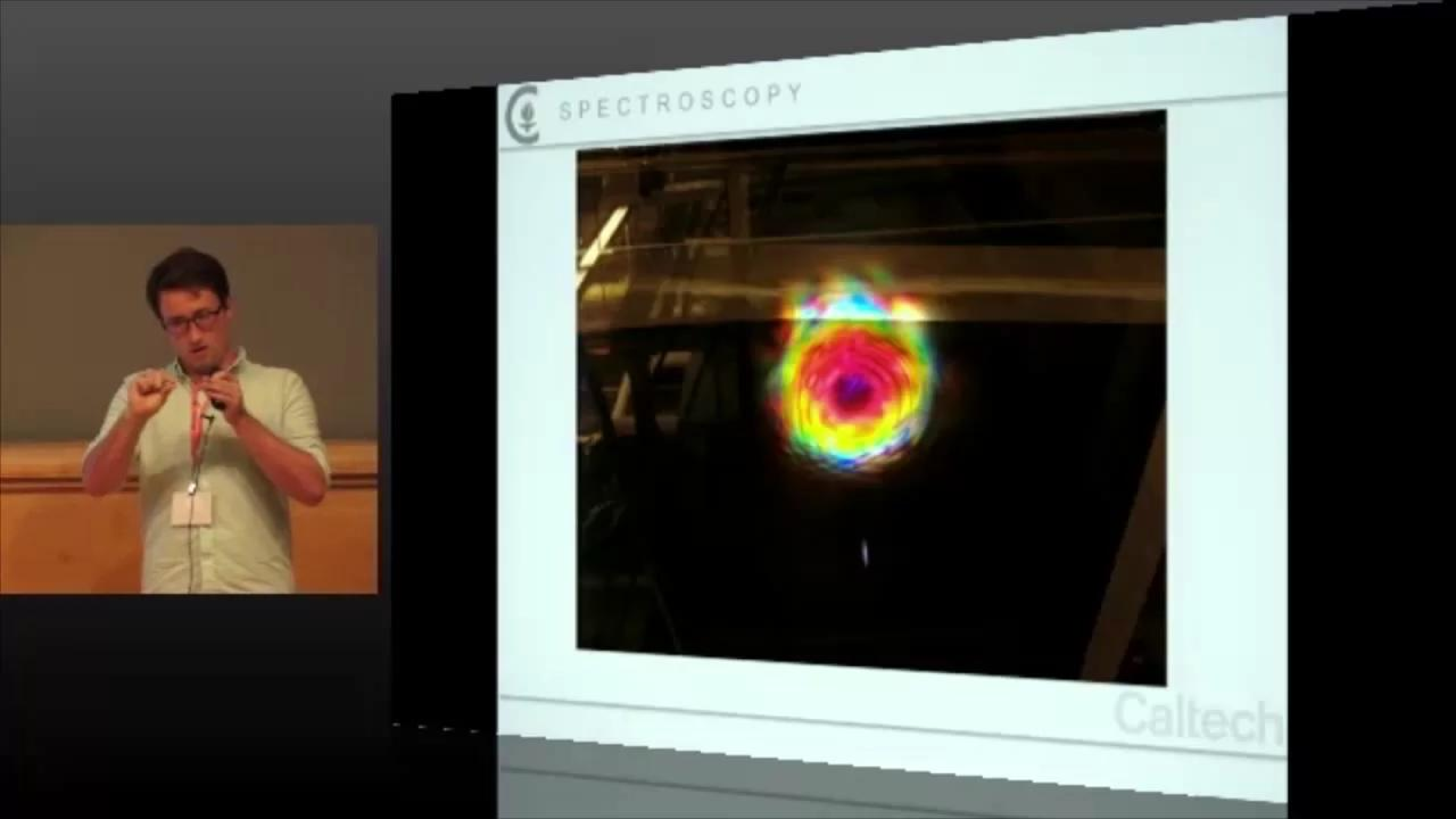
SPECTROSCOPY
Caltech

1
00:00:10,440 --> 00:00:08,250
alright thank you very much so I'll

2
00:00:12,049 --> 00:00:10,450
complete the trifecta Lake lab talks

3
00:00:15,000 --> 00:00:12,059
today I'm going to be talking about

4
00:00:17,550 --> 00:00:15,010
polycyclic aromatic hydrocarbons or pahs

5
00:00:19,980 --> 00:00:17,560
for short so what r PAH is there these

6
00:00:21,720 --> 00:00:19,990
things they are any combination of

7
00:00:25,050 --> 00:00:21,730
aromatic hydrocarbon rings that you can

8
00:00:28,019 --> 00:00:25,060
think of so big round p a big round PAH

9
00:00:29,849 --> 00:00:28,029
is long linear ones crazy branch chains

10
00:00:32,069 --> 00:00:29,859
any combination you can think of is a

11
00:00:33,720 --> 00:00:32,079
PAH it's a broad class of molecules and

12
00:00:34,650 --> 00:00:33,730
that's really interesting features that

13
00:00:37,110 --> 00:00:34,660

we think are very useful for

14
00:00:39,540 --> 00:00:37,120
astrophysics mainly it's this conjugated

15
00:00:41,220 --> 00:00:39,550
PI system gives it a ton of stability so

16
00:00:43,140 --> 00:00:41,230
you can ionize the heck out of it singly

17
00:00:45,210 --> 00:00:43,150
doubly triply ionize it you can add

18
00:00:47,010 --> 00:00:45,220
electrons to the system you can take

19
00:00:49,290 --> 00:00:47,020
every single hydrogen off the edge of

20
00:00:50,880 --> 00:00:49,300
this ring you can take every single

21
00:00:52,800 --> 00:00:50,890
hydrogen and give it a second one and

22
00:00:54,450 --> 00:00:52,810
they're completely stable very happy and

23
00:00:56,760 --> 00:00:54,460
will continue to just float in space

24
00:00:58,560 --> 00:00:56,770
they're also highly photo staples so

25
00:01:00,990 --> 00:00:58,570
they can withstand extremely high UV

26
00:01:03,180 --> 00:01:01,000
flux without dissociating and you can

27
00:01:04,890 --> 00:01:03,190
also do a lot of functionalization so

28
00:01:07,350 --> 00:01:04,900
you can start adding nitrogens into the

29
00:01:09,960 --> 00:01:07,360
ring it's not terribly difficult to add

30
00:01:11,279 --> 00:01:09,970
sort of carboxylic acids or ketones or

31
00:01:12,899 --> 00:01:11,289
alcohols to the edge of these things

32
00:01:15,359 --> 00:01:12,909
this is a lot of really cool chemistry

33
00:01:16,590 --> 00:01:15,369
that goes on with these but why we care

34
00:01:18,270 --> 00:01:16,600
about them for astronomy and

35
00:01:19,950 --> 00:01:18,280
astrophysics astra chemistry is these

36
00:01:22,559 --> 00:01:19,960
things you IRS this is one of the

37
00:01:24,690 --> 00:01:22,569
longest standing mysteries in astronomy

38
00:01:26,639 --> 00:01:24,700

is these set of near and mid-infrared

39
00:01:28,319 --> 00:01:26,649
bands that are seen towards a plethora

40
00:01:30,090 --> 00:01:28,329
of sources the really interesting thing

41
00:01:33,660 --> 00:01:30,100
is they have to be coming from some kind

42
00:01:35,340 --> 00:01:33,670
of SP two aromatic hydrocarbon the CH

43
00:01:36,870 --> 00:01:35,350
stretches the CC stretches all line up

44
00:01:38,819 --> 00:01:36,880
perfectly with it but the weird thing is

45
00:01:40,440 --> 00:01:38,829
they don't match up with any individual

46
00:01:42,660 --> 00:01:40,450
spectra you can't take a lab spectra of

47
00:01:45,779 --> 00:01:42,670
a molecule and go and compare it and see

48
00:01:47,279 --> 00:01:45,789
perfect match up towards most sources so

49
00:01:50,340 --> 00:01:47,289
what you have to invoke is this weird

50
00:01:52,080 --> 00:01:50,350
mix of some kind of big aromatic class

51
00:01:54,449 --> 00:01:52,090
of molecules and so the obvious answer

52
00:01:58,230 --> 00:01:54,459
is it's pahs but the problem is we've

53
00:02:00,149 --> 00:01:58,240
never identified any individual pah also

54
00:02:02,429 --> 00:02:00,159
this is infrared emission so any place

55
00:02:04,830 --> 00:02:02,439
that's cold or dusty and obscure it is

56
00:02:07,019 --> 00:02:04,840
very hard to observe so this big gap we

57
00:02:08,820 --> 00:02:07,029
can't identify any individual pages we

58
00:02:10,380 --> 00:02:08,830
can't see the size distributions it's

59
00:02:11,880 --> 00:02:10,390
very difficult to tell how functionalize

60
00:02:13,710 --> 00:02:11,890
they are and there's a lot of places we

61
00:02:17,039 --> 00:02:13,720
can't naturally look for them so it's a

62
00:02:18,600 --> 00:02:17,049
big ongoing problem in astrophysics but

63
00:02:19,460 --> 00:02:18,610

it's not just a neat problem it's a big

64
00:02:23,120 --> 00:02:19,470
problem if you

65
00:02:25,340 --> 00:02:23,130
look at em 81 this is a Hubble image

66
00:02:27,980 --> 00:02:25,350
with a Spitzer map overlaid on top of it

67
00:02:29,870 --> 00:02:27,990
and this red in the red emission here is

68
00:02:31,880 --> 00:02:29,880
all PA ages so if you work through the

69
00:02:33,860 --> 00:02:31,890
math of you I if the you IRS really are

70
00:02:36,020 --> 00:02:33,870
coming from PAH is something like twenty

71
00:02:38,180 --> 00:02:36,030
percent of all the carbon and for the

72
00:02:39,200 --> 00:02:38,190
biologists it's reduced carbon twenty

73
00:02:41,330 --> 00:02:39,210
percent of all the carbon in the

74
00:02:43,880 --> 00:02:41,340
universe has to be tied up in whatever

75
00:02:45,440 --> 00:02:43,890
is emitting these you IRS not just that

76
00:02:47,420 --> 00:02:45,450
something like ten percent of all the

77
00:02:48,950 --> 00:02:47,430
power emitted by our galaxy is mediated

78
00:02:50,000 --> 00:02:48,960
through these things so it's not just a

79
00:02:51,680 --> 00:02:50,010
cool little problem it's actually a

80
00:02:55,280 --> 00:02:51,690
really big and interesting problem in

81
00:02:57,170 --> 00:02:55,290
astronomy and the other really cool

82
00:02:59,030 --> 00:02:57,180
thing is some of the suggestions are

83
00:03:01,160 --> 00:02:59,040
that these things are synthesized in the

84
00:03:03,290 --> 00:03:01,170
stellar atmospheres of carbon stars they

85
00:03:04,790 --> 00:03:03,300
then get ejected into space they stick

86
00:03:05,870 --> 00:03:04,800
with the molecular cloud and condense

87
00:03:08,210 --> 00:03:05,880
with it all the way down to a

88
00:03:09,830 --> 00:03:08,220

protoplanetary disk and then this carbon

89
00:03:12,170 --> 00:03:09,840
gets incorporated into the planets

90
00:03:14,330 --> 00:03:12,180
meteorites comets in the planetary

91
00:03:15,440 --> 00:03:14,340
system so it's it's something like

92
00:03:16,880 --> 00:03:15,450
twenty percent of the carbon that's

93
00:03:18,949 --> 00:03:16,890
going to be accreted into the planets

94
00:03:21,080 --> 00:03:18,959
and also into meteorites and comets that

95
00:03:23,870 --> 00:03:21,090
can then bombard the planets as the

96
00:03:25,040 --> 00:03:23,880
system of all so it really is universal

97
00:03:27,740 --> 00:03:25,050
it sticks with it all the way through

98
00:03:30,920 --> 00:03:27,750
the planetary evolution system so the

99
00:03:32,360 --> 00:03:30,930
cool thing for astrobiology is if you go

100
00:03:33,710 --> 00:03:32,370
back to something Bret talked about

101
00:03:35,990 --> 00:03:33,720
which is the merchants and meteorite you

102
00:03:39,050 --> 00:03:36,000
take it and you just grind up an organic

103
00:03:40,880 --> 00:03:39,060
sample you extract the organic fraction

104
00:03:42,380 --> 00:03:40,890
and then you dissolve it in water with

105
00:03:44,180 --> 00:03:42,390
fluorescent dye what you get is a

106
00:03:46,250 --> 00:03:44,190
spontaneous formation of these vesicles

107
00:03:47,840 --> 00:03:46,260
and they actually they truly are

108
00:03:49,699 --> 00:03:47,850
vesicles they can sequester the

109
00:03:51,229 --> 00:03:49,709
fluorescent dye or they can be hollow so

110
00:03:52,610 --> 00:03:51,239
it means they're actually whole they're

111
00:03:54,440 --> 00:03:52,620
poor they're not that course they can

112
00:03:56,300 --> 00:03:54,450
actually segregate the aqueous matter

113
00:03:58,190 --> 00:03:56,310

and the really cool thing about is it's

114
00:04:01,039 --> 00:03:58,200
completely spontaneous so what this is

115
00:04:03,320 --> 00:04:01,049
is amphiphilic molecules so polar head

116
00:04:05,090 --> 00:04:03,330
and in a polar tail in the molecule are

117
00:04:06,920 --> 00:04:05,100
self-assembling together and it's just

118
00:04:08,570 --> 00:04:06,930
spontaneous it's on something that's

119
00:04:10,520 --> 00:04:08,580
being delivered to earth and it's

120
00:04:12,560 --> 00:04:10,530
completely abiotic so I think that's

121
00:04:14,479 --> 00:04:12,570
really cool and so one of the things if

122
00:04:16,550 --> 00:04:14,489
you look into murcheson one of the big

123
00:04:18,710 --> 00:04:16,560
constituents is aromatic hydrocarbons

124
00:04:20,570 --> 00:04:18,720
and things like fan also functionalized

125
00:04:22,940 --> 00:04:20,580
aromatic hydrocarbons or one of the big

126
00:04:25,070 --> 00:04:22,950
parts of this and it's not it's nothing

127
00:04:26,480 --> 00:04:25,080
like the carboxylic acids but it is

128
00:04:27,890 --> 00:04:26,490
actually a decent fraction of the

129
00:04:30,980 --> 00:04:27,900
organic matter found in murcheson

130
00:04:32,360 --> 00:04:30,990
there's a lot of organic pahs some of

131
00:04:33,590 --> 00:04:32,370
which are functionalized and in fact

132
00:04:35,480 --> 00:04:33,600
amphiphilic that are stuck in

133
00:04:37,520 --> 00:04:35,490
these things so one of the really cool

134
00:04:39,050 --> 00:04:37,530
experiments somebody did was this is

135
00:04:41,390 --> 00:04:39,060
murcheson on the right and this is a

136
00:04:43,490 --> 00:04:41,400
mixture of organic matter that came from

137
00:04:46,130 --> 00:04:43,500
a radiation of Isis what they did they

138
00:04:47,780 --> 00:04:46,140

take a nice you put pahs in the ice and

139
00:04:49,040 --> 00:04:47,790
you blast it with UV light something

140
00:04:51,710 --> 00:04:49,050
like you would find around a star and

141
00:04:54,050 --> 00:04:51,720
what you get out is functionalize pahs

142
00:04:55,550 --> 00:04:54,060
so ketones alcohols ethers things like

143
00:04:57,260 --> 00:04:55,560
that and when you dissolve them in water

144
00:04:59,810 --> 00:04:57,270
in the same same way you did with

145
00:05:01,760 --> 00:04:59,820
murcheson extract you get self-assembled

146
00:05:04,130 --> 00:05:01,770
little vesicles the really cool thing is

147
00:05:06,410 --> 00:05:04,140
now you can make something that looks a

148
00:05:08,000 --> 00:05:06,420
lot like a cell membrane so they self is

149
00:05:10,640 --> 00:05:08,010
simple and completely segregate and the

150
00:05:12,230 --> 00:05:10,650
really cool thing for biology is well if

151
00:05:13,760 --> 00:05:12,240
you look at life on Earth basically

152
00:05:15,470 --> 00:05:13,770
everything has a cell membrane it's such

153
00:05:17,840 --> 00:05:15,480
a massive evolutionary advantage that

154
00:05:19,400 --> 00:05:17,850
once you develop it you never go back it

155
00:05:20,930 --> 00:05:19,410
maintains the chemical gradients

156
00:05:23,060 --> 00:05:20,940
concentration it gives you protection

157
00:05:24,980 --> 00:05:23,070
from extreme from the external

158
00:05:27,200 --> 00:05:24,990
environment so it's such a huge

159
00:05:29,450 --> 00:05:27,210
evolutionary advantage once you make it

160
00:05:31,430 --> 00:05:29,460
you never go back and the question has

161
00:05:32,990 --> 00:05:31,440
always been when you start to make life

162
00:05:35,630 --> 00:05:33,000
on Earth how do you do it what's the

163
00:05:37,160 --> 00:05:35,640

first step and at some point you have to

164
00:05:38,870 --> 00:05:37,170
make a cell membrane the question is

165
00:05:40,760 --> 00:05:38,880
when did that happen in the process of

166
00:05:43,220 --> 00:05:40,770
making sort of a self-replicating system

167
00:05:45,080 --> 00:05:43,230
and the neat thing here is that one of

168
00:05:46,730 --> 00:05:45,090
the ways you can do this is completely

169
00:05:49,520 --> 00:05:46,740
abiotic ly you don't have to mess with

170
00:05:51,880 --> 00:05:49,530
small molecule synthesis on an early

171
00:05:53,960 --> 00:05:51,890
Earth you can directly deposit a

172
00:05:56,570 --> 00:05:53,970
self-assembling system that looks just

173
00:05:59,390 --> 00:05:56,580
like her very much like of primitive

174
00:06:02,030 --> 00:05:59,400
cell as the earth is forming so it's a

175
00:06:03,620 --> 00:06:02,040
really cool idea and pahs are probably

176
00:06:07,460 --> 00:06:03,630
one of the big contributors to doing

177
00:06:09,170 --> 00:06:07,470
this so pretty excited about it but like

178
00:06:10,580 --> 00:06:09,180
I said we've never identified a single

179
00:06:12,860 --> 00:06:10,590
pH and we'd like to know a lot more

180
00:06:14,930 --> 00:06:12,870
about what's going on with these so the

181
00:06:16,720 --> 00:06:14,940
big trick is to go and do astronomy to

182
00:06:20,600 --> 00:06:16,730
identify these and to try to identify

183
00:06:22,250 --> 00:06:20,610
individual molecules so Marco already

184
00:06:23,810 --> 00:06:22,260
kind of took you through the terahertz

185
00:06:26,120 --> 00:06:23,820
spectrum that's where we like to work

186
00:06:28,820 --> 00:06:26,130
and one of the nice things is as marco

187
00:06:31,100 --> 00:06:28,830
was explaining these big polyatomic

188
00:06:33,110 --> 00:06:31,110

vibrations are completely specific to

189
00:06:35,360 --> 00:06:33,120
the molecule that's doing it so it's not

190
00:06:37,990 --> 00:06:35,370
just the CH stretch of an aromatic

191
00:06:41,510 --> 00:06:38,000
species of some kind now it's the

192
00:06:43,250 --> 00:06:41,520
vibration of a specific PAH so we'd like

193
00:06:45,110 --> 00:06:43,260
to go and do observations of these

194
00:06:46,239 --> 00:06:45,120
things and our favorite Observatory is

195
00:06:49,179 --> 00:06:46,249
Sofia in fact

196
00:06:50,619 --> 00:06:49,189
I think really cool it's a 747 short

197
00:06:52,149 --> 00:06:50,629
with a three meter dish that they

198
00:06:55,209 --> 00:06:52,159
actually just open up the door

199
00:06:57,609 --> 00:06:55,219
mid-flight to do spectroscopy above the

200
00:07:00,219 --> 00:06:57,619
earth's water and actually see into the

201
00:07:02,529 --> 00:07:00,229
far infrared but the trick is we need

202
00:07:04,089 --> 00:07:02,539
spectra of these molecules to compare to

203
00:07:08,529 --> 00:07:04,099
if we actually want to find these things

204
00:07:10,389 --> 00:07:08,539
at space all right so how do we do it

205
00:07:12,489 --> 00:07:10,399
well some of you may be pretty familiar

206
00:07:14,919 --> 00:07:12,499
with this this is just an ex rd pellet

207
00:07:16,739 --> 00:07:14,929
press we take our sample we grind it up

208
00:07:18,309 --> 00:07:16,749
and then we press it with just

209
00:07:20,589 --> 00:07:18,319
polyethylene powder it's very

210
00:07:22,209 --> 00:07:20,599
transparent the terahertz and we make a

211
00:07:24,069 --> 00:07:22,219
little pup like this with sample

212
00:07:25,449 --> 00:07:24,079
embedded in it and the idea is hopefully

213
00:07:28,089 --> 00:07:25,459

to get some kind of temperature

214
00:07:29,649 --> 00:07:28,099
dependent spectra out and so then this

215
00:07:32,529 --> 00:07:29,659
is one other thing that's really cool in

216
00:07:34,989 --> 00:07:32,539
our lab the way we make our light one of

217
00:07:36,669 --> 00:07:34,999
the few good ways of getting into the

218
00:07:38,889 --> 00:07:36,679
terahertz is we actually take an

219
00:07:41,019 --> 00:07:38,899
ultra-fast laser about 60 gigawatts of

220
00:07:43,389 --> 00:07:41,029
peak power we focus it down to a point

221
00:07:45,729 --> 00:07:43,399
and we make a small little plasma

222
00:07:47,949 --> 00:07:45,739
filament in the lab so we get this tiny

223
00:07:49,479 --> 00:07:47,959
little plasma filament we ionize it's so

224
00:07:51,159 --> 00:07:49,489
completely we take all the electrons off

225
00:07:53,829 --> 00:07:51,169
and we get this mold plasma that throws

226
00:07:56,379 --> 00:07:53,839
off this beautiful rainbow of color and

227
00:07:58,659 --> 00:07:56,389
it also gives off a very short very

228
00:08:02,319 --> 00:07:58,669
broad band so about eight terahertz wide

229
00:08:03,789 --> 00:08:02,329
pulse of terror I pulse of terahertz

230
00:08:05,319 --> 00:08:03,799
light so actually we have to lock the

231
00:08:08,199 --> 00:08:05,329
rainbow it's kind of sad but it's not

232
00:08:10,899 --> 00:08:08,209
useful for our spectroscopy so what we

233
00:08:12,999 --> 00:08:10,909
pay we get this plasma we set our sample

234
00:08:14,949 --> 00:08:13,009
in the way and then we get a short

235
00:08:17,350 --> 00:08:14,959
terahertz pulse out now this is in time

236
00:08:20,019 --> 00:08:17,360
domain so not frequency domain and it's

237
00:08:21,759 --> 00:08:20,029
it's only a few picoseconds wide but it

238
00:08:23,439 --> 00:08:21,769

covers our entire bandwidth at once so

239
00:08:25,239 --> 00:08:23,449
this would be like doing your entire

240
00:08:27,429 --> 00:08:25,249
spectra you're taking your entire

241
00:08:29,409 --> 00:08:27,439
spectra at once we pass it through the

242
00:08:30,909 --> 00:08:29,419
sample it gets somewhat absorbed and we

243
00:08:32,769 --> 00:08:30,919
detected and then we just take the

244
00:08:35,019 --> 00:08:32,779
Fourier transform of that and we have

245
00:08:36,549 --> 00:08:35,029
our spectra so we do sample reference

246
00:08:40,240 --> 00:08:36,559
and then we take the ratio between those

247
00:08:42,399 --> 00:08:40,250
and we get a nice absorption spectra so

248
00:08:45,819 --> 00:08:42,409
to start off with what we wanted to do

249
00:08:48,579 --> 00:08:45,829
was start fairly simple at two three and

250
00:08:51,639 --> 00:08:48,589
four membered PAH no functionalization

251
00:08:53,679 --> 00:08:51,649
nothing crazy just three simple systems

252
00:08:55,809 --> 00:08:53,689
to test this out there all crystalline

253
00:08:57,850 --> 00:08:55,819
polyethylene substrate and as Marcos

254
00:08:59,110 --> 00:08:57,860
explaining the subtle shifts in the

255
00:09:01,329 --> 00:08:59,120
spectra

256
00:09:02,680 --> 00:09:01,339
by temperature variations and if we

257
00:09:04,150 --> 00:09:02,690
actually really want to get the

258
00:09:05,860 --> 00:09:04,160
spectroscopy right and identify these

259
00:09:07,630 --> 00:09:05,870
things well in space we need to do this

260
00:09:09,460 --> 00:09:07,640
at a lot of temperatures so what we do

261
00:09:11,410 --> 00:09:09,470
is we place the samples in a cold head

262
00:09:13,530 --> 00:09:11,420
and just tune the temperature and take

263
00:09:17,620 --> 00:09:13,540

spectra at each individual temperature

264
00:09:20,380 --> 00:09:17,630
so we went and did this so first this is

265
00:09:21,610 --> 00:09:20,390
our spectra for Nath naphthalene so this

266
00:09:23,260 --> 00:09:21,620
right here is actually a polyethylene

267
00:09:25,390 --> 00:09:23,270
resonance we can't get rid of it's a

268
00:09:27,910 --> 00:09:25,400
little on well we can't get rid of it

269
00:09:30,519 --> 00:09:27,920
but for this run it was actually kind of

270
00:09:32,110 --> 00:09:30,529
rough so going back to the question that

271
00:09:34,720 --> 00:09:32,120
was asked earlier if you want to do

272
00:09:36,579 --> 00:09:34,730
theory on these things simple harmonic

273
00:09:38,110 --> 00:09:36,589
vibrational frequency calculations you'd

274
00:09:40,000 --> 00:09:38,120
think oh maybe I can sort of work out

275
00:09:41,350 --> 00:09:40,010
what some of the vibrations are identify

276
00:09:43,870 --> 00:09:41,360
what we should see in the spectra ahead

277
00:09:45,460 --> 00:09:43,880
of time but it turns out if you do that

278
00:09:47,140 --> 00:09:45,470
calculation what you get are two modes

279
00:09:49,750 --> 00:09:47,150
right here and right here one of which

280
00:09:51,850 --> 00:09:49,760
we might see but there's I should say

281
00:09:55,329 --> 00:09:51,860
actually this is transmittance not

282
00:09:57,790 --> 00:09:55,339
absorption and it got cut off so my peak

283
00:09:59,650 --> 00:09:57,800
point down not up like Marcos did so we

284
00:10:01,750 --> 00:09:59,660
have strong absorption here here and

285
00:10:03,550 --> 00:10:01,760
here that are completely missed by

286
00:10:05,680 --> 00:10:03,560
theory but this is actually nice because

287
00:10:07,329 --> 00:10:05,690
we get several very strong absorption

288
00:10:09,610 --> 00:10:07,339

features so going down to zero is

289
00:10:11,470 --> 00:10:09,620
basically completely opaque so several

290
00:10:15,100 --> 00:10:11,480
strong unique absorption features for

291
00:10:17,019 --> 00:10:15,110
Natalie moving on to anthro scene same

292
00:10:18,550 --> 00:10:17,029
thing we got two very nice strong

293
00:10:21,010 --> 00:10:18,560
absorption features and maybe one more

294
00:10:23,110 --> 00:10:21,020
over here ah Siri says we should have

295
00:10:24,880 --> 00:10:23,120
three this one may just be a sensitivity

296
00:10:27,760 --> 00:10:24,890
issue with our instrument but these two

297
00:10:29,620 --> 00:10:27,770
may actually be the same two it's just

298
00:10:32,440 --> 00:10:29,630
that they're so an harmonic the theory

299
00:10:34,360 --> 00:10:32,450
gets it very very wrong and then for

300
00:10:35,620 --> 00:10:34,370
hiring this is what we got we were

301
00:10:37,420 --> 00:10:35,630
really excited because we got a ton of

302
00:10:38,530 --> 00:10:37,430
absorption features all the way across

303
00:10:40,810 --> 00:10:38,540
our spectre that are completely

304
00:10:43,120 --> 00:10:40,820
different from any of the other PAH as

305
00:10:46,210 --> 00:10:43,130
we studied and if you ask what the two

306
00:10:48,250 --> 00:10:46,220
Theory theory says we should get too so

307
00:10:50,110 --> 00:10:48,260
there's a lot of features going on here

308
00:10:53,440 --> 00:10:50,120
that we didn't expect to see we're very

309
00:10:56,410 --> 00:10:53,450
excited about so that's it that we have

310
00:10:59,170 --> 00:10:56,420
our spectra so I sort of take home

311
00:11:01,380 --> 00:10:59,180
messages for this are well the pH vector

312
00:11:04,320 --> 00:11:01,390
are unique and they're very promising

313
00:11:06,670 --> 00:11:04,330

crystalyn samples are pretty useful and

314
00:11:09,040 --> 00:11:06,680
the big thing is simple have an issue

315
00:11:10,630 --> 00:11:09,050
it's okay but it's pretty it's a

316
00:11:11,090 --> 00:11:10,640
guidepost at best for what you're going

317
00:11:13,670 --> 00:11:11,100
to see

318
00:11:15,200 --> 00:11:13,680
and so actually going forward we

319
00:11:16,880 --> 00:11:15,210
actually have applied for time with

320
00:11:18,370 --> 00:11:16,890
Sophia to go look for the so do

321
00:11:20,450 --> 00:11:18,380
preliminary proof-of-concept

322
00:11:22,940 --> 00:11:20,460
observations to see if this can be done

323
00:11:24,290 --> 00:11:22,950
at all and then obviously we want to

324
00:11:26,750 --> 00:11:24,300
move the lab spectra on to more

325
00:11:28,340 --> 00:11:26,760
interesting species so bigger PA ages

326
00:11:30,440 --> 00:11:28,350
that are more relevant for astrophysics

327
00:11:32,780 --> 00:11:30,450
and more functionalized systems things

328
00:11:34,760 --> 00:11:32,790
with o-h bonds nitrogen inserted into

329
00:11:37,040 --> 00:11:34,770
the ring to start building up a library

330
00:11:41,030 --> 00:11:37,050
of more diverse PHS that we expect to

331
00:11:43,670 --> 00:11:41,040
see in space alright with that I'd like

332
00:11:53,000 --> 00:11:43,680
to thank my group our funding agencies

333
00:12:02,690 --> 00:11:53,010
and you for your attention questions for

334
00:12:05,450 --> 00:12:02,700
Brandon gotcha so I'm just curious what

335
00:12:08,030 --> 00:12:05,460
do you know what those abiotic membranes

336
00:12:09,680 --> 00:12:08,040
are actually composed with its a mix of

337
00:12:11,270 --> 00:12:09,690
things so that's actually the big

338
00:12:14,510 --> 00:12:11,280

suggestion isn't that they're just pah

339
00:12:16,370 --> 00:12:14,520
is there's a mix of fatty at there are

340
00:12:18,140 --> 00:12:16,380
some short chain fatty acids that are in

341
00:12:19,730 --> 00:12:18,150
there so actually the big suggestion is

342
00:12:21,020 --> 00:12:19,740
that maybe the fatty acids are doing a

343
00:12:22,610 --> 00:12:21,030
lot of the heavy lifting in terms of

344
00:12:24,440 --> 00:12:22,620
self-assembly but you incorporate

345
00:12:26,090 --> 00:12:24,450
functionalized PHS because they're there

346
00:12:27,290 --> 00:12:26,100
in reasonable abundance and it might

347
00:12:28,670 --> 00:12:27,300
actually look something like what

348
00:12:30,320 --> 00:12:28,680
cholesterol looks like in a cell

349
00:12:31,610 --> 00:12:30,330
membrane now and that if you start

350
00:12:32,990 --> 00:12:31,620
inserting that you can do this

351
00:12:34,310 --> 00:12:33,000
experiment if you insert them into the

352
00:12:36,350 --> 00:12:34,320
cell membrane you actually mess with the

353
00:12:38,630 --> 00:12:36,360
porosity quite a bit so it actually my

354
00:12:43,400 --> 00:12:38,640
tunic pretty well to act as a very

355
00:12:47,330 --> 00:12:43,410
primitive cell membrane one more really