2017 Astrobiology Graduate Conference

Charlottesville, VA

1
00:00:00,790 --> 00:00:09,640
[Music]

2
00:00:16,010 --> 00:00:12,280
and thanks Brandon for the delightful

3
00:00:17,300 --> 00:00:16,020
introductory um my name is Elsa cook I'm

4
00:00:18,680 --> 00:00:17,310
a graduate student here in

5
00:00:20,660 --> 00:00:18,690
Charlottesville at the Department of

6
00:00:22,759 --> 00:00:20,670
Chemistry and at the University of

7
00:00:24,529 --> 00:00:22,769
Virginia and today I want to talk to you

8
00:00:26,859 --> 00:00:24,539
about some work that we've been doing to

9
00:00:29,509 --> 00:00:26,869
measure the UV photo distraction of um

10
00:00:31,700 --> 00:00:29,519
astro chemical Isis of interstellar

11
00:00:34,100 --> 00:00:31,710
importance now this work is being done

12
00:00:35,660 --> 00:00:34,110
in collaboration with Karen Oberg and

13
00:00:36,920 --> 00:00:35,670

Edith Vail and at the

14
00:00:39,319 --> 00:00:36,930
harvard-smithsonian Center for

15
00:00:41,990 --> 00:00:39,329
Astrophysics and I'd also like to thank

16
00:00:44,660 --> 00:00:42,000
John Yates whose laboratory this work

17
00:00:47,500 --> 00:00:44,670
has been conducted in and as well as

18
00:00:50,569 --> 00:00:47,510
Eric herbs Rob Garrett and Matthew rash

19
00:00:52,100 --> 00:00:50,579
so I just wanted to begin by talking a

20
00:00:55,189 --> 00:00:52,110
little bit about how we tend to think

21
00:00:56,630 --> 00:00:55,199
about UV radiation in life and most of

22
00:00:59,150 --> 00:00:56,640
you will be more familiar with the

23
00:01:01,369 --> 00:00:59,160
left-hand side of this plot so how we

24
00:01:03,170 --> 00:01:01,379
think about UV radiation on earth and

25
00:01:06,109 --> 00:01:03,180
and we tend to think of it as a

26
00:01:08,929 --> 00:01:06,119
destructive and mechanism so for example

27
00:01:11,960 --> 00:01:08,939
in skin damage so sunburn and Sun tans

28
00:01:14,810 --> 00:01:11,970
and as well as DNA damage on the

29
00:01:17,539 --> 00:01:14,820
cellular level and we also use a UV

30
00:01:20,300 --> 00:01:17,549
radiation on earth as a sanitizer so for

31
00:01:23,210 --> 00:01:20,310
example in food storage and though we

32
00:01:25,910 --> 00:01:23,220
also know that on a UV radiation can be

33
00:01:28,160 --> 00:01:25,920
essential to life forming and so for

34
00:01:30,740 --> 00:01:28,170
example in vitamin D production which is

35
00:01:33,170 --> 00:01:30,750
important in calcium metabolism as well

36
00:01:36,350 --> 00:01:33,180
as producing our own ozone layer by the

37
00:01:38,210 --> 00:01:36,360
photo distraction of oxygen and in

38
00:01:40,490 --> 00:01:38,220

interstellar space we tend to think of

39
00:01:42,830 --> 00:01:40,500
UV radiation as a heat or energy source

40
00:01:45,620 --> 00:01:42,840
which can drive reactions that wouldn't

41
00:01:48,319 --> 00:01:45,630
occur at such low temperatures a UV

42
00:01:50,660 --> 00:01:48,329
radiation is able to dissolve molecules

43
00:01:53,359 --> 00:01:50,670
as well as destroying molecules and ions

44
00:01:54,950 --> 00:01:53,369
and creating reactive fragments they can

45
00:02:00,289 --> 00:01:54,960
then combine and form more complex

46
00:02:01,910 --> 00:02:00,299
species as these icy dust grains play a

47
00:02:03,830 --> 00:02:01,920
key role in producing the complex

48
00:02:06,830 --> 00:02:03,840
organic molecules that we observe in

49
00:02:08,830 --> 00:02:06,840
interstellar regions and so with

50
00:02:11,360 --> 00:02:08,840
infrared telescopes we can see the

51
00:02:13,760 --> 00:02:11,370
actual bands of several condensed phase

52
00:02:16,520 --> 00:02:13,770
molecules and I'm showing some of them

53
00:02:18,800 --> 00:02:16,530
are on the right and where the areas

54
00:02:21,020 --> 00:02:18,810
roughly correspond to their relative

55
00:02:23,390 --> 00:02:21,030
abundance and the Isis so we have water

56
00:02:26,810 --> 00:02:23,400
which is the most abundant ice species

57
00:02:29,060 --> 00:02:26,820
followed by co2 and co and then we have

58
00:02:32,420 --> 00:02:29,070
less abundant species like methanol

59
00:02:34,370 --> 00:02:32,430
ammonia and methane and these ices can

60
00:02:37,190 --> 00:02:34,380
be processed and not only by thermal

61
00:02:39,290 --> 00:02:37,200
heating but also by UV photons as well

62
00:02:42,620 --> 00:02:39,300
as other energetic particles like

63
00:02:44,990 --> 00:02:42,630

electrons cosmic rays and ions and this

64
00:02:46,910 --> 00:02:45,000
ice processing can result in reactive

65
00:02:49,400 --> 00:02:46,920
fragments that can then recombine and

66
00:02:51,740 --> 00:02:49,410
form potentially prebiotic organic

67
00:02:53,570 --> 00:02:51,750
molecules so to understand the

68
00:02:55,070 --> 00:02:53,580
importance of these processes we really

69
00:03:01,280 --> 00:02:55,080
need our accurate laboratory

70
00:03:04,490 --> 00:03:01,290
measurements of their cross-sections go

71
00:03:07,190 --> 00:03:04,500
back okay so what do I mean when I'm

72
00:03:08,660 --> 00:03:07,200
talking about a cross-section and so I

73
00:03:10,880 --> 00:03:08,670
just talk to you a little bit about how

74
00:03:14,870 --> 00:03:10,890
I'll refer to these cross-sections in

75
00:03:17,000 --> 00:03:14,880
this talk so for example when we're

76
00:03:18,830 --> 00:03:17,010
talking about UV photodissociation we

77
00:03:20,930 --> 00:03:18,840
have some molecule that has a rate of

78
00:03:23,870 --> 00:03:20,940
being destroyed which is d molecule by

79
00:03:26,480 --> 00:03:23,880
DT and then this is equal to the photon

80
00:03:29,390 --> 00:03:26,490
flux and this is a number of photons per

81
00:03:31,310 --> 00:03:29,400
some area per time and the concentration

82
00:03:33,110 --> 00:03:31,320
of the molecule in the ice and then we

83
00:03:35,030 --> 00:03:33,120
have this Sigma value which is

84
00:03:36,830 --> 00:03:35,040
essentially a probability that the

85
00:03:39,410 --> 00:03:36,840
photon will be absorbed and then destroy

86
00:03:41,449 --> 00:03:39,420
the ice molecule and these probability

87
00:03:43,730 --> 00:03:41,459
factors are especially important because

88
00:03:46,730 --> 00:03:43,740

once we've measured them in the lab we

89
00:03:48,890 --> 00:03:46,740
can then use them with the UV flux in

90
00:03:51,350 --> 00:03:48,900
interstellar space to calculate some

91
00:03:56,360 --> 00:03:51,360
rate coefficient K which can then be

92
00:03:58,670 --> 00:03:56,370
input into extra chemical models and so

93
00:03:59,570 --> 00:03:58,680
how do we go about creating the UV field

94
00:04:02,120 --> 00:03:59,580
in the laboratory

95
00:04:03,740 --> 00:04:02,130
well the UV field and interstellar space

96
00:04:06,440 --> 00:04:03,750
really depends on the physical

97
00:04:08,900 --> 00:04:06,450
properties of the environment so near

98
00:04:11,540 --> 00:04:08,910
stars the UV radiation tends to be

99
00:04:14,390 --> 00:04:11,550
dominated by blackbody emission but when

100
00:04:16,520 --> 00:04:14,400
we go deep into dense cloud cores or on

101
00:04:18,050 --> 00:04:16,530
the disk surfaces you can see we have

102
00:04:20,030 --> 00:04:18,060
this really strong emission at

103
00:04:22,280 --> 00:04:20,040
lyman-alpha which comes from the

104
00:04:25,250 --> 00:04:22,290
recombination of hydrogen with cosmic

105
00:04:26,510 --> 00:04:25,260
rays so in the laboratory and there's

106
00:04:27,190 --> 00:04:26,520
several different ways that we can

107
00:04:29,080 --> 00:04:27,200
create the

108
00:04:31,780 --> 00:04:29,090
radiation and so people have used

109
00:04:34,360 --> 00:04:31,790
discharge lamps lasers and synchrotrons

110
00:04:36,460 --> 00:04:34,370
in our laboratory we're using a hydrogen

111
00:04:39,010 --> 00:04:36,470
discharge lamp that's shown in this

112
00:04:40,960 --> 00:04:39,020
image here and this is a spectra that

113
00:04:43,510 --> 00:04:40,970

shows the emission from our hydrogen

114
00:04:45,310 --> 00:04:43,520
lamp so it's 10 percent hydrogen diluted

115
00:04:47,890 --> 00:04:45,320
an argon and you can see it also has

116
00:04:52,960 --> 00:04:47,900
this really strong emission at 121

117
00:04:54,850 --> 00:04:52,970
nanometers as this brings me to our

118
00:04:56,830 --> 00:04:54,860
current work where we're measuring the

119
00:04:58,720 --> 00:04:56,840
photo distraction of a range of astra

120
00:05:02,470 --> 00:04:58,730
chemically relevant ice species and

121
00:05:04,420 --> 00:05:02,480
they've been oh go back there been

122
00:05:07,780 --> 00:05:04,430
several studies of the photo destruction

123
00:05:10,300 --> 00:05:07,790
of interstellar ices and that most of

124
00:05:12,430 --> 00:05:10,310
them don't report a UV cross-section two

125
00:05:14,110 --> 00:05:12,440
main studies have been conducted which

126
00:05:17,140 --> 00:05:14,120
do report the cross section however

127
00:05:18,640 --> 00:05:17,150
their ices were really thick so only the

128
00:05:21,240 --> 00:05:18,650
about the top team bassoon of the ice

129
00:05:23,740 --> 00:05:21,250
and was able to absorb the photons a

130
00:05:25,720 --> 00:05:23,750
study of Isis and the optically thin

131
00:05:28,600 --> 00:05:25,730
regime hasn't been previously attempted

132
00:05:30,520 --> 00:05:28,610
and while some case studies do exist and

133
00:05:32,530 --> 00:05:30,530
there's no systematic study that

134
00:05:35,380 --> 00:05:32,540
measures the ice photo distraction for

135
00:05:36,880 --> 00:05:35,390
optically thin ices and so I'm going to

136
00:05:39,120 --> 00:05:36,890
talk to you a little bit today about the

137
00:05:42,580 --> 00:05:39,130
ices better shown in red so the co2

138
00:05:44,380 --> 00:05:42,590

methanol water and ammonia ices and we

139
00:05:47,230 --> 00:05:44,390
will study their photo destruction in

140
00:05:50,080 --> 00:05:47,240
optically thin ices and will also

141
00:05:52,690 --> 00:05:50,090
measure not only the pure ices but also

142
00:05:55,540 --> 00:05:52,700
their photo destruction in Astrophysical

143
00:05:58,960 --> 00:05:55,550
irrelevant matrices like water and Co

144
00:06:00,310 --> 00:05:58,970
and also in a noble gas matrices just to

145
00:06:02,680 --> 00:06:00,320
understand the physics a little bit

146
00:06:03,760 --> 00:06:02,690
better and we also measure the cross

147
00:06:05,650 --> 00:06:03,770
sections at a range of different

148
00:06:08,920 --> 00:06:05,660
temperatures which can tell us more

149
00:06:10,330 --> 00:06:08,930
about the chemistry okay so I just want

150
00:06:12,910 --> 00:06:10,340
to tell you a little bit about the

151
00:06:14,860 --> 00:06:12,920
experimental setup that we're using so

152
00:06:17,350 --> 00:06:14,870
we use a vacuum chamber so as Brandon

153
00:06:18,940 --> 00:06:17,360
was saying and in interstellar space the

154
00:06:21,640 --> 00:06:18,950
pressures are much lower so we need to

155
00:06:23,650 --> 00:06:21,650
pump away all the air so we use a vacuum

156
00:06:25,990 --> 00:06:23,660
chamber it's coupled to an infrared

157
00:06:29,350 --> 00:06:26,000
spectrometer which means it measures the

158
00:06:31,390 --> 00:06:29,360
condensed phase of the ice and the ices

159
00:06:33,970 --> 00:06:31,400
are deposited from the gas phase at the

160
00:06:36,760 --> 00:06:33,980
back of the chamber from using a gas

161
00:06:38,620 --> 00:06:36,770
phase dozer and then we have our photon

162
00:06:40,780 --> 00:06:38,630
source which is as I said before a

163
00:06:43,120 --> 00:06:40,790

hydrogen discharge lamp it's

164
00:06:45,450 --> 00:06:43,130
with a hydrogen argon mixture and then

165
00:06:47,770 --> 00:06:45,460
excited by a radiofrequency coil and

166
00:06:49,420 --> 00:06:47,780
then beneath the cell we have a mass

167
00:06:53,890 --> 00:06:49,430
spectrometer which is able to monitor

168
00:06:55,600 --> 00:06:53,900
the gas phase and so if I just cut away

169
00:06:57,520 --> 00:06:55,610
the walls of the chamber you can get a

170
00:06:59,950 --> 00:06:57,530
clearer image of the radiation

171
00:07:01,990 --> 00:06:59,960
configuration and so the ice is

172
00:07:04,060 --> 00:07:02,000
condensed here on a potassium bromide

173
00:07:06,220 --> 00:07:04,070
disk that's pressed into a tungsten grid

174
00:07:10,180 --> 00:07:06,230
and this is cooled by a closed cycle

175
00:07:12,700 --> 00:07:10,190
helium Croat and the ice is suspended at

176
00:07:18,370 --> 00:07:12,710
45 degrees to both the infrared beam and

177
00:07:20,080 --> 00:07:18,380
our UV photon source and so I just want

178
00:07:22,360 --> 00:07:20,090
to introduce a couple of the preliminary

179
00:07:24,160 --> 00:07:22,370
results from our experiments so the

180
00:07:27,430 --> 00:07:24,170
first ice species that we've studied in

181
00:07:29,920 --> 00:07:27,440
co2 ice so to co2 ices have only one

182
00:07:31,540 --> 00:07:29,930
major channel at 121 nanometers and

183
00:07:34,240 --> 00:07:31,550
that's the formation of carbon monoxide

184
00:07:36,250 --> 00:07:34,250
and oxygen atoms and then the gas phase

185
00:07:40,150 --> 00:07:36,260
thus precedes with efficiency that's

186
00:07:42,490 --> 00:07:40,160
near unity however in Isis the co can

187
00:07:45,220 --> 00:07:42,500
recombine of oxygen atoms to reform the

188
00:07:46,660 --> 00:07:45,230

co2 molecules and but this does have

189
00:07:48,550 --> 00:07:46,670
some barriers so we will need some

190
00:07:51,610 --> 00:07:48,560
excess energy we want that process to

191
00:07:54,070 --> 00:07:51,620
happen the oxygen atoms can also combine

192
00:07:56,980 --> 00:07:54,080
or co2 to form this carbon trioxide

193
00:08:00,310 --> 00:07:56,990
species or also with other oxygen atoms

194
00:08:03,520 --> 00:08:00,320
to form Oh to or ozone and so this these

195
00:08:05,560 --> 00:08:03,530
pictures show the radiation of co2 over

196
00:08:07,930 --> 00:08:05,570
time so the scale bar is just a measure

197
00:08:09,820 --> 00:08:07,940
of the time of the irradiation you can

198
00:08:13,060 --> 00:08:09,830
see the loss of this stretching mode of

199
00:08:15,190 --> 00:08:13,070
co2 over time and you can see the co in

200
00:08:19,000 --> 00:08:15,200
the carbon dioxide are growing in during

201
00:08:20,890 --> 00:08:19,010
the experiment and so in order to

202
00:08:22,840 --> 00:08:20,900
extract the cross-section from these

203
00:08:25,810 --> 00:08:22,850
measurements we fit a first-order decay

204
00:08:28,870 --> 00:08:25,820
to the data and so this has the form d

205
00:08:31,330 --> 00:08:28,880
co2 by DT and is the concentration of

206
00:08:34,330 --> 00:08:31,340
the co2 times some rate coefficient J

207
00:08:36,850 --> 00:08:34,340
and the integrated rate expression is an

208
00:08:39,940 --> 00:08:36,860
exponential so we plot the logarithm of

209
00:08:41,920 --> 00:08:39,950
the loss of the co2 over time and then

210
00:08:44,800 --> 00:08:41,930
the slope is that rate coefficient J and

211
00:08:47,230 --> 00:08:44,810
then from J we can extract our cross

212
00:08:48,840 --> 00:08:47,240
section using the knowing laboratory

213
00:08:52,829 --> 00:08:48,850

photon flux

214
00:08:55,949 --> 00:08:52,839
I see here some initial results for the

215
00:08:59,370 --> 00:08:55,959
co2 Isis and you can see we've ran these

216
00:09:02,340 --> 00:08:59,380
experiments at 25 40 and 55 Kelvin for

217
00:09:03,559 --> 00:09:02,350
co2 is shown in the black circles and

218
00:09:05,999 --> 00:09:03,569
you can see that the co2

219
00:09:08,670 --> 00:09:06,009
photodissociation cross-section doesn't

220
00:09:10,559 --> 00:09:08,680
really change over temperature and the

221
00:09:12,990 --> 00:09:10,569
photodissociation cross-section is low

222
00:09:15,540 --> 00:09:13,000
compared to the gas phase so only around

223
00:09:17,579 --> 00:09:15,550
one co2 per seven photons is destroyed

224
00:09:21,059 --> 00:09:17,589
whereas it's near unity and the gas

225
00:09:22,740 --> 00:09:21,069
phase we also add co2 the ice in the

226
00:09:26,249 --> 00:09:22,750
cross section is essentially the same

227
00:09:27,870 --> 00:09:26,259
and compared to adding water a water ice

228
00:09:30,300 --> 00:09:27,880
matrix where we can see the cross

229
00:09:32,579 --> 00:09:30,310
section is decreased and this is

230
00:09:34,680 --> 00:09:32,589
probably because the water ice when it's

231
00:09:36,990 --> 00:09:34,690
floated associated forms these hydroxyl

232
00:09:42,990 --> 00:09:37,000
radicals which can react with the photo

233
00:09:45,269 --> 00:09:43,000
produced Co and reform the co2 we also

234
00:09:47,309 --> 00:09:45,279
looked at methanol Isis so it's branding

235
00:09:49,199 --> 00:09:47,319
kind of mentioned methanol is really

236
00:09:51,329 --> 00:09:49,209
important to us because for us it's a

237
00:09:53,249 --> 00:09:51,339
complex molecule and it can be a

238
00:09:55,980 --> 00:09:53,259

precursor to potentially prebiotic

239
00:09:57,900 --> 00:09:55,990
molecules like Geico aldehyde and so

240
00:10:00,840 --> 00:09:57,910
these spectra show the loss of the

241
00:10:02,189 --> 00:10:00,850
methanol band over time and you can see

242
00:10:04,999 --> 00:10:02,199
some of the photo products that are

243
00:10:08,730 --> 00:10:05,009
growing in so we have co2 and co and

244
00:10:10,319 --> 00:10:08,740
formaldehyde and also methane and there

245
00:10:15,150 --> 00:10:10,329
are some other smaller signatures of

246
00:10:16,769 --> 00:10:15,160
more complex species as well so here are

247
00:10:19,170 --> 00:10:16,779
the results of the measurements of the

248
00:10:21,509 --> 00:10:19,180
cross sections for methanol and so in

249
00:10:23,069 --> 00:10:21,519
contrary to co2 you can see that the

250
00:10:24,329 --> 00:10:23,079
cross section does increase with

251
00:10:26,879 --> 00:10:24,339
temperature actually it's almost

252
00:10:28,579 --> 00:10:26,889
exponential I mean there are a couple of

253
00:10:31,259 --> 00:10:28,589
explanations for why this might happen

254
00:10:33,360 --> 00:10:31,269
so as we increase the temperature the

255
00:10:34,829 --> 00:10:33,370
photo fragments and the methanol ice can

256
00:10:37,530 --> 00:10:34,839
diffuse away from each other more easily

257
00:10:39,960 --> 00:10:37,540
so we'll have less recombinations to

258
00:10:41,579 --> 00:10:39,970
reform the methanol and the photo

259
00:10:44,970 --> 00:10:41,589
fragments also as temperature is

260
00:10:46,710 --> 00:10:44,980
increased can dissolve more easily so we

261
00:10:49,189 --> 00:10:46,720
also would have this reformation of

262
00:10:51,540 --> 00:10:49,199
methanol and we can see again that the

263
00:10:54,689 --> 00:10:51,550

cross section is lower compared to the

264
00:10:58,230 --> 00:10:54,699
gas phase so only about one in 25

265
00:11:00,509 --> 00:10:58,240
photons and resulted in it dissociation

266
00:11:02,060 --> 00:11:00,519
of methanol at 25 Kelvin and this

267
00:11:05,330 --> 00:11:02,070
increases to about one and

268
00:11:07,880 --> 00:11:05,340
even at 100 Kelvin we can also see

269
00:11:09,410 --> 00:11:07,890
contrary to co2 adding a water ice

270
00:11:11,660 --> 00:11:09,420
matrix doesn't really change the

271
00:11:13,810 --> 00:11:11,670
cross-section indicating that the photo

272
00:11:16,970 --> 00:11:13,820
fragment diffusion in the water s matrix

273
00:11:21,800 --> 00:11:16,980
isn't really changed by having a water

274
00:11:23,750 --> 00:11:21,810
ace and some of these results can be

275
00:11:26,690 --> 00:11:23,760
explained in part by the cage effect in

276
00:11:28,700 --> 00:11:26,700
Isis so we saw that the gas phase cross

277
00:11:31,610 --> 00:11:28,710
section tended to be much higher than

278
00:11:33,560 --> 00:11:31,620
the solid phase cross section and this

279
00:11:36,830 --> 00:11:33,570
is because the ice matrix so these red

280
00:11:38,930 --> 00:11:36,840
ice species and hinders the diffusion of

281
00:11:41,840 --> 00:11:38,940
the photo fragments so then we just get

282
00:11:43,930 --> 00:11:41,850
more recombination events as we increase

283
00:11:47,540 --> 00:11:43,940
the temperature the photo fragment

284
00:11:48,860 --> 00:11:47,550
diffusion becomes more easy and then we

285
00:11:50,510 --> 00:11:48,870
will see that the cross section would

286
00:11:55,910 --> 00:11:50,520
increase with temperature and we see

287
00:11:57,740 --> 00:11:55,920
this result for our methanol ices and so

288
00:11:59,030 --> 00:11:57,750

the next steps in our survey are to

289
00:12:01,580 --> 00:11:59,040
continue these measurements for other

290
00:12:03,110 --> 00:12:01,590
ices of interstellar importance so we've

291
00:12:05,210 --> 00:12:03,120
made just a couple of preliminary

292
00:12:07,640 --> 00:12:05,220
measurements for water and ammonia races

293
00:12:10,070 --> 00:12:07,650
and so ammonia at around 70 Kelvin and

294
00:12:11,960 --> 00:12:10,080
water at 120 Kelvin and you can see

295
00:12:14,650 --> 00:12:11,970
actually the cross sections are very low

296
00:12:17,570 --> 00:12:14,660
even compared to our co2 in methanol

297
00:12:21,020 --> 00:12:17,580
ices and this is probably because the

298
00:12:22,850 --> 00:12:21,030
recombination it happens really fast in

299
00:12:24,380 --> 00:12:22,860
the water ice or ammonia matrix because

300
00:12:29,750 --> 00:12:24,390
it's most likely due to hydrogen

301
00:12:31,880 --> 00:12:29,760
recombination and so just in summary so

302
00:12:33,860 --> 00:12:31,890
we're conducting the survey of photo

303
00:12:36,020 --> 00:12:33,870
destruction cross sections for optically

304
00:12:38,840 --> 00:12:36,030
thin ices of interstellar importance and

305
00:12:40,160 --> 00:12:38,850
the photodissociation rates will help us

306
00:12:42,320 --> 00:12:40,170
provide some information about the

307
00:12:44,750 --> 00:12:42,330
chemistry occurring in the ices and the

308
00:12:46,580 --> 00:12:44,760
radical recombination rates and the

309
00:12:49,190 --> 00:12:46,590
temperature dependencies and relative

310
00:12:51,500 --> 00:12:49,200
rates can and in part be explained by

311
00:12:53,150 --> 00:12:51,510
the cage effect and these quantitative

312
00:12:55,130 --> 00:12:53,160
measurements will be especially

313
00:12:56,870 --> 00:12:55,140

important for understanding ice

314
00:12:58,580 --> 00:12:56,880
chemistry that could potentially form

315
00:13:08,280 --> 00:12:58,590
prebiotic molecules and interstellar

316
00:13:21,370 --> 00:13:17,800
questions just I didn't get the part

317
00:13:24,490 --> 00:13:21,380
that you had to excite your sample with

318
00:13:26,199 --> 00:13:24,500
radio frequency before doing so it's not

319
00:13:28,749 --> 00:13:26,209
the sample the radio frequency is just

320
00:13:31,059 --> 00:13:28,759
to provide the radiation source so we

321
00:13:33,160 --> 00:13:31,069
need some we're just providing a

322
00:13:35,350 --> 00:13:33,170
hydrogen discharge lamp to create the UV

323
00:13:37,840 --> 00:13:35,360
radiation the radio frequency source

324
00:13:44,230 --> 00:13:37,850
isn't involved in the sample dye sample

325
00:13:47,110 --> 00:13:44,240
okay so it has been shown in prebiotic

326
00:13:51,400 --> 00:13:47,120
chemistry Studies on early Earth that

327
00:13:55,900 --> 00:13:51,410
hydrogen cyanide has a potential clue

328
00:13:58,749 --> 00:13:55,910
role in combination with UV light so I

329
00:14:01,780 --> 00:13:58,759
was wondering if first you have done

330
00:14:04,840 --> 00:14:01,790
some studies on hydrogen cyanide and

331
00:14:07,389 --> 00:14:04,850
then if you have done some studies on

332
00:14:09,040 --> 00:14:07,399
combination of molecules so if you can

333
00:14:12,610 --> 00:14:09,050
detect something different when you mix

334
00:14:14,379 --> 00:14:12,620
kind different kind of molecules sure so

335
00:14:16,600 --> 00:14:14,389
we haven't done hydrogen cyanide it's a

336
00:14:19,269 --> 00:14:16,610
possibility and it's very dangerous so

337
00:14:22,179 --> 00:14:19,279
we tend to stick with somewhat dangerous

338
00:14:24,189 --> 00:14:22,189

species last weekend and that people

339
00:14:25,660 --> 00:14:24,199
have studied the photodissociation of

340
00:14:28,269 --> 00:14:25,670
hydrogen cyanide as well

341
00:14:30,189 --> 00:14:28,279
and we haven't done it yet and as for

342
00:14:31,840 --> 00:14:30,199
the ice mixtures this is also something

343
00:14:34,030 --> 00:14:31,850
we'd like to do but we start with the

344
00:14:35,829 --> 00:14:34,040
simplest I supposed and then work our

345
00:14:37,509 --> 00:14:35,839
way up to the more complicated species

346
00:14:46,059 --> 00:14:37,519
just so we can really understand what's

347
00:14:47,590 --> 00:14:46,069
happening in the ice anybody else so

348
00:14:49,269 --> 00:14:47,600
this is really cool I was curious you

349
00:14:51,160 --> 00:14:49,279
mentioned that you have Co plus o

350
00:14:53,019 --> 00:14:51,170
recombination and from a photochemical

351
00:14:55,210 --> 00:14:53,029
perspective that's often treated as

352
00:14:56,980 --> 00:14:55,220
being spin forbidden so what do you

353
00:14:59,019 --> 00:14:56,990
think there's any intermediate steps or

354
00:15:01,600 --> 00:14:59,029
do you have any impurities that to drive

355
00:15:03,129 --> 00:15:01,610
that catalysis I would say that we don't

356
00:15:05,019 --> 00:15:03,139
know that we have Co plus our

357
00:15:06,819 --> 00:15:05,029
recombination is just a possibility and

358
00:15:09,490 --> 00:15:06,829
the reason why I just showed it is

359
00:15:11,170 --> 00:15:09,500
because we may have some excited CO and

360
00:15:13,360 --> 00:15:11,180
oxygen atoms that this process could

361
00:15:14,050 --> 00:15:13,370
occur so when we radiate the ice some of

362
00:15:16,510 --> 00:15:14,060
them will stay in

363
00:15:18,760 --> 00:15:16,520

excited state maybe allowing some synth

364
00:15:20,230 --> 00:15:18,770
ridden process to heaven but there's no

365
00:15:21,700 --> 00:15:20,240
way that we can possibly tell that

366
00:15:23,320 --> 00:15:21,710
that's happening and actually I would

367
00:15:25,210 --> 00:15:23,330
think it's not happening because we

368
00:15:29,410 --> 00:15:25,220
don't have a temperature dependence with

369
00:15:31,510 --> 00:15:29,420
a co2 irradiation so something we can't

370
00:15:32,980 --> 00:15:31,520
really distinguish but is differently

371
00:15:34,930 --> 00:15:32,990
forbidden and I think the barrier is

372
00:15:37,390 --> 00:15:34,940
pretty high it's maybe like a thousand

373
00:15:44,470 --> 00:15:37,400
Kelvin or something so maybe it doesn't

374
00:15:47,230 --> 00:15:44,480
happen high house I enjoyed your talk

375
00:15:49,210 --> 00:15:47,240
quick question I understand that the

376
00:15:51,820 --> 00:15:49,220
more complex organic molecules don't

377
00:15:53,680 --> 00:15:51,830
show up in the actual samples what I'm

378
00:15:55,150 --> 00:15:53,690
wondering is has there been any work in

379
00:16:03,270 --> 00:15:55,160
terms of modeling them numerically that

380
00:16:07,060 --> 00:16:03,280
would show necessarily if it's not so

381
00:16:08,980 --> 00:16:07,070
the gong the I was wondering if the if

382
00:16:10,900 --> 00:16:08,990
the molecules more complex molecules

383
00:16:13,210 --> 00:16:10,910
have been modeled to show what the rate

384
00:16:16,240 --> 00:16:13,220
of dissociation or probability of more

385
00:16:18,010 --> 00:16:16,250
complex yeah those would be um I don't

386
00:16:20,020 --> 00:16:18,020
as far as I know I don't think that

387
00:16:23,980 --> 00:16:20,030
there are any cross-section measurements

388
00:16:25,230 --> 00:16:23,990

for really complex I species I'm sorry

389
00:16:27,700 --> 00:16:25,240
go ahead

390
00:16:29,110 --> 00:16:27,710
yeah and the modeling why are you going

391
00:16:31,810 --> 00:16:29,120
to hear about some modeling in the next

392
00:16:33,820 --> 00:16:31,820
door and but I think modeling for

393
00:16:35,980 --> 00:16:33,830
complex Isis gets really complicated

394
00:16:38,260 --> 00:16:35,990
really fast so Chris will talk about the

395
00:16:41,230 --> 00:16:38,270
most simplest ice system but even

396
00:16:43,840 --> 00:16:41,240
getting to water or just a methanol ice

397
00:16:46,510 --> 00:16:43,850
it gets so complicated so I think it's

398
00:16:49,900 --> 00:16:46,520
something that the field should do but

399
00:16:51,610 --> 00:16:49,910
it's going to take a lot of time um but

400
00:16:53,620 --> 00:16:51,620
as for the experiments which is what I

401
00:16:55,750 --> 00:16:53,630
know a little bit more about there are

402
00:16:57,820 --> 00:16:55,760
experiments where people do see complex

403
00:16:59,800 --> 00:16:57,830
molecules and Isis if you want to look

404
00:17:01,780 --> 00:16:59,810
at really complicated species you need

405
00:17:04,450 --> 00:17:01,790
to do something like GCMs so you would

406
00:17:06,400 --> 00:17:04,460
collect the ice sample and then look at

407
00:17:07,780 --> 00:17:06,410
the mass spectrometer and figure out

408
00:17:10,360 --> 00:17:07,790
what's in there and people have seen

409
00:17:12,770 --> 00:17:10,370
things like amino acids and other things

410
00:17:16,600 --> 00:17:12,780
well I say they have