2017 Astrobiology Graduate Conference

Charlottesville, VA

1
00:00:00,790 --> 00:00:07,570
[Music]

2
00:00:13,640 --> 00:00:11,990
hi my name is Reyes uh and I'm a zero

3
00:00:15,950 --> 00:00:13,650
three year grad student at Cal Tech I'll

4
00:00:18,950 --> 00:00:15,960
be starting there in the fall I did most

5
00:00:19,939 --> 00:00:18,960
of this stuff at Columbia um and like

6
00:00:21,200 --> 00:00:19,949
Brandon said I'm going to be talking

7
00:00:22,939 --> 00:00:21,210
about predicting complex organic

8
00:00:25,490 --> 00:00:22,949
molecule emission from the TW hydro

9
00:00:27,290 --> 00:00:25,500
protoplanetary disc which is this eye of

10
00:00:29,810 --> 00:00:27,300
Sauron like thing in the center of the

11
00:00:31,490 --> 00:00:29,820
slide um so that's a lot and I'm going

12
00:00:33,530 --> 00:00:31,500
to try to break this project down into

13
00:00:36,139 --> 00:00:33,540

little pieces so that hopefully you can

14
00:00:39,410 --> 00:00:36,149
take something away from it starting

15
00:00:41,470 --> 00:00:39,420
with this um you know roomful of astro

16
00:00:43,670 --> 00:00:41,480
chemists or astrobiologists rather uh

17
00:00:45,860 --> 00:00:43,680
why do you all care about what a

18
00:00:47,479 --> 00:00:45,870
protoplanetary disk is well I wrote this

19
00:00:50,060 --> 00:00:47,489
talk before realizing that everyone was

20
00:00:51,139 --> 00:00:50,070
going to talk about this so bear with me

21
00:00:53,990 --> 00:00:51,149
while I go through the introduction

22
00:00:55,910 --> 00:00:54,000
again um but I'm going to try to pay a

23
00:00:56,900 --> 00:00:55,920
little bit more attention to why they

24
00:01:00,560 --> 00:00:56,910
might be asked about logically

25
00:01:02,540 --> 00:01:00,570
significant so as astrobiologists we are

26
00:01:04,700 --> 00:01:02,550
in some way or another all interested in

27
00:01:07,219 --> 00:01:04,710
life in the universe right as we know it

28
00:01:09,410 --> 00:01:07,229
it's a planetary phenomenon we obviously

29
00:01:11,870 --> 00:01:09,420
know about life on Earth we had a great

30
00:01:14,510 --> 00:01:11,880
talk yesterday about habitable zones and

31
00:01:17,690 --> 00:01:14,520
bio signatures on in exoplanetary

32
00:01:19,999 --> 00:01:17,700
systems so our mindset is sort of a

33
00:01:21,200 --> 00:01:20,009
planetary one and that brings to light

34
00:01:24,020 --> 00:01:21,210
an interesting question is there

35
00:01:26,810 --> 00:01:24,030
anything inherent within the process of

36
00:01:28,340 --> 00:01:26,820
how these planets form that seeds these

37
00:01:30,679 --> 00:01:28,350
planetary systems with the materials

38
00:01:32,330 --> 00:01:30,689

necessary for life and by materials

39
00:01:34,190 --> 00:01:32,340
necessary for life I mean complex

40
00:01:37,539 --> 00:01:34,200
organic molecules as has been talked

41
00:01:39,649 --> 00:01:37,549
about at length by like everyone else um

42
00:01:41,149 --> 00:01:39,659
so that kind of behooves us to look at

43
00:01:42,590 --> 00:01:41,159
the process of how stars and planets

44
00:01:44,149 --> 00:01:42,600
form and see if there are any

45
00:01:47,270 --> 00:01:44,159
interesting chemical environments that

46
00:01:49,780 --> 00:01:47,280
we can investigate so yeah you've seen

47
00:01:53,539 --> 00:01:49,790
this picture before you start off with a

48
00:01:55,490 --> 00:01:53,549
large cold cloud of gas and dust in the

49
00:01:57,109 --> 00:01:55,500
interstellar medium parts of this cloud

50
00:01:58,459 --> 00:01:57,119
can become over dense and get dense or

51
00:02:00,560 --> 00:01:58,469
denser and hotter and hotter as they

52
00:02:03,469 --> 00:02:00,570
create more material thus forming a baby

53
00:02:05,959 --> 00:02:03,479
star or a protostar um but this process

54
00:02:07,850 --> 00:02:05,969
isn't rotationally static um the

55
00:02:09,710 --> 00:02:07,860
accreting material has angular momentum

56
00:02:11,540 --> 00:02:09,720
and so to conserve it what ends up

57
00:02:13,220 --> 00:02:11,550
forming around the protostar is a disk

58
00:02:13,880 --> 00:02:13,230
of that same gas and dust called the

59
00:02:16,340 --> 00:02:13,890
proto planet

60
00:02:18,320 --> 00:02:16,350
disk and it's so-called because the

61
00:02:20,420 --> 00:02:18,330
material in that disk is what ultimately

62
00:02:24,260 --> 00:02:20,430
ends up being the stuff that forms

63
00:02:26,690 --> 00:02:24,270

planetary systems so in some way you can

64
00:02:28,190 --> 00:02:26,700
kind of think about um the

65
00:02:30,560 --> 00:02:28,200
protoplanetary disk is setting the

66
00:02:31,970 --> 00:02:30,570
chemical inventory for the material

67
00:02:33,770 --> 00:02:31,980
available in this form and planetary

68
00:02:36,980 --> 00:02:33,780
system which makes it really interesting

69
00:02:41,210 --> 00:02:36,990
and important to study so let's do that

70
00:02:44,090 --> 00:02:41,220
um before I jump into explaining this

71
00:02:46,160 --> 00:02:44,100
cartoon of a disk I want to reiterate

72
00:02:48,470 --> 00:02:46,170
something that's been talked at length

73
00:02:49,730 --> 00:02:48,480
before there's kind of two ways we can

74
00:02:51,800 --> 00:02:49,740
think about forming complex organic

75
00:02:53,449 --> 00:02:51,810
molecules one way is in the gas phase

76
00:02:56,240 --> 00:02:53,459
where you have you know two body gas

77
00:02:58,040 --> 00:02:56,250
phase collisions or another way is on

78
00:03:00,770 --> 00:02:58,050
icy grant surfaces right keep that in

79
00:03:03,260 --> 00:03:00,780
mind and as was mentioned twice before I

80
00:03:05,210 --> 00:03:03,270
think we can't really detect complex

81
00:03:07,370 --> 00:03:05,220
organics in the ice phase unless the

82
00:03:10,640 --> 00:03:07,380
source is backlit so we really can only

83
00:03:11,870 --> 00:03:10,650
detect things in the gas phase so with

84
00:03:14,060 --> 00:03:11,880
that in mind let's look at the different

85
00:03:15,350 --> 00:03:14,070
parts of this disc and see where the

86
00:03:17,780 --> 00:03:15,360
complex organic species might be

87
00:03:20,000 --> 00:03:17,790
residing so in this sort of red region

88
00:03:21,440 --> 00:03:20,010

up here the disc atmosphere is kind of

89
00:03:23,240 --> 00:03:21,450
hot so there's not a lot of gas phase

90
00:03:24,890 --> 00:03:23,250
canvas not a lot of ice phase chemistry

91
00:03:26,660 --> 00:03:24,900
happening um and there's a lot of

92
00:03:28,520 --> 00:03:26,670
radiation so even if you know complex

93
00:03:31,220 --> 00:03:28,530
organics do form they're oftentimes

94
00:03:33,350 --> 00:03:31,230
broken up by radiation into like

95
00:03:36,830 --> 00:03:33,360
radicals ions other constituent species

96
00:03:40,190 --> 00:03:36,840
so no dice there right so in this blue

97
00:03:41,570 --> 00:03:40,200
region the disc mid plane um it is cold

98
00:03:44,600 --> 00:03:41,580
so you do have the ability to make

99
00:03:46,430 --> 00:03:44,610
complex organics on ICE's um but in this

100
00:03:47,870 --> 00:03:46,440
you know cartoon scenario sometimes

101
00:03:49,550 --> 00:03:47,880
there's not enough radiation that comes

102
00:03:51,920 --> 00:03:49,560
in and pops those things off of the ices

103
00:03:53,660 --> 00:03:51,930
for us to observe so this is kind of

104
00:03:55,430 --> 00:03:53,670
like you know in this situation a

105
00:03:56,840 --> 00:03:55,440
Goldilocks thing right it's up here it's

106
00:03:58,670 --> 00:03:56,850
too hot down here it's too cold so

107
00:04:00,350 --> 00:03:58,680
somewhere in the middle in this yellow

108
00:04:02,180 --> 00:04:00,360
region there's just the right amount of

109
00:04:04,370 --> 00:04:02,190
heat and radiation to have these

110
00:04:06,340 --> 00:04:04,380
molecules form in the ices but come off

111
00:04:08,479 --> 00:04:06,350
into the gas phase for us to observe

112
00:04:10,819 --> 00:04:08,489
that's what's called the molecular layer

113
00:04:13,220 --> 00:04:10,829

of the disk and that's where we expect

114
00:04:17,360 --> 00:04:13,230
to find molecules like methanol ch3oh

115
00:04:20,360 --> 00:04:17,370
and methyl cyanide CH dcn now I keep

116
00:04:22,039 --> 00:04:20,370
saying um observation of these molecules

117
00:04:23,480 --> 00:04:22,049
I want to take a second and talk about

118
00:04:25,010 --> 00:04:23,490
how that actually works I'm not a radio

119
00:04:27,020 --> 00:04:25,020
astronomer but I'll just go through it

120
00:04:27,740 --> 00:04:27,030
quickly how these molecules emit light

121
00:04:31,220 --> 00:04:27,750
which are then

122
00:04:33,410 --> 00:04:31,230
observed by us here on earth so in this

123
00:04:34,640 --> 00:04:33,420
obviously cartoon situation imagine a

124
00:04:36,680 --> 00:04:34,650
methanol molecule floating out in space

125
00:04:38,990 --> 00:04:36,690
we know the rotation of molecules is

126
00:04:41,120 --> 00:04:39,000
quantized it can be excited to a higher

127
00:04:43,670 --> 00:04:41,130
rotational state maybe by collision with

128
00:04:45,650 --> 00:04:43,680
h2 or something it can relax to a lower

129
00:04:47,450 --> 00:04:45,660
rotational state but only if it's

130
00:04:49,520 --> 00:04:47,460
accompanied by the release of a photon

131
00:04:50,630 --> 00:04:49,530
at a very specific wavelength and of

132
00:04:52,580 --> 00:04:50,640
course if that wavelength is in the

133
00:04:54,110 --> 00:04:52,590
millimeter/submillimeter regime it can

134
00:04:56,000 --> 00:04:54,120
be picked up by Alma well not one

135
00:04:57,020 --> 00:04:56,010
specific photon but you know you can

136
00:04:59,000 --> 00:04:57,030
imagine if this is an astronomical

137
00:05:01,490 --> 00:04:59,010
source you can get enough photons to

138
00:05:03,560 --> 00:05:01,500

produce an observable signal so that's

139
00:05:05,360 --> 00:05:03,570
kind of how that works but as I said

140
00:05:07,220 --> 00:05:05,370
before this kind of rotational

141
00:05:10,340 --> 00:05:07,230
spectroscopy only works for molecules in

142
00:05:11,720 --> 00:05:10,350
the gas phase right um and I mentioned

143
00:05:14,510 --> 00:05:11,730
how a lot of these molecules are thought

144
00:05:16,820 --> 00:05:14,520
to form on ICE's so let's briefly lay

145
00:05:17,900 --> 00:05:16,830
out how that happens for one example so

146
00:05:20,480 --> 00:05:17,910
this is kind of a picture of how

147
00:05:22,370 --> 00:05:20,490
methanol forms um basically you start

148
00:05:24,350 --> 00:05:22,380
off with the carbon monoxide ice and you

149
00:05:25,640 --> 00:05:24,360
keep hydrogenating it and hydrogenating

150
00:05:27,320 --> 00:05:25,650
it on the surface until you end up with

151
00:05:28,730 --> 00:05:27,330
methanol the different directions of

152
00:05:30,770 --> 00:05:28,740
arrows suggest that this is not as

153
00:05:33,740 --> 00:05:30,780
simple process as that but for now we

154
00:05:35,540 --> 00:05:33,750
can treat it as it is um but even then

155
00:05:36,290 --> 00:05:35,550
you get methanol on ice right so how do

156
00:05:38,150 --> 00:05:36,300
we get it off

157
00:05:39,409 --> 00:05:38,160
one way is thermal desorption if it's

158
00:05:41,630 --> 00:05:39,419
hot enough the methanol can just come

159
00:05:43,880 --> 00:05:41,640
off on its own another way is photo

160
00:05:45,950 --> 00:05:43,890
desorption wherein you have an energetic

161
00:05:47,719 --> 00:05:45,960
photon that pops it off that way there's

162
00:05:50,659 --> 00:05:47,729
also reactive desorption which I won't

163
00:05:52,159 --> 00:05:50,669

get too much into but basically yeah

164
00:05:54,020 --> 00:05:52,169
this is kind of the status quo right we

165
00:05:55,640 --> 00:05:54,030
have we feel like we have a good idea of

166
00:05:57,740 --> 00:05:55,650
how some of these complex organics are

167
00:06:01,040 --> 00:05:57,750
forming how they come off the grains and

168
00:06:03,080 --> 00:06:01,050
how they emit light so putting that all

169
00:06:05,060 --> 00:06:03,090
together if we have all these components

170
00:06:07,159 --> 00:06:05,070
we should be able to build some kind of

171
00:06:09,520 --> 00:06:07,169
predictive model for how chemistry

172
00:06:11,480 --> 00:06:09,530
occurs in these protoplanetary discs and

173
00:06:13,490 --> 00:06:11,490
that's sort of what i was tasked with

174
00:06:15,409 --> 00:06:13,500
doing is trying to build such a model

175
00:06:17,150 --> 00:06:15,419
for one specific protoplanetary disc

176
00:06:21,080 --> 00:06:17,160
namely the one around the pro to start

177
00:06:24,650 --> 00:06:21,090
TW Hydra so let me talk about how I

178
00:06:26,540 --> 00:06:24,660
built that model we started off with a

179
00:06:29,150 --> 00:06:26,550
physical structure that's sort of been

180
00:06:30,950 --> 00:06:29,160
pre calculated by another group um if

181
00:06:33,770 --> 00:06:30,960
you're interested in who did that stuff

182
00:06:35,450 --> 00:06:33,780
come make friends with me later um but

183
00:06:37,420 --> 00:06:35,460
what you're looking at is a radial slice

184
00:06:40,550 --> 00:06:37,430
of the disk so radius on the x-axis

185
00:06:41,399 --> 00:06:40,560
height on the Y and the color scale

186
00:06:43,559 --> 00:06:41,409
represents the

187
00:06:45,169 --> 00:06:43,569
temperature so parameters like gas

188
00:06:47,999 --> 00:06:45,179

temperature dust temperature density

189
00:06:49,769 --> 00:06:48,009
ionization field all sorts of stuff have

190
00:06:51,959 --> 00:06:49,779
basically been pre calculated for us on

191
00:06:55,559 --> 00:06:51,969
this you know cylindrical isometric grid

192
00:06:57,839 --> 00:06:55,569
and to this grid we hook on a chemical

193
00:06:59,609 --> 00:06:57,849
model and if you're unfamiliar with how

194
00:07:01,799 --> 00:06:59,619
like rate equation based chemical

195
00:07:03,389 --> 00:07:01,809
modeling works let me like briefly walk

196
00:07:05,850 --> 00:07:03,399
you through that because I'm sure some

197
00:07:07,919 --> 00:07:05,860
people don't know what it is so you have

198
00:07:11,549 --> 00:07:07,929
you know a chemical reaction

199
00:07:13,139 --> 00:07:11,559
X plus y equals Z you can write down the

200
00:07:15,089 --> 00:07:13,149
rate for that reaction as sort of an

201
00:07:16,259 --> 00:07:15,099
ordinary differential equation so the

202
00:07:18,149 --> 00:07:16,269
rate at which Z is formed is

203
00:07:19,979 --> 00:07:18,159
proportional to the concentrations of

204
00:07:22,619 --> 00:07:19,989
the reactants times some kind of rate

205
00:07:25,350 --> 00:07:22,629
coefficient um so people much smarter

206
00:07:28,259 --> 00:07:25,360
than I have compiled enormous databases

207
00:07:30,799 --> 00:07:28,269
of reactions like these in the gas phase

208
00:07:33,809 --> 00:07:30,809
and on ICE's that occur in these sources

209
00:07:35,879 --> 00:07:33,819
and so you can imagine that's a like

210
00:07:37,949 --> 00:07:35,889
ninety four hundred equate equation

211
00:07:40,169 --> 00:07:37,959
strong system of coupled OD es so you

212
00:07:41,759 --> 00:07:40,179
need a computer to solve that and once

213
00:07:43,409 --> 00:07:41,769

you do you get something called like the

214
00:07:45,269 --> 00:07:43,419
chemical evolution as a function of time

215
00:07:46,859 --> 00:07:45,279
so in this case you know you could get

216
00:07:49,679 --> 00:07:46,869
the concentration of Z as a function of

217
00:07:52,919 --> 00:07:49,689
time um so you pick a suitable time to

218
00:07:55,230 --> 00:07:52,929
stop at uh and we do that at each grid

219
00:07:57,029 --> 00:07:55,240
point throughout the disk and doing so

220
00:08:00,290 --> 00:07:57,039
allows us to kind of see the chemical

221
00:08:03,089 --> 00:08:00,300
structure of the disk on a large scale

222
00:08:04,829 --> 00:08:03,099
so what does that look like in practice

223
00:08:07,350 --> 00:08:04,839
I'm sure people don't really care about

224
00:08:09,989 --> 00:08:07,360
the methodology um so in practice this

225
00:08:12,989 --> 00:08:09,999
is what it looks like for methanol again

226
00:08:15,359 --> 00:08:12,999
you're looking at a radial slice of disk

227
00:08:16,739 --> 00:08:15,369
so radius on the X height on the Y and

228
00:08:20,219 --> 00:08:16,749
the color scale is a number density of

229
00:08:21,899 --> 00:08:20,229
methanol um and I've sort of labeled the

230
00:08:24,689 --> 00:08:21,909
kind of different phases in which you

231
00:08:26,689 --> 00:08:24,699
can form gas phase methanol and sort of

232
00:08:29,579 --> 00:08:26,699
the precursors to the gas phase methanol

233
00:08:31,499 --> 00:08:29,589
in parentheses so what do we see here we

234
00:08:33,420 --> 00:08:31,509
see sort of a you know small but

235
00:08:35,279 --> 00:08:33,430
significant hot gas reservoir in the

236
00:08:37,170 --> 00:08:35,289
upper disc atmosphere but most of the

237
00:08:39,209 --> 00:08:37,180
methanol scene is becoming you know that

238
00:08:41,219 --> 00:08:39,219

same thing that I was talking about with

239
00:08:42,990 --> 00:08:41,229
things being formed on ice and photo

240
00:08:44,340 --> 00:08:43,000
desorbing or reactively desorbing off of

241
00:08:48,079 --> 00:08:44,350
the ice into the gas phase for us to

242
00:08:50,579 --> 00:08:48,089
observe so great it seems like things

243
00:08:52,740 --> 00:08:50,589
kind of stack up the way we thought they

244
00:08:54,449 --> 00:08:52,750
would right so the next step is taking

245
00:08:55,140 --> 00:08:54,459
the output from this chemical model and

246
00:08:56,880 --> 00:08:55,150
running it through

247
00:08:59,430 --> 00:08:56,890
radiative transfer code which I

248
00:09:00,960 --> 00:08:59,440
definitely don't have time to talk about

249
00:09:03,540 --> 00:09:00,970
in detail but you can think of it as a

250
00:09:05,940 --> 00:09:03,550
black body that turns the chemical model

251
00:09:09,060 --> 00:09:05,950
into a synthetic observation comparable

252
00:09:11,640 --> 00:09:09,070
to real Alma data so that's what we did

253
00:09:13,290 --> 00:09:11,650
my adviser was involved in observations

254
00:09:16,200 --> 00:09:13,300
of methanol on this source like last

255
00:09:19,950 --> 00:09:16,210
year so she gave me data for that and I

256
00:09:21,570 --> 00:09:19,960
compared that with my stuff so what

257
00:09:23,430 --> 00:09:21,580
you're looking at is the disk which is

258
00:09:25,590 --> 00:09:23,440
actually oriented close to face on

259
00:09:27,000 --> 00:09:25,600
towards us RA and Dec on the x and y

260
00:09:28,860 --> 00:09:27,010
axis so you looking at position on the

261
00:09:30,780 --> 00:09:28,870
sky don't worry about the color scale

262
00:09:33,150 --> 00:09:30,790
that's like the velocity structure of

263
00:09:34,800 --> 00:09:33,160

the disk but the black contours are my

264
00:09:37,880 --> 00:09:34,810
synthetic observations and the green

265
00:09:41,220 --> 00:09:37,890
contours are effectively the real

266
00:09:43,170 --> 00:09:41,230
observations that were carried out so

267
00:09:44,580 --> 00:09:43,180
you might be looking at this image and

268
00:09:46,830 --> 00:09:44,590
thinking you know for all this talk

269
00:09:48,660 --> 00:09:46,840
about this like fancy astro chemical

270
00:09:53,880 --> 00:09:48,670
model that you may like it seems to do a

271
00:09:56,970 --> 00:09:53,890
pretty bad job and you're right so so

272
00:09:58,830 --> 00:09:56,980
let's let's try to figure out why what's

273
00:10:00,840 --> 00:09:58,840
going on here right the first thing you

274
00:10:02,730 --> 00:10:00,850
might notice is that the sort of green

275
00:10:05,280 --> 00:10:02,740
contours aren't really super symmetric

276
00:10:07,260 --> 00:10:05,290
about the origin of the disk um and

277
00:10:09,330 --> 00:10:07,270
according to my adviser who is a radio

278
00:10:11,550 --> 00:10:09,340
astronomer not me who is not um this is

279
00:10:13,740 --> 00:10:11,560
due to low signal-to-noise ratio in the

280
00:10:17,520 --> 00:10:13,750
observations so that's not something I

281
00:10:19,050 --> 00:10:17,530
can directly fix the another thing you

282
00:10:21,870 --> 00:10:19,060
might notice is that the black contours

283
00:10:24,450 --> 00:10:21,880
are really extended relative to the

284
00:10:26,160 --> 00:10:24,460
green contours um and you know I'll talk

285
00:10:27,030 --> 00:10:26,170
about that in a second the third thing

286
00:10:29,070 --> 00:10:27,040
which you definitely couldn't have

287
00:10:30,450 --> 00:10:29,080
noticed because I had to artificially

288
00:10:32,670 --> 00:10:30,460

inflate this so that the plot would even

289
00:10:34,560 --> 00:10:32,680
show up is that the black contours are

290
00:10:36,120 --> 00:10:34,570
actually really weak they're about five

291
00:10:37,530 --> 00:10:36,130
times weaker than the observations which

292
00:10:39,960 --> 00:10:37,540
Ron Lewis pointed out yesterday are

293
00:10:41,880 --> 00:10:39,970
already pretty weak to begin with so

294
00:10:43,380 --> 00:10:41,890
what this means in essence is that

295
00:10:45,720 --> 00:10:43,390
there's something missing from the model

296
00:10:47,700 --> 00:10:45,730
that should be producing a more compact

297
00:10:50,280 --> 00:10:47,710
more abundant reservoir of methanol than

298
00:10:53,190 --> 00:10:50,290
we're already than we're seeing um and

299
00:10:55,440 --> 00:10:53,200
we've been looking into mechanisms to

300
00:10:58,020 --> 00:10:55,450
try and figure out why this might be

301
00:10:59,370 --> 00:10:58,030
happening I have if I have time we'll

302
00:11:01,680 --> 00:10:59,380
talk about at the end if not come make

303
00:11:04,070 --> 00:11:01,690
friends with me at lunch um but for

304
00:11:06,210 --> 00:11:04,080
right now this is kind of the status quo

305
00:11:08,250 --> 00:11:06,220
but we can play the same game for other

306
00:11:09,060 --> 00:11:08,260
complex organics right so we did the

307
00:11:10,920 --> 00:11:09,070
same thing for meth

308
00:11:13,920 --> 00:11:10,930
cyanide same physical structure same

309
00:11:15,870 --> 00:11:13,930
chemical model etc and this is what the

310
00:11:16,800 --> 00:11:15,880
chemical model output looks like for

311
00:11:18,630 --> 00:11:16,810
methyl cyanide

312
00:11:20,520 --> 00:11:18,640
and you can see it's like kind of

313
00:11:21,210 --> 00:11:20,530

markedly different than the the methanol

314
00:11:22,830 --> 00:11:21,220
story right

315
00:11:24,920 --> 00:11:22,840
whereas with methanol we had a lot of

316
00:11:27,480 --> 00:11:24,930
stuff forming on Isis and you know for

317
00:11:30,060 --> 00:11:27,490
Devoto desorbing or reactively desorbing

318
00:11:31,890 --> 00:11:30,070
off of the Isis with methyl cyanide you

319
00:11:34,380 --> 00:11:31,900
see that there's a lot of methyl cyanide

320
00:11:35,700 --> 00:11:34,390
gas up here in the disk atmosphere so

321
00:11:38,100 --> 00:11:35,710
there's a lot of methyl cyanide forming

322
00:11:39,540 --> 00:11:38,110
in the gas phase and this is kind of at

323
00:11:40,800 --> 00:11:39,550
odds with that whole like working

324
00:11:43,020 --> 00:11:40,810
hypothesis we had before that

325
00:11:45,240 --> 00:11:43,030
observations of these complex organics

326
00:11:47,490 --> 00:11:45,250
are tracing the molecular layer and the

327
00:11:49,050 --> 00:11:47,500
disk ice structure on because in this

328
00:11:50,670 --> 00:11:49,060
case because methyl cyanide has

329
00:11:54,000 --> 00:11:50,680
increased gas phase pathways to

330
00:11:55,650 --> 00:11:54,010
formation it might according to our

331
00:11:58,560 --> 00:11:55,660
model and might be tracing the disk

332
00:12:02,010 --> 00:11:58,570
atmosphere more so than the you know

333
00:12:04,710 --> 00:12:02,020
cold gas in the disk molecular layer so

334
00:12:06,570 --> 00:12:04,720
the next step from here would be to you

335
00:12:07,500 --> 00:12:06,580
know compare these two observations but

336
00:12:10,290 --> 00:12:07,510
unfortunately we don't have any

337
00:12:13,380 --> 00:12:10,300
published observations of methyl cyanide

338
00:12:17,310 --> 00:12:13,390

and the source yet um but we also did

339
00:12:19,650 --> 00:12:17,320
some some feasibility things studies to

340
00:12:20,370 --> 00:12:19,660
see if if we could do that with Alma in

341
00:12:22,440 --> 00:12:20,380
the next cycle

342
00:12:25,590 --> 00:12:22,450
if you're interested in talking to me

343
00:12:27,840 --> 00:12:25,600
about that later let come find me um I

344
00:12:30,180 --> 00:12:27,850
also have extra slides for that to

345
00:12:32,040 --> 00:12:30,190
5-time but for now I just kind of want

346
00:12:33,810 --> 00:12:32,050
to go back and give a summary what we

347
00:12:35,220 --> 00:12:33,820
talked about so first of all we talked

348
00:12:37,080 --> 00:12:35,230
about how protoplanetary discs are

349
00:12:39,360 --> 00:12:37,090
important environments because they can

350
00:12:42,150 --> 00:12:39,370
set the chemical inventory for forming

351
00:12:43,770 --> 00:12:42,160
planetary systems we then talked about

352
00:12:47,340 --> 00:12:43,780
how complex organic molecules

353
00:12:48,960 --> 00:12:47,350
um can trace uh disk ices in the disk

354
00:12:50,460 --> 00:12:48,970
molecular layer but then we sort of

355
00:12:51,900 --> 00:12:50,470
challenged that by showing the example

356
00:12:54,270 --> 00:12:51,910
of methyl cyanide which might actually

357
00:12:56,430 --> 00:12:54,280
be tracing the disk atmosphere due to

358
00:12:59,300 --> 00:12:56,440
its increased gas phase pathway to

359
00:13:01,650 --> 00:12:59,310
formation that's a mouthful um and

360
00:13:03,540 --> 00:13:01,660
finally we show that even when we do

361
00:13:05,190 --> 00:13:03,550
think complex organics should be tracing

362
00:13:08,190 --> 00:13:05,200
the disk Isis there's an enormous

363
00:13:10,140 --> 00:13:08,200

discrepancy between what our modeling

364
00:13:11,970 --> 00:13:10,150
and what theory says should happen and

365
00:13:14,040 --> 00:13:11,980
what the observations observations

366
00:13:16,320 --> 00:13:14,050
actually show um which is as of yet

367
00:13:19,200 --> 00:13:16,330
unresolved so clearly there's a lot of

368
00:13:20,670 --> 00:13:19,210
work left to be done I have a little bit

369
00:13:22,950 --> 00:13:20,680
of extra extra time actually so I'll

370
00:13:27,570 --> 00:13:22,960
talk a little bit about what we're

371
00:13:31,110 --> 00:13:27,580
what we're looking at for reasons that

372
00:13:32,190 --> 00:13:31,120
this discrepancy might exist so how well

373
00:13:35,850 --> 00:13:32,200
what are ways in which we can produce

374
00:13:37,650 --> 00:13:35,860
compact abundant methanol one way that

375
00:13:39,930 --> 00:13:37,660
we've been considering is called Co

376
00:13:41,610 --> 00:13:39,940
desorption in which you know this

377
00:13:44,820 --> 00:13:41,620
methanol is forming on carbon monoxide

378
00:13:47,010 --> 00:13:44,830
Isis sometimes you know the carbon

379
00:13:48,540 --> 00:13:47,020
monoxide can get the methanol can get

380
00:13:51,480 --> 00:13:48,550
caught up in the carbon monoxide and

381
00:13:52,890 --> 00:13:51,490
thus when the carbon monoxide desorbs it

382
00:13:54,770 --> 00:13:52,900
can carry off a little bit of methanol

383
00:13:59,580 --> 00:13:54,780
which is more volatile on these surfaces

384
00:14:01,500 --> 00:13:59,590
and so we thought that this might give

385
00:14:05,730 --> 00:14:01,510
sort of a boost near the carbon monoxide

386
00:14:07,410 --> 00:14:05,740
snowline um unfortunately we've gotten

387
00:14:08,880 --> 00:14:07,420
laboratory results back about this

388
00:14:12,780 --> 00:14:08,890

process and it doesn't look like it's

389
00:14:14,550 --> 00:14:12,790
actually a thing so um that's that's one

390
00:14:16,320 --> 00:14:14,560
way we were looking at there's other

391
00:14:19,000 --> 00:14:16,330
stuff too but I think I'm running out of

392
00:14:28,700 --> 00:14:19,010
time so I will stop there thank you

393
00:14:34,320 --> 00:14:32,310
hey really nice talk so you said in your

394
00:14:35,850 --> 00:14:34,330
model you're calculating the you're

395
00:14:38,130 --> 00:14:35,860
running the chemical model for every

396
00:14:39,750 --> 00:14:38,140
individual cell in your model disk is

397
00:14:42,120 --> 00:14:39,760
there any crosstalk between the cells

398
00:14:43,350 --> 00:14:42,130
like turbulent mixing or transport or

399
00:14:46,320 --> 00:14:43,360
any of that yeah that's a good question

400
00:14:48,000 --> 00:14:46,330
no there's no okay um and how do you

401
00:14:50,730 --> 00:14:48,010
think that would affect the the results

402
00:14:53,250 --> 00:14:50,740
so yeah there's the the turbulent mixing

403
00:14:57,270 --> 00:14:53,260
thing one thing that we were thinking it

404
00:14:59,700 --> 00:14:57,280
might do is um like there's a the

405
00:15:01,770 --> 00:14:59,710
vertical turbulence settling that in

406
00:15:03,240 --> 00:15:01,780
which like a lot of these species drift

407
00:15:05,070 --> 00:15:03,250
to where it's inwards towards a mid plan

408
00:15:06,360 --> 00:15:05,080
so that might be one way in which

409
00:15:07,920 --> 00:15:06,370
there's also like the inward radial

410
00:15:09,510 --> 00:15:07,930
drift of the dust grains to consider

411
00:15:11,700 --> 00:15:09,520
that's actually one of the other things

412
00:15:14,820 --> 00:15:11,710
we're considering is radial drift but we

413
00:15:24,200 --> 00:15:14,830

haven't done it yet I should say so stay

414
00:15:31,290 --> 00:15:26,820
great talk um if you go back to the

415
00:15:33,030 --> 00:15:31,300
plots of the methanol abundance you plot

416
00:15:36,120 --> 00:15:33,040
that as absolute abundance is that both

417
00:15:38,340 --> 00:15:36,130
gas phase and a surface no it's just gas

418
00:15:40,860 --> 00:15:38,350
it it's just gas phase okay yeah so then

419
00:15:42,360 --> 00:15:40,870
the the hot component up there what is

420
00:15:44,520 --> 00:15:42,370
the pathway that's producing that

421
00:15:46,500 --> 00:15:44,530
because methanol can only form through

422
00:15:49,890 --> 00:15:46,510
grain surface processes right so is that

423
00:15:51,600 --> 00:15:49,900
just through transient sorption and

424
00:15:54,240 --> 00:15:51,610
desorption off of grain surfaces up

425
00:15:57,900 --> 00:15:54,250
there or yeah it's a lot of that and

426
00:15:58,950 --> 00:15:57,910
there's a lot of like so when we were

427
00:16:00,720 --> 00:15:58,960
looking at this there were a lot of

428
00:16:02,850 --> 00:16:00,730
other gas phase processes that will

429
00:16:04,860 --> 00:16:02,860
honestly look kind of suss um and it's

430
00:16:06,600 --> 00:16:04,870
because I don't think the the chemical

431
00:16:08,430 --> 00:16:06,610
Network is super complete at high

432
00:16:12,930 --> 00:16:08,440
temperatures the high temperatures that

433
00:16:18,330 --> 00:16:12,940
are uh sort of in that kind of region so

434
00:16:20,450 --> 00:16:18,340
okay great yeah astro chemists aren't

435
00:16:24,560 --> 00:16:20,460
scary I promise

436
00:16:28,310 --> 00:16:24,570
all right I got one so how how

437
00:16:30,910 --> 00:16:28,320
representative is say the hot core phase

438
00:16:33,770 --> 00:16:30,920

after you run it through the

439
00:16:35,450 --> 00:16:33,780
protoplanetary disk phase how much if I

440
00:16:37,070 --> 00:16:35,460
if I knew the abundance in a hot core

441
00:16:39,830 --> 00:16:37,080
phase and then I ran it through a disk

442
00:16:42,880 --> 00:16:39,840
how badly does the disk scramble the

443
00:16:46,070 --> 00:16:42,890
chemistry that is a really good question

444
00:16:50,210 --> 00:16:46,080
for which I don't have a really good

445
00:16:52,940 --> 00:16:50,220
answer um I think there's evidence that

446
00:16:55,160 --> 00:16:52,950
it does scramble the chemistry some but

447
00:16:56,630 --> 00:16:55,170
not all I think you know there are

448
00:16:58,820 --> 00:16:56,640
people that have shown that a lot of

449
00:17:01,100 --> 00:16:58,830
water is inherited directly from like

450
00:17:02,960 --> 00:17:01,110
the cloud the initial cloud but we

451
00:17:05,990 --> 00:17:02,970
assume for our initial conditions here

452
00:17:08,150 --> 00:17:06,000
is we take a dark cloud model run it to

453
00:17:10,670 --> 00:17:08,160
an appropriate time and then assume that

454
00:17:11,300 --> 00:17:10,680
the disk inherits Isis from the dark

455
00:17:13,280 --> 00:17:11,310
cloud model

456
00:17:15,079 --> 00:17:13,290
um which is obviously not the most

457
00:17:20,960 --> 00:17:15,089
accurate thing to do but if you have a

458
00:17:23,449 --> 00:17:20,970
better solution please let me know ok

459
00:17:24,230 --> 00:17:23,459
any more questions then let's thank the

460
00:17:27,140 --> 00:17:24,240
speaker again

461
00:17:27,640 --> 00:17:27,150
[Applause]