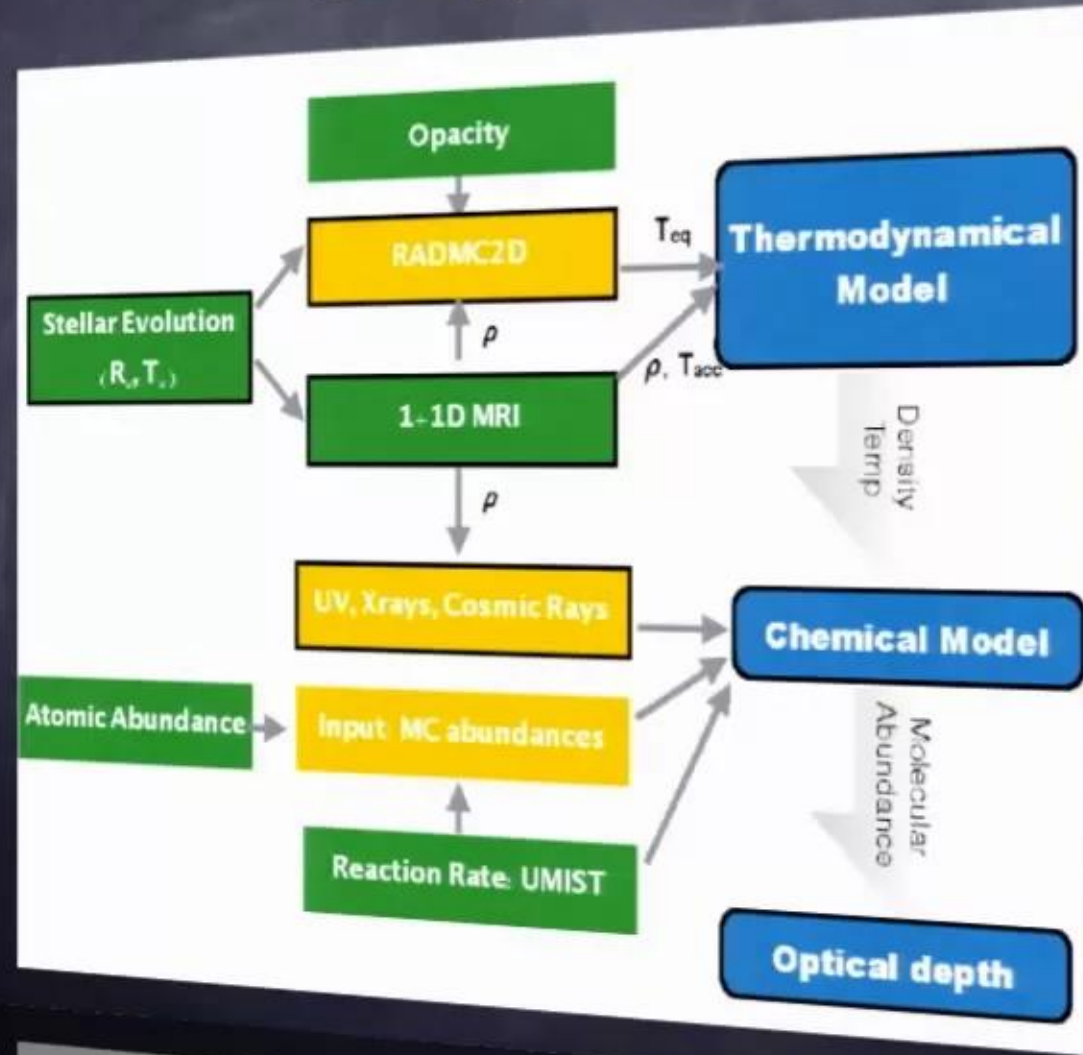


Our approach



1
00:00:11,240 --> 00:00:08,720
my name is Emma you I'm from University

2
00:00:13,220 --> 00:00:11,250
of Texas at Austin I want to first send

3
00:00:15,980 --> 00:00:13,230
the organizers for having me here I've

4
00:00:19,010 --> 00:00:15,990
been having fun learning a lot over the

5
00:00:22,130 --> 00:00:19,020
weekend so I work with Neil Allen cell

6
00:00:26,180 --> 00:00:22,140
doesn't Robinson Caramella see and neyo

7
00:00:28,070 --> 00:00:26,190
turn around this project so first I'll

8
00:00:29,990 --> 00:00:28,080
give a really quick review on or

9
00:00:32,779 --> 00:00:30,000
understanding of protoplanetary disc red

10
00:00:36,139 --> 00:00:32,789
star formation and then I'll move on to

11
00:00:39,350 --> 00:00:36,149
our attempt to find the optically thin

12
00:00:42,110 --> 00:00:39,360
tracer for the dismay play Liriano I'll

13
00:00:44,870 --> 00:00:42,120

talk about our finding and our modeling

14

00:00:47,600 --> 00:00:44,880

approach so first of all this is my

15

00:00:49,729 --> 00:00:47,610

version of the start and information

16

00:00:56,000 --> 00:00:49,739

picture borrow from actually Jeff's left

17

00:00:59,030 --> 00:00:56,010

side okay so single star formations

18

00:01:02,000 --> 00:00:59,040

start from the caps of very very dense

19

00:01:03,530 --> 00:01:02,010

core and molecular crows because there is

20

00:01:05,539 --> 00:01:03,540

some sort of rotation at the very

21

00:01:07,760 --> 00:01:05,549

beginning so materials can only fall

22

00:01:09,830 --> 00:01:07,770

allowing the rotation axis but not

23

00:01:11,840 --> 00:01:09,840

perpendicular to it so we end up with

24

00:01:16,309 --> 00:01:11,850

the rotating disk around the newly

25

00:01:19,370 --> 00:01:16,319

formed youngstarr this stage is very

26
00:01:21,590 --> 00:01:19,380
valid after probably 100,000 years we

27
00:01:23,510 --> 00:01:21,600
enter relatively stable state what we

28
00:01:26,629 --> 00:01:23,520
call T Tauri face around solar-type

29
00:01:28,730 --> 00:01:26,639
stars so this stage plus for a few

30
00:01:31,730 --> 00:01:28,740
million years for solar-type stars and

31
00:01:33,649 --> 00:01:31,740
with a relatively mild equation rate of

32
00:01:36,529 --> 00:01:33,659
10 to the minus eight solar mass per

33
00:01:41,239 --> 00:01:36,539
year after this relatively stable stage

34
00:01:43,160 --> 00:01:41,249
the disk enter very rapid a dissipation

35
00:01:45,169 --> 00:01:43,170
stage actually the next speaker is going

36
00:01:48,529 --> 00:01:45,179
to talk more about that so this will

37
00:01:51,230 --> 00:01:48,539
dissipate in around 100,000 years if

38
00:01:55,339 --> 00:01:51,240

you're lucky we live with the live with

39

00:01:57,199 --> 00:01:55,349

the planetary system we actually seen

40

00:01:58,870 --> 00:01:57,209

those disks in many different

41

00:02:03,469 --> 00:01:58,880

wavelengths in many different situations

42

00:02:06,979 --> 00:02:03,479

so the poem upper left side this is the

43

00:02:09,830 --> 00:02:06,989

HST Hubble image of the scatter light of

44

00:02:12,410 --> 00:02:09,840

the disk surface so we're seeing here is

45

00:02:15,230 --> 00:02:12,420

the central stars for somewhere around

46

00:02:17,810 --> 00:02:15,240

here the life hit on the disservice is

47

00:02:19,290 --> 00:02:17,820

scattered into our telescope the problem

48

00:02:21,060 --> 00:02:19,300

is were only seeing that

49

00:02:23,460 --> 00:02:21,070

surface we can only tell properties from

50

00:02:27,300 --> 00:02:23,470

a very very surface little disk through

51
00:02:29,160 --> 00:02:27,310
this kind of image another really

52
00:02:30,900 --> 00:02:29,170
dominated way of seeing those disks

53
00:02:35,040 --> 00:02:30,910
actually lives there has be a lot of

54
00:02:37,320 --> 00:02:35,050
progress made in the past 15 years is by

55
00:02:39,480 --> 00:02:37,330
observing the infrared sed s so what

56
00:02:42,780 --> 00:02:39,490
we're seeing here is a function of

57
00:02:44,430 --> 00:02:42,790
energy outside is the luminosity the

58
00:02:47,370 --> 00:02:44,440
energy as a function of the wavelength

59
00:02:49,320 --> 00:02:47,380
so we're seeing a really broad spectrum

60
00:02:52,230 --> 00:02:49,330
this part it makes it an inner part of

61
00:02:55,380 --> 00:02:52,240
this and other part of a disk but the

62
00:02:57,420 --> 00:02:55,390
problem is we want this to be relatively

63
00:02:59,640 --> 00:02:57,430

warm you're going to show up in this

64

00:03:01,800 --> 00:02:59,650

loop and so again we're seeing the

65

00:03:06,570 --> 00:03:01,810

relative warm surface and the inner part

66

00:03:09,780 --> 00:03:06,580

of the Jesse self so with the

67

00:03:12,210 --> 00:03:09,790

development of amazing interferometry is

68

00:03:14,730 --> 00:03:12,220

we're beginning to see molecular lying

69

00:03:17,460 --> 00:03:14,740

wishes from those disks so the most

70

00:03:19,380 --> 00:03:17,470

common leveraging is 12 CEO just because

71

00:03:22,860 --> 00:03:19,390

CEO is everywhere and there's a mission

72

00:03:25,320 --> 00:03:22,870

straight strong the problem is again the

73

00:03:27,510 --> 00:03:25,330

lines are a click so we're only seeing

74

00:03:29,280 --> 00:03:27,520

the very surface of the disk but in

75

00:03:31,710 --> 00:03:29,290

order to entice them plan information we

76

00:03:33,540 --> 00:03:31,720

want to be see inside out of the

77

00:03:39,740 --> 00:03:33,550

district line cuz that's where plan

78

00:03:42,120 --> 00:03:39,750

informations are actually happening so

79

00:03:44,760 --> 00:03:42,130

we try to ask some really fundamental

80

00:03:46,860 --> 00:03:44,770

questions like how massive the distance

81

00:03:48,510 --> 00:03:46,870

that's available for plan information it

82

00:03:50,850 --> 00:03:48,520

turns out we don't know that very well

83

00:03:53,370 --> 00:03:50,860

so first of all our understanding is

84

00:03:57,240 --> 00:03:53,380

heavily biased toward our solar system

85

00:04:01,410 --> 00:03:57,250

the zero order magnitude approximation

86

00:04:04,610 --> 00:04:01,420

is to simply smear out the matter for

87

00:04:07,530 --> 00:04:04,620

known planets so we have mercury various

88

00:04:10,560 --> 00:04:07,540

planets out here we just smear it out

89

00:04:12,479 --> 00:04:10,570

over the orbits and then we add up the

90

00:04:14,670 --> 00:04:12,489

ball is health just lost during planet

91

00:04:17,970 --> 00:04:14,680

formation process so we add up the

92

00:04:19,409 --> 00:04:17,980

oxygen the hydrogen stuff like that the

93

00:04:22,470 --> 00:04:19,419

may end up with the surface density

94

00:04:25,260 --> 00:04:22,480

distribution which is a the surface

95

00:04:28,860 --> 00:04:25,270

density as a function of distance to the

96

00:04:32,310 --> 00:04:28,870

central star and this is your prime I

97

00:04:32,879 --> 00:04:32,320

mean were lower limit or like the basic

98

00:04:35,760 --> 00:04:32,889

picture

99

00:04:37,649 --> 00:04:35,770

of the solar nebula but there's a

100

00:04:41,519 --> 00:04:37,659

problem with this picture because we

101
00:04:44,339 --> 00:04:41,529
assume everything we see today was the

102
00:04:45,959 --> 00:04:44,349
case when it was first formed I'm Zoey

103
00:04:48,330 --> 00:04:45,969
assume one hundred percent daily

104
00:04:51,059 --> 00:04:48,340
attention which is obviously not the

105
00:04:53,820 --> 00:04:51,069
case Moses you know planets or form in

106
00:04:55,739 --> 00:04:53,830
situ so they've their form where we see

107
00:04:58,830 --> 00:04:55,749
they are right now which we now found as

108
00:05:03,629 --> 00:04:58,840
not the case planets migrate all the

109
00:05:07,140 --> 00:05:03,639
time another way of seeing this is to

110
00:05:09,209 --> 00:05:07,150
observe disks around other stars so

111
00:05:15,269 --> 00:05:09,219
traditionally this has been done by

112
00:05:17,219 --> 00:05:15,279
observing dust emissions okay the

113
00:05:19,980 --> 00:05:17,229

problem with this approach is we observe

114

00:05:22,529 --> 00:05:19,990

those discs in submillimeter so that

115

00:05:25,200 --> 00:05:22,539

we're only most sensitive to dust grains

116

00:05:28,200 --> 00:05:25,210

up around the same size when no dust

117

00:05:30,540 --> 00:05:28,210

grains grow up into pebbles into folders

118

00:05:32,489 --> 00:05:30,550

once they grow into larger bodies they

119

00:05:35,489 --> 00:05:32,499

are less invasive in those business so

120

00:05:37,200 --> 00:05:35,499

we're now able to see them anymore so

121

00:05:41,659 --> 00:05:37,210

we're really only seeing a small

122

00:05:44,309 --> 00:05:41,669

fraction of this mess from this approach

123

00:05:46,860 --> 00:05:44,319

annoyingly the result from the dust

124

00:05:48,839 --> 00:05:46,870

emissions or a minimum a solar nebula

125

00:05:52,010 --> 00:05:48,849

agree with each other radio a well but

126

00:05:56,700 --> 00:05:52,020

we know both of them are probably wrong

127

00:05:58,860 --> 00:05:56,710

so we try to ask the question what if we

128

00:06:01,019 --> 00:05:58,870

just measure the dispatch directly from

129

00:06:02,610 --> 00:06:01,029

the gas phase as Brandon just mentioned

130

00:06:04,559 --> 00:06:02,620

ninety-nine percent of this mess it's

131

00:06:08,010 --> 00:06:04,569

actually in the gas phase so there has

132

00:06:09,899 --> 00:06:08,020

been done before once this HD with

133

00:06:14,399 --> 00:06:09,909

deuterium because that's the last

134

00:06:16,170 --> 00:06:14,409

pendant as the top of hydrogen the

135

00:06:19,019 --> 00:06:16,180

problem with that is that was done with

136

00:06:21,269 --> 00:06:19,029

her show her shows dad is gone it does

137

00:06:23,579 --> 00:06:21,279

not exist anymore and also this line

138

00:06:25,800 --> 00:06:23,589

requires relatively high excitation

139

00:06:27,570 --> 00:06:25,810

temperature so it's sensitive not just

140

00:06:30,389 --> 00:06:27,580

to the amount of material out there also

141

00:06:33,450 --> 00:06:30,399

to the temperature of the disk however

142

00:06:35,189 --> 00:06:33,460

this example told us is important to

143

00:06:37,679 --> 00:06:35,199

measure the distance from the gas phase

144

00:06:39,839 --> 00:06:37,689

because the math day Frank was actually

145

00:06:42,809 --> 00:06:39,849

heavier than what people people to

146

00:06:46,740 --> 00:06:42,819

really find from dust emission is also

147

00:06:50,790 --> 00:06:46,750

way better than minimum a solar nebula

148

00:06:53,520 --> 00:06:50,800

so our goal is to find the rare optical

149

00:06:55,680 --> 00:06:53,530

we're sorry I stole a rare molecule in

150

00:06:58,430 --> 00:06:55,690

order to allow us to trace directly to

151
00:07:02,460 --> 00:06:58,440
the dismay plan allow us to measure the

152
00:07:05,090 --> 00:07:02,470
dispatch from the gas phase so we want

153
00:07:10,200 --> 00:07:05,100
to use this awesome array alma of

154
00:07:12,110 --> 00:07:10,210
doubling chili so that we have so so

155
00:07:15,300 --> 00:07:12,120
that we can have enough sensibility

156
00:07:21,659 --> 00:07:15,310
sensitivity to probe very very wicked

157
00:07:24,240 --> 00:07:21,669
missions it turns out that's a really

158
00:07:26,730 --> 00:07:24,250
hard thing to do just in order to build

159
00:07:28,740 --> 00:07:26,740
a model right just because the

160
00:07:30,690 --> 00:07:28,750
temperature the dead seed chemistry

161
00:07:33,840 --> 00:07:30,700
immediately transfer there Oh cobble

162
00:07:36,030 --> 00:07:33,850
together so it breaks the mold down into

163
00:07:38,040 --> 00:07:36,040

three components so ask me about a

164

00:07:40,650 --> 00:07:38,050

details later but right now I'm just

165

00:07:42,840 --> 00:07:40,660

going to focus on the big components so

166

00:07:46,800 --> 00:07:42,850

we model the thermo dynamical evolution

167

00:07:48,300 --> 00:07:46,810

of the disc by putting in MRI again the

168

00:07:51,540 --> 00:07:48,310

next speaker is going to talk more about

169

00:07:53,880 --> 00:07:51,550

that and then we recalculate the

170

00:07:56,159 --> 00:07:53,890

evolution of density and temperature in

171

00:07:57,900 --> 00:07:56,169

each individual grade point and then

172

00:08:00,270 --> 00:07:57,910

running chemical model on the top of it

173

00:08:03,270 --> 00:08:00,280

so we care about where as a top lock so

174

00:08:05,880 --> 00:08:03,280

we need to consider say you very

175

00:08:07,400 --> 00:08:05,890

structures and self shouting and

176

00:08:11,100 --> 00:08:07,410

photochemical reactions stuff like that

177

00:08:14,090 --> 00:08:11,110

so we did that and then we end up with a

178

00:08:16,290 --> 00:08:14,100

profile of chemical dependence

179

00:08:17,969 --> 00:08:16,300

temperature and density for every single

180

00:08:20,310 --> 00:08:17,979

point in the disk for three million

181

00:08:21,990 --> 00:08:20,320

years and then we run radius transfer

182

00:08:23,790 --> 00:08:22,000

model on the top of it and try to

183

00:08:27,719 --> 00:08:23,800

estimate the output depths of those

184

00:08:30,840 --> 00:08:27,729

molecules so this is the temperature

185

00:08:34,260 --> 00:08:30,850

profile to take away unpleasing oh so

186

00:08:36,360 --> 00:08:34,270

imagine the torus of the disk this here

187

00:08:39,659 --> 00:08:36,370

is the central star and now we're taking

188

00:08:41,850 --> 00:08:39,669

a cross-section of the disk so this the

189

00:08:44,310 --> 00:08:41,860

x axis is the distance from the central

190

00:08:47,790 --> 00:08:44,320

star so the stars here and this is the

191

00:08:50,100 --> 00:08:47,800

thickness and the height so the disk

192

00:08:52,380 --> 00:08:50,110

surface is heated by the central star and

193

00:08:54,180 --> 00:08:52,390

the heat propagates down so that's why

194

00:08:55,650 --> 00:08:54,190

it's hotter here right means hot sorry

195

00:08:58,710 --> 00:08:55,660

this is the temperature in Kelvin and

196

00:09:00,809 --> 00:08:58,720

the takeaway here is equation heating

197

00:09:04,619 --> 00:09:00,819

doesn't matter that much easier does

198

00:09:09,449 --> 00:09:04,629

dollars that's actually different from

199

00:09:11,699 --> 00:09:09,459

what people have been assuming and take

200

00:09:13,349 --> 00:09:11,709

away from chemistry is in our dismal

201
00:09:15,179 --> 00:09:13,359
that we actually don't see Co face

202
00:09:17,429 --> 00:09:15,189
outcomes the heating from the central

203
00:09:19,169 --> 00:09:17,439
star is pretty efficient but we do see a

204
00:09:22,729 --> 00:09:19,179
drop of sea abandons due to the

205
00:09:24,960 --> 00:09:22,739
formation or organics so carbon alpha is

206
00:09:28,469 --> 00:09:24,970
primarily in the ice form that's

207
00:09:30,840 --> 00:09:28,479
inherited from the cloud and the CEOs go

208
00:09:34,129 --> 00:09:30,850
so rad means a lot Blue means almost

209
00:09:36,960 --> 00:09:34,139
nothing and this is the badness of

210
00:09:40,469 --> 00:09:36,970
normalized by the amount of total portal

211
00:09:44,489 --> 00:09:40,479
never danske so we're seeing a lot of

212
00:09:46,439 --> 00:09:44,499
complicated organic molecules it exactly

213
00:09:48,840 --> 00:09:46,449

what kind of organic were seeing depends

214

00:09:51,779 --> 00:09:48,850

on the model and the initial conditions

215

00:09:53,579 --> 00:09:51,789

but we tested with input from

216

00:09:55,650 --> 00:09:53,589

observational data and also from

217

00:10:02,039 --> 00:09:55,660

Wellington it seems that this result is

218

00:10:04,590 --> 00:10:02,049

pretty robust okay um so last year for

219

00:10:07,039 --> 00:10:04,600

sorry two years ago there was a big

220

00:10:10,079 --> 00:10:07,049

discussion I mean discovery itself

221

00:10:12,299 --> 00:10:10,089

imaging co Iceland in the polyp into

222

00:10:14,899 --> 00:10:12,309

this that's really cool because we can

223

00:10:17,579 --> 00:10:14,909

use that as a direct temperature tracer

224

00:10:20,519 --> 00:10:17,589

people don't have time to talk about it

225

00:10:22,349 --> 00:10:20,529

so we're only trying to see if we're

226

00:10:24,509 --> 00:10:22,359

only trying to say if they don't see Co

227

00:10:27,179 --> 00:10:24,519

around it doesn't necessarily mean that

228

00:10:32,460 --> 00:10:27,189

cos resell on the gray surface there can

229

00:10:34,739 --> 00:10:32,470

be something else yeah so after doing

230

00:10:37,259 --> 00:10:34,749

all this we sit down and estimate lack

231

00:10:40,859 --> 00:10:37,269

of depth of different cos o top logs and

232

00:10:43,679 --> 00:10:40,869

here we're seeing a the octo depth in

233

00:10:46,439 --> 00:10:43,689

vertical direction for face out geometry

234

00:10:49,199 --> 00:10:46,449

so you're seeing a disk facing right

235

00:10:51,479 --> 00:10:49,209

from for you as a function of the

236

00:10:54,119 --> 00:10:51,489

distance from the central star and it

237

00:10:59,609 --> 00:10:54,129

turns out that sees 70 know the blue

238

00:11:03,049 --> 00:10:59,619

line here is a brief AVL Pollock tourney

239

00:11:09,389 --> 00:11:03,059

at you and see 18yo is ugly thing beyond

240

00:11:12,599 --> 00:11:09,399

1780 I believe so we hope to use that

241

00:11:14,610 --> 00:11:12,609

line in order to measure the dispatch

242

00:11:17,060 --> 00:11:14,620

with el Mazo we proposed for

243

00:11:20,580 --> 00:11:17,070

psycho 3 tired we'll see how that goes

244

00:11:22,440 --> 00:11:20,590

so the idea is this this will be a line

245

00:11:25,440 --> 00:11:22,450

profile this is the velocity just

246

00:11:29,610 --> 00:11:25,450

because the disk is rotating so save

247

00:11:31,860 --> 00:11:29,620

this part is moving towards you oh the

248

00:11:34,200 --> 00:11:31,870

inner part of this rotates faster so

249

00:11:36,210 --> 00:11:34,210

that goes to the line shoulder and then

250

00:11:39,030 --> 00:11:36,220

the other part road takes a little bit

251
00:11:41,640 --> 00:11:39,040
slower so that goes in in the war so we

252
00:11:44,400 --> 00:11:41,650
have a double pick signature for a disc

253
00:11:47,070 --> 00:11:44,410
and we can translate the luminosity the

254
00:11:49,320 --> 00:11:47,080
intensity of those lines and back to the

255
00:11:54,450 --> 00:11:49,330
amount of material that's gaming up the

256
00:11:56,310 --> 00:11:54,460
emissions so that's where we'll go I'll

257
00:12:10,290 --> 00:11:56,320
leave the conclusion here and take

258
00:12:15,360 --> 00:12:10,300
questions thank you so that was really

259
00:12:18,060 --> 00:12:15,370
cool I'm wondering if the result that co

260
00:12:21,030 --> 00:12:18,070
can turn into complex organics in the

261
00:12:22,950 --> 00:12:21,040
disk is a new results and if so what

262
00:12:25,550 --> 00:12:22,960
does that imply is it possible to

263
00:12:28,980 --> 00:12:25,560

directly look at organics with also or

264

00:12:30,660 --> 00:12:28,990

what's the future for that the problem

265

00:12:32,580 --> 00:12:30,670

is it would be really hard for us to see

266

00:12:34,440 --> 00:12:32,590

them the way it happens is we actually

267

00:12:36,390 --> 00:12:34,450

see the growth of carbonate in the gas

268

00:12:37,950 --> 00:12:36,400

phase and then it's easier for those

269

00:12:39,660 --> 00:12:37,960

organs to freeze out of the green

270

00:12:41,190 --> 00:12:39,670

surface so they will freeze on the grace

271

00:12:44,610 --> 00:12:41,200

and just get out of the gas phase

272

00:12:47,820 --> 00:12:44,620

reaction Network but when Kari news is

273

00:12:51,030 --> 00:12:47,830

people are seeing the depletion of

274

00:12:54,900 --> 00:12:51,040

carbon in the gas phase I think as well

275

00:12:56,640 --> 00:12:54,910

as oxygen so they're thinking about okay

276
00:12:59,010 --> 00:12:56,650
carbon might go to something somewhere

277
00:13:02,280 --> 00:12:59,020
else and it could well be there again

278
00:13:05,250 --> 00:13:02,290
excellent surface so it's encouraging

279
00:13:13,950 --> 00:13:05,260
it's encouraging that people are seeing

280
00:13:15,840 --> 00:13:13,960
observationally already yeah I I have

281
00:13:19,470 --> 00:13:15,850
one so what are the prospects for

282
00:13:22,680 --> 00:13:19,480
imaging rare isotope log snow minds with

283
00:13:25,080 --> 00:13:22,690
Alma is it gonna be yeah actually I

284
00:13:27,210 --> 00:13:25,090
think this is unpublished result people

285
00:13:28,400 --> 00:13:27,220
are seeing it alright yes I'll poster

286
00:13:32,180 --> 00:13:28,410
from typer

287
00:13:36,259 --> 00:13:32,190
group they have c18 eau de don t leave a

288
00:13:42,170 --> 00:13:36,269

hydro so they are seeing a Iceland actor

289

00:13:44,540 --> 00:13:42,180

here you exactly where yeah that's def a

290

00:13:49,100 --> 00:13:44,550

creep are saying I mean into h plus and