AbGradCon 2018

1
00:00:00,260 --> 00:00:10,740
[Music]

2
00:00:16,240 --> 00:00:13,570
yeah this is very interesting topic

3
00:00:20,050 --> 00:00:16,250
maybe I'm not prepared enough but please

4
00:00:24,250 --> 00:00:20,060
follow carefully just if you need to

5
00:00:27,189 --> 00:00:24,260
stop me anytime you can do that because

6
00:00:31,060 --> 00:00:27,199
I want you to follow to the end it's a

7
00:00:34,660 --> 00:00:31,070
very I think it's a beautiful story I

8
00:00:37,750 --> 00:00:34,670
got my PhD recently in physical

9
00:00:43,920 --> 00:00:37,760
chemistry and this is totally different

10
00:00:54,819 --> 00:00:50,619
so from simplicity to complexity I had

11
00:00:58,779 --> 00:00:54,829
hard time to pick this topic let's get

12
00:01:01,599 --> 00:00:58,789
started okay when you want to study the

13
00:01:06,690 --> 00:01:01,609

dynamic of a system or evolution of a

14
00:01:10,780 --> 00:01:06,700
system in time you need to somehow

15
00:01:15,999 --> 00:01:10,790
either calculate the energy and then

16
00:01:19,480 --> 00:01:16,009
from that you can get force and force is

17
00:01:23,499 --> 00:01:19,490
the first derivative of energy with

18
00:01:25,330 --> 00:01:23,509
respect to displacement or you can dump

19
00:01:28,810 --> 00:01:25,340
some energy in your system as

20
00:01:32,920 --> 00:01:28,820
temperature some systems are well known

21
00:01:34,870 --> 00:01:32,930
you can have force field and again you

22
00:01:37,660 --> 00:01:34,880
can calculate force and from that you

23
00:01:41,800 --> 00:01:37,670
can study the dynamic of the system as

24
00:01:47,139 --> 00:01:41,810
you see here or this pointer okay

25
00:01:51,240 --> 00:01:47,149
so yeah force is connected to position

26
00:01:58,060 --> 00:01:51,250
and time so you can see how your system

27
00:02:00,310 --> 00:01:58,070
moves in space within time so the

28
00:02:03,130 --> 00:02:00,320
equilibrium of the system is when you're

29
00:02:07,800 --> 00:02:03,140
when there is no force on your system

30
00:02:12,490 --> 00:02:07,810
and that can be also interpreted as when

31
00:02:16,850 --> 00:02:12,500
you have all the existing energy is

32
00:02:20,090 --> 00:02:16,860
dispersed dispersed in your system

33
00:02:24,760 --> 00:02:20,100
and the this person dispersion of energy

34
00:02:26,900 --> 00:02:24,770
is shown with this guy is

35
00:02:29,720 --> 00:02:26,910
thermodynamical term it's called entropy

36
00:02:39,610 --> 00:02:29,730
many of you familiar with that well

37
00:02:49,190 --> 00:02:45,710
yeah so before equilibrium Delta G this

38
00:02:52,640 --> 00:02:49,200

is another term that's called free

39
00:02:56,420 --> 00:02:52,650
energy or maximal what you can get out

40
00:02:58,760 --> 00:02:56,430
of the system and that guy is negative

41
00:03:01,790 --> 00:02:58,770
and that's the driving force of the

42
00:03:03,470 --> 00:03:01,800
system before equilibrium to reach the

43
00:03:08,840 --> 00:03:03,480
equilibrium but once you get to

44
00:03:12,740 --> 00:03:08,850
equilibrium Delta G is zero and your

45
00:03:19,479 --> 00:03:12,750
system is not doing anything macro mark

46
00:03:30,830 --> 00:03:26,030
so for Delta G to be negative either

47
00:03:33,770 --> 00:03:30,840
Delta H that's enthalpy it's called

48
00:03:37,310 --> 00:03:33,780
enthalpy so Delta H should be negative

49
00:03:42,080 --> 00:03:37,320
meaning that your system should release

50
00:03:47,830 --> 00:03:42,090
some energy or these Delta s as we call

51
00:03:56,620 --> 00:03:52,610
increase disorder so if these two

52
00:04:00,350 --> 00:03:56,630
condition you know either of them are

53
00:04:02,900 --> 00:04:00,360
that you know if you have one of these

54
00:04:05,930 --> 00:04:02,910
two or two of two of them you can have

55
00:04:11,210 --> 00:04:05,940
negative Delta G and your process is

56
00:04:13,520 --> 00:04:11,220
spontaneous or natural but you see in

57
00:04:19,009 --> 00:04:13,530
the nature there are a lot of things

58
00:04:21,860 --> 00:04:19,019
that they decrease disorder what they

59
00:04:28,100 --> 00:04:21,870
still happen they are natural and one of

60
00:04:29,950 --> 00:04:28,110
the very good example is life so in life

61
00:04:33,310 --> 00:04:29,960
you have

62
00:04:36,790 --> 00:04:33,320
decrease of entropy or disorder but yet

63
00:04:40,060 --> 00:04:36,800

it happens and that's because there is

64
00:04:42,570 --> 00:04:40,070
another restriction for that the second

65
00:04:49,120 --> 00:04:42,580
law of thermodynamics when you have

66
00:04:52,900 --> 00:04:49,130
isolated system your this the entropy of

67
00:04:57,880 --> 00:04:52,910
your system can decrease as long as the

68
00:05:05,110 --> 00:04:57,890
that leads to an increase of the entropy

69
00:05:10,050 --> 00:05:05,120
of the environment so then that's how

70
00:05:13,840 --> 00:05:10,060
life can form so let's put this in

71
00:05:18,940 --> 00:05:13,850
better words from Schrodinger he has a

72
00:05:22,030 --> 00:05:18,950
he's actually one of the founding

73
00:05:25,060 --> 00:05:22,040
fathers of quantum mechanics and he has

74
00:05:27,870 --> 00:05:25,070
a book it's called what is life it's

75
00:05:30,940 --> 00:05:27,880
very good book you can get it for free

76
00:05:33,610 --> 00:05:30,950
from so there is a link in Wikipedia

77
00:05:38,770 --> 00:05:33,620
it's only the version I got I think it's

78
00:05:43,900 --> 00:05:38,780
only 32 books 32 pages and it's very

79
00:05:47,050 --> 00:05:43,910
short and sweet so he I just borrowed

80
00:05:51,340 --> 00:05:47,060
some quotes from him so living organisms

81
00:05:53,140 --> 00:05:51,350
are highly structured systems that we

82
00:05:55,200 --> 00:05:53,150
know that we know that they are actually

83
00:05:59,370 --> 00:05:55,210
the most struck a highly structured

84
00:06:02,590 --> 00:05:59,380
system that we have or we know of and

85
00:06:06,250 --> 00:06:02,600
the structure the ordered structures on

86
00:06:09,100 --> 00:06:06,260
large scale are due to chaos in small

87
00:06:14,160 --> 00:06:09,110
scale and that's because the foundation

88
00:06:18,940 --> 00:06:14,170

of everything or the fundamental

89
00:06:24,190 --> 00:06:18,950
particles are obeying quantum rule which

90
00:06:27,280 --> 00:06:24,200
is all probabilistic and when you have

91
00:06:31,950 --> 00:06:27,290
less number of atoms in the particles

92
00:06:36,430 --> 00:06:31,960
you have more randomness more

93
00:06:40,540 --> 00:06:36,440
probabilistic nature and this one I want

94
00:06:43,510 --> 00:06:40,550
to read it leading matter evades decay

95
00:06:46,270 --> 00:06:43,520
to thermo dynamical equilibrium

96
00:06:50,650 --> 00:06:46,280
by maintaining negative entropy in open

97
00:06:57,249 --> 00:06:50,660
system that's very important that's how

98
00:07:01,930 --> 00:06:57,259
life can for to put it in equations

99
00:07:05,529 --> 00:07:01,940
again Delta G is negative so the process

100
00:07:11,189 --> 00:07:05,539
happens but they avoid reaching

101
00:07:15,640 --> 00:07:11,199
equilibrium and with that they can

102
00:07:18,999 --> 00:07:15,650
increase the entropy or disorder of this

103
00:07:23,620 --> 00:07:19,009
surrounding so if you want to interpret

104
00:07:26,580 --> 00:07:23,630
that you can say life cannot be isolated

105
00:07:29,700 --> 00:07:26,590
or good life cannot be formed in

106
00:07:34,080 --> 00:07:29,710
isolated systems

107
00:07:38,920 --> 00:07:34,090
another thing is life has to make mess

108
00:07:47,649 --> 00:07:38,930
so we are big and messing machines in

109
00:07:51,459 --> 00:07:47,659
fact okay so here I just made a

110
00:07:55,420 --> 00:07:51,469
comparison between this natural

111
00:07:58,809 --> 00:07:55,430
evolution natural processes and computer

112
00:08:00,670 --> 00:07:58,819
simulation so many of us when you're

113
00:08:03,490 --> 00:08:00,680

doing computer simulation when we do

114
00:08:06,930 --> 00:08:03,500
optimization we are actually somehow

115
00:08:14,800 --> 00:08:11,399
we are making an evolution in a system

116
00:08:16,809 --> 00:08:14,810
so we start with initial simplicity and

117
00:08:19,120 --> 00:08:16,819
then there we have we introduce some

118
00:08:24,339 --> 00:08:19,130
forces on the system acting on the

119
00:08:28,110 --> 00:08:24,349
system and so then you have self

120
00:08:31,390 --> 00:08:28,120
repeating self-organizing and that in

121
00:08:33,209 --> 00:08:31,400
simulation terms is you have for example

122
00:08:37,449 --> 00:08:33,219
different simulation you have self

123
00:08:39,310 --> 00:08:37,459
consistency or feedback loops whenever

124
00:08:42,670 --> 00:08:39,320
you have feedback loops it's actually

125
00:08:44,310 --> 00:08:42,680
it's a kind of self-fulfilling and you

126
00:08:45,460 --> 00:08:44,320
might be familiar with these terms

127
00:08:47,610 --> 00:08:45,470
interference

128
00:08:50,920 --> 00:08:47,620
overlap coupling they all the same

129
00:08:54,100 --> 00:08:50,930
concept and we want and then you get to

130
00:08:56,170 --> 00:08:54,110
a complexity and complexity you can

131
00:08:59,639 --> 00:08:56,180
represent it by this

132
00:09:03,310 --> 00:08:59,649
superposition chaos probabilistic and

133
00:09:10,090 --> 00:09:03,320
then you have evolution or natural

134
00:09:11,889 --> 00:09:10,100
selection mutations on people say so

135
00:09:14,260 --> 00:09:11,899
when you do optimization you actually

136
00:09:16,960 --> 00:09:14,270
say hey I'm gonna just keep this

137
00:09:21,220 --> 00:09:16,970
coefficient because it optimizes my

138
00:09:23,920 --> 00:09:21,230

system and then this code I mean ignore

139
00:09:26,769 --> 00:09:23,930
the other one or amplify one and then

140
00:09:29,590 --> 00:09:26,779
decrease the weight of the other one so

141
00:09:31,300 --> 00:09:29,600
that's actually kind of natural

142
00:09:35,199 --> 00:09:31,310
selection I mean it's not natural but

143
00:09:38,050 --> 00:09:35,209
you're just picking and then that can be

144
00:09:42,519 --> 00:09:38,060
represented with the emergence the

145
00:09:45,699 --> 00:09:42,529
coupling iteration and then at the end

146
00:09:48,579 --> 00:09:45,709
when you get to equilibrium that does

147
00:09:53,079 --> 00:09:48,589
your system becomes simple in a sense

148
00:09:55,780 --> 00:09:53,089
again and so you have equilibrium you

149
00:09:57,850 --> 00:09:55,790
have collapse interval if you have

150
00:10:00,850 --> 00:09:57,860
working for example quantum mechanics

151
00:10:02,560 --> 00:10:00,860
coop collapse of wavefunction and you'll

152
00:10:08,380 --> 00:10:02,570
be cut your system becomes deterministic

153
00:10:11,170 --> 00:10:08,390
again and just want to read this again

154
00:10:15,490 --> 00:10:11,180
is there are some quotes I think they

155
00:10:18,040 --> 00:10:15,500
are important evolution is blind it's an

156
00:10:22,540 --> 00:10:18,050
emergent effect of mutation and natural

157
00:10:27,550 --> 00:10:22,550
selection may be a good example for this

158
00:10:31,600 --> 00:10:27,560
is a stock market so some small changes

159
00:10:36,430 --> 00:10:31,610
very random they can change the whole

160
00:10:40,540 --> 00:10:36,440
market and that's another I mean that's

161
00:10:43,930 --> 00:10:40,550
exactly how natural selection or

162
00:10:48,310 --> 00:10:43,940
evolution works it's completely rights

163
00:10:48,880 --> 00:10:48,320

blind but yet it just changes the whole

164
00:10:53,280 --> 00:10:48,890
thing

165
00:10:56,290 --> 00:10:53,290
according to probability probability and

166
00:11:00,490 --> 00:10:56,300
so but there are three main questions we

167
00:11:03,519 --> 00:11:00,500
have is this process reversible at least

168
00:11:06,670 --> 00:11:03,529
it's not in simulation

169
00:11:10,569 --> 00:11:06,680
is there any interactive force with our

170
00:11:14,769 --> 00:11:10,579
system again in simulation

171
00:11:16,989 --> 00:11:14,779
don't think so but we can change the for

172
00:11:19,569 --> 00:11:16,999
I mean some sometimes we need to after

173
00:11:23,829 --> 00:11:19,579
we see the result we can go back and

174
00:11:28,449 --> 00:11:23,839
remodel or system redesign it another

175
00:11:31,629 --> 00:11:28,459
question is so again if you introduce

176
00:11:36,669 --> 00:11:31,639
your forces or loss for the system are

177
00:11:43,989 --> 00:11:36,679
they evolved in time in simulation you

178
00:11:47,979 --> 00:11:43,999
can do that but how about in nature I

179
00:11:50,650 --> 00:11:47,989
just give you two examples two schools

180
00:11:54,759 --> 00:11:50,660
of thoughts one of them is this guy

181
00:12:00,519 --> 00:11:54,769
James Gates he came to our school few

182
00:12:03,910 --> 00:12:00,529
months ago he gave a talk about finding

183
00:12:05,889 --> 00:12:03,920
the computer codes in the fabric of

184
00:12:12,789 --> 00:12:05,899
universe I didn't get anything from his

185
00:12:17,799 --> 00:12:12,799
thought but what he was asked so he is

186
00:12:19,900 --> 00:12:17,809
he's a string theorist and he said when

187
00:12:23,650 --> 00:12:19,910
you basically work with this equation

188
00:12:27,519 --> 00:12:23,660

passing through light cones you get

189
00:12:32,889 --> 00:12:27,529
computer codes okay he's a phase a

190
00:12:36,609 --> 00:12:32,899
famous guy so he believed him but what

191
00:12:41,379 --> 00:12:36,619
he was asked are you saying that we are

192
00:12:45,569 --> 00:12:41,389
living in a matrix and what he answered

193
00:12:49,449 --> 00:12:45,579
was okay yeah that's a probability but

194
00:12:55,869 --> 00:12:49,459
that's not scientific because we cannot

195
00:12:58,869 --> 00:12:55,879
test that idea well what he answered he

196
00:13:02,139 --> 00:12:58,879
said there is another probability that

197
00:13:06,460 --> 00:13:02,149
we are we are one of the probabilities

198
00:13:10,239 --> 00:13:06,470
we are one of the universes or we are

199
00:13:12,850 --> 00:13:10,249
living in one universe I mean we have

200
00:13:14,919 --> 00:13:12,860
multiverse and then we are one of the

201
00:13:17,710 --> 00:13:14,929
check one of the probabilities that we

202
00:13:23,130 --> 00:13:17,720
have like computer codes in your

203
00:13:29,310 --> 00:13:27,600
okay so that's actually the main I think

204
00:13:32,460 --> 00:13:29,320
is the main is say I'm not a physicist

205
00:13:34,500 --> 00:13:32,470
so I try to be more careful when I'm

206
00:13:37,440 --> 00:13:34,510
using these terms but I think the main

207
00:13:40,400 --> 00:13:37,450
is a stream of physics is that so

208
00:13:44,280 --> 00:13:40,410
whenever they're trying to explain I

209
00:13:48,449 --> 00:13:44,290
mean why they are these forces in nature

210
00:13:52,740 --> 00:13:48,459
are so tuned why we have these physical

211
00:13:54,930 --> 00:13:52,750
constants the answer is so maybe is one

212
00:13:59,759 --> 00:13:54,940
of the one of the probabilities one of

213
00:14:02,490 --> 00:13:59,769

one outcome of the probability so

214
00:14:07,639 --> 00:14:02,500
another school of thought is my favorite

215
00:14:10,620 --> 00:14:07,649
scientist Paul Dirac so he noticed that

216
00:14:16,880 --> 00:14:10,630
the strength of the ratio the strength

217
00:14:21,210 --> 00:14:16,890
ratio of strong interaction force to

218
00:14:24,870 --> 00:14:21,220
gravity is proportional similar to the

219
00:14:29,610 --> 00:14:24,880
age of universe so if age of universe is

220
00:14:33,630 --> 00:14:29,620
changing so so is this one this might

221
00:14:36,090 --> 00:14:33,640
must change and but there is no evidence

222
00:14:39,480 --> 00:14:36,100
for that there is actually if there are

223
00:14:42,930 --> 00:14:39,490
search for finding for example different

224
00:14:46,680 --> 00:14:42,940
constants of nature if they are changing

225
00:14:50,840 --> 00:14:46,690
then yes so actually laws of nature are

226
00:14:55,019 --> 00:14:50,850
changing or evolving but we haven't

227
00:14:57,000 --> 00:14:55,029
observed that yet but I'm sure I mean

228
00:14:59,900 --> 00:14:57,010
I'm just gonna put some words in the

229
00:15:03,870 --> 00:14:59,910
rocks mouth if he was there with us

230
00:15:07,380 --> 00:15:03,880
listening to James gave talk he would

231
00:15:14,100 --> 00:15:07,390
say okay dr. gates

232
00:15:17,579 --> 00:15:14,110
that's multiverse is good idea but if

233
00:15:23,090 --> 00:15:17,589
you found computer codes in the fabric

234
00:15:32,010 --> 00:15:26,130
maybe that's the simplest way that

235
00:15:34,110 --> 00:15:32,020
nature can store information and that's

236
00:15:38,879 --> 00:15:34,120
back up based on

237
00:15:45,739 --> 00:15:38,889
Occam's razor principle so nature finds

238
00:15:50,129 --> 00:15:45,749

the simplest way to evolve now too much

239
00:15:54,350 --> 00:15:50,139
think review of literature review this

240
00:16:01,910 --> 00:15:54,360
now let's let me go to my simulation

241
00:16:09,389 --> 00:16:07,199
I'm sorry so put the okay so let's say

242
00:16:11,480 --> 00:16:09,399
just introduce a fictitious fictitious

243
00:16:15,179 --> 00:16:11,490
system we have positions we have

244
00:16:17,549 --> 00:16:15,189
particles of per unit for we have a

245
00:16:20,220 --> 00:16:17,559
fixed number of positions per unit of

246
00:16:22,619 --> 00:16:20,230
volume and we have we introduced

247
00:16:27,210 --> 00:16:22,629
particles in that in it we can calculate

248
00:16:29,189 --> 00:16:27,220
the what is the permutation and that's

249
00:16:33,749 --> 00:16:29,199
related to entropy or disorder of the

250
00:16:36,780 --> 00:16:33,759
system local sometimes we have local

251
00:16:40,460 --> 00:16:36,790
decrease in entropy I say I tell you why

252
00:16:43,860 --> 00:16:40,470
but that we call a structure and then

253
00:16:47,879 --> 00:16:43,870
space-time is actually they follow

254
00:16:50,730 --> 00:16:47,889
entropy so whenever so this is they

255
00:16:54,840 --> 00:16:50,740
going from more entropy entropic regions

256
00:16:58,259 --> 00:16:54,850
to less and then the equilibrium is just

257
00:17:01,439 --> 00:16:58,269
then when Delta is the total Delta s or

258
00:17:05,730 --> 00:17:01,449
it is so the change in this order is 0

259
00:17:09,840 --> 00:17:05,740
and ok so and then we can introduce

260
00:17:12,600 --> 00:17:09,850
entropy entropic force which is related

261
00:17:16,049 --> 00:17:12,610
to or proportional to the change in

262
00:17:21,389 --> 00:17:16,059
gradient of this order so that's I try

263
00:17:23,449 --> 00:17:21,399

to explain very ok entropic forces by

264
00:17:26,779 --> 00:17:23,459
definition maximum entropy production

265
00:17:29,360 --> 00:17:26,789
within the present and future time

266
00:17:37,470 --> 00:17:29,370
horizon rather than just greedily

267
00:17:41,279 --> 00:17:37,480
maximizing is in sorry in instantaneous

268
00:17:43,740 --> 00:17:41,289
entropy production okay so that's the

269
00:17:46,710 --> 00:17:43,750
sentence is important what does it mean

270
00:17:47,460 --> 00:17:46,720
is when you have a when you have a

271
00:17:52,470 --> 00:17:47,470
system

272
00:17:54,600 --> 00:17:52,480
and so at the edge the the the simplest

273
00:17:56,669 --> 00:17:54,610
way of increasing the entropy of the

274
00:17:58,169 --> 00:17:56,679
system is just at the edge they're just

275
00:18:00,620 --> 00:17:58,179
moving away from each other but that's

276
00:18:04,680 --> 00:18:00,630
not true for that for the inner layers

277
00:18:06,870 --> 00:18:04,690
so sometimes some of these particles in

278
00:18:09,630 --> 00:18:06,880
order to increase the enters that are

279
00:18:11,610 --> 00:18:09,640
affected by their neighbors so in order

280
00:18:13,380 --> 00:18:11,620
to increase the interview sometimes they

281
00:18:17,730 --> 00:18:13,390
have to get closer to each other and

282
00:18:22,110 --> 00:18:17,740
that from an observer here in inner

283
00:18:25,649 --> 00:18:22,120
layers it's it can be seen as emergent

284
00:18:27,899 --> 00:18:25,659
effect this force so people saw an

285
00:18:30,659 --> 00:18:27,909
observer sitting right here doesn't know

286
00:18:33,450 --> 00:18:30,669
about anything about the edge just sees

287
00:18:39,140 --> 00:18:33,460
for example particles getting closer to

288
00:18:42,360 --> 00:18:39,150

each other so local entropy changes

289
00:18:48,090 --> 00:18:42,370
results in emergent forces that we

290
00:18:52,260 --> 00:18:48,100
observed I mean that kind of obvious I

291
00:18:54,120 --> 00:18:52,270
think and I think the best example you

292
00:18:56,940 --> 00:18:54,130
can look at look at the movement of this

293
00:18:58,520 --> 00:18:56,950
guy it's called it slinky dot please do

294
00:19:03,649 --> 00:18:58,530
that

295
00:19:09,419 --> 00:19:03,659
it's also the best example I could find

296
00:19:12,210 --> 00:19:09,429
so our simulation on the boundaries you

297
00:19:14,159 --> 00:19:12,220
can see this the the flow of entropy

298
00:19:16,260 --> 00:19:14,169
that's the maximum change but the

299
00:19:18,930 --> 00:19:16,270
important result I want to show that

300
00:19:21,270 --> 00:19:18,940
whenever you have any decrease in

301
00:19:24,630 --> 00:19:21,280
entropy in the structure that I

302
00:19:32,370 --> 00:19:24,640
mentioned that that results in an

303
00:19:37,080 --> 00:19:32,380
overall increase in total volume entropy

304
00:19:39,930 --> 00:19:37,090
if you remember I said living organism

305
00:19:42,060 --> 00:19:39,940
they just release energy to increase the

306
00:19:44,789 --> 00:19:42,070
entropy of the system but here in this

307
00:19:47,490 --> 00:19:44,799
fictitious system what happens is the

308
00:19:52,169 --> 00:19:47,500
emergent effect is increasing of the

309
00:19:56,090 --> 00:19:52,179
volume entropy so that I just

310
00:19:58,680 --> 00:19:56,100
exaggerated this to show this effect

311
00:20:01,020 --> 00:19:58,690
these are the conclusion you can read up

312
00:20:04,400 --> 00:20:01,030
sorry so

313
00:20:07,440 --> 00:20:04,410

the same stuff just for Samaritans

314
00:20:09,720 --> 00:20:07,450
emerges as an attempt to reach local

315
00:20:12,360 --> 00:20:09,730
equilibrium entropic forces driving

316
00:20:14,700 --> 00:20:12,370
force before or to reach equilibrium an

317
00:20:17,130 --> 00:20:14,710
evolution happens in the local

318
00:20:20,190 --> 00:20:17,140
structures we haven't reached that point

319
00:20:22,920 --> 00:20:20,200
yet to simulate the evolution in the

320
00:20:27,960 --> 00:20:22,930
structures yet but we are so excited

321
00:20:29,880 --> 00:20:27,970
about this results thank you my

322
00:20:31,310 --> 00:20:29,890
collaborators if you have any questions

323
00:20:35,240 --> 00:20:31,320
sorry

324
00:20:39,120 --> 00:20:37,620
thank you Syed I think in the interest

325
00:20:41,430 --> 00:20:39,130
of time we should just move on to the

326
00:20:43,280 --> 00:20:41,440
next presentation so let's thanks I and