



**SABINE
HOSSENFELDER**

**I DON'T CARE
ABOUT YOUR TOE**

1
00:00:03,350 --> 00:00:01,670
yeah so so thanks for your great

2
00:00:05,590 --> 00:00:03,360
questions uh you know it's

3
00:00:06,950 --> 00:00:05,600
usually i get a lot of uh you know

4
00:00:08,549 --> 00:00:06,960
shallow questions that i've answered a

5
00:00:10,950 --> 00:00:08,559
million times already but you're

6
00:00:12,549 --> 00:00:10,960
really uh really well done i looked at

7
00:00:16,950 --> 00:00:12,559
your list with questions and i thought

8
00:00:19,109 --> 00:00:16,960
that's going to be a tough one

9
00:00:19,990 --> 00:00:19,119
all right i'm here with the

10
00:00:22,230 --> 00:00:20,000
scintillating

11
00:00:23,990 --> 00:00:22,240
sabine sabine haasenfelder and we're

12
00:00:26,070 --> 00:00:24,000
going to talk about physics

13
00:00:28,390 --> 00:00:26,080

a bit of consciousness a bit of

14

00:00:30,950 --> 00:00:28,400

something called emergence

15

00:00:33,110 --> 00:00:30,960

so sabine why don't you tell us tell the

16

00:00:37,670 --> 00:00:33,120

audience a bit about yourself

17

00:00:41,830 --> 00:00:40,229

uh i'm a theoretical physicist and i

18

00:00:43,830 --> 00:00:41,840

presently work at the frankfurt

19

00:00:46,950 --> 00:00:43,840

institute for advanced studies

20

00:00:48,630 --> 00:00:46,960

in germany and you know my day-to-day

21

00:00:50,709 --> 00:00:48,640

research is mostly

22

00:00:52,470 --> 00:00:50,719

dark matter super fluid dark matter in

23

00:00:55,029 --> 00:00:52,480

particular

24

00:00:56,950 --> 00:00:55,039

but i also do some stuff in the

25

00:00:59,110 --> 00:00:56,960

foundations of quantum mechanics and you

26
00:01:01,349 --> 00:00:59,120
know i'm generally broadly interested in

27
00:01:03,990 --> 00:01:01,359
the foundations of physics

28
00:01:05,189 --> 00:01:04,000
super fluid dark matter dark matter is

29
00:01:07,670 --> 00:01:05,199
it's dark and it's not

30
00:01:09,590 --> 00:01:07,680
clear what it is and you're qualifying

31
00:01:12,789 --> 00:01:09,600
it by saying superfluid dark matter

32
00:01:15,190 --> 00:01:12,799
why is that well um

33
00:01:16,230 --> 00:01:15,200
so this is a particular type of dark

34
00:01:19,350 --> 00:01:16,240
matter that

35
00:01:21,990 --> 00:01:19,360
um was proposed by

36
00:01:23,109 --> 00:01:22,000
a group around justin curry about five

37
00:01:25,749 --> 00:01:23,119
years ago

38
00:01:27,910 --> 00:01:25,759

and the curious thing about it is that

39

00:01:31,590 --> 00:01:27,920

this kind of super fluid

40

00:01:32,710 --> 00:01:31,600

um appears like modified gravity

41

00:01:34,390 --> 00:01:32,720

and i don't know if you've been

42

00:01:36,069 --> 00:01:34,400

following this whole debate but there's

43

00:01:39,670 --> 00:01:36,079

there's this big fight

44

00:01:40,149 --> 00:01:39,680

in astrophysics about whether it's dark

45

00:01:41,990 --> 00:01:40,159

matter

46

00:01:43,910 --> 00:01:42,000

so it's stuff made of particles or

47

00:01:46,310 --> 00:01:43,920

whether we have gotten something wrong

48

00:01:49,109 --> 00:01:46,320

with gravity and we need to modify

49

00:01:49,590 --> 00:01:49,119

einstein's theory of general relativity

50

00:01:52,469 --> 00:01:49,600

and

51
00:01:53,510 --> 00:01:52,479
um so that there are benefits to either

52
00:01:55,109 --> 00:01:53,520
side i would say

53
00:01:56,870 --> 00:01:55,119
and and people can't decide what's the

54
00:01:59,429 --> 00:01:56,880
right thing and

55
00:02:01,270 --> 00:01:59,439
um the amazing thing about this type of

56
00:02:03,510 --> 00:02:01,280
superfluid dark matter is that it

57
00:02:06,389 --> 00:02:03,520
combines the benefits of both

58
00:02:06,950 --> 00:02:06,399
without the disadvantages of either so

59
00:02:10,710 --> 00:02:06,960
when i

60
00:02:13,670 --> 00:02:10,720
that's the thing to do

61
00:02:15,510 --> 00:02:13,680
and um i feel super super lucky that i

62
00:02:18,070 --> 00:02:15,520
actually got a research grant that

63
00:02:20,630 --> 00:02:18,080

allows me to further study um this type

64

00:02:22,390 --> 00:02:20,640

of dark matter how does it combine the

65

00:02:25,030 --> 00:02:22,400

benefits of modifying the field

66

00:02:27,589 --> 00:02:25,040

equations of einstein

67

00:02:29,510 --> 00:02:27,599

well it doesn't exactly modify the field

68

00:02:32,470 --> 00:02:29,520

equations but what this

69

00:02:33,750 --> 00:02:32,480

superfluid dark matter does is that

70

00:02:37,190 --> 00:02:33,760

there is an additional

71

00:02:38,630 --> 00:02:37,200

force in the fluid which is mediated by

72

00:02:41,750 --> 00:02:38,640

the phonons

73

00:02:45,350 --> 00:02:41,760

after condensation and um it

74

00:02:46,550 --> 00:02:45,360

this force appears like it sits on top

75

00:02:49,509 --> 00:02:46,560

of gravity

76

00:02:50,309 --> 00:02:49,519

so it makes gravity stronger which is

77

00:02:53,430 --> 00:02:50,319

exactly

78

00:02:55,990 --> 00:02:53,440

um what we observe and now the

79

00:02:58,070 --> 00:02:56,000

interesting thing about it is that

80

00:02:59,190 --> 00:02:58,080

since it's generated by this

81

00:03:02,390 --> 00:02:59,200

condensation

82

00:03:02,790 --> 00:03:02,400

process it's a very regular force that

83

00:03:06,070 --> 00:03:02,800

has

84

00:03:08,790 --> 00:03:06,080

a lot more patterns to it than you would

85

00:03:09,750 --> 00:03:08,800

get by normal dark matter that you can

86

00:03:12,149 --> 00:03:09,760

distribute

87

00:03:13,670 --> 00:03:12,159

however which way you like so this

88

00:03:15,990 --> 00:03:13,680

normal dark matter

89

00:03:17,509 --> 00:03:16,000

has a big problem reproducing certain

90

00:03:19,350 --> 00:03:17,519

patterns that we observe

91

00:03:22,229 --> 00:03:19,360

like the baryonic tolerant fischer

92

00:03:25,509 --> 00:03:22,239

relation just to mention an example

93

00:03:27,270 --> 00:03:25,519

and superfluid dark matter can reproduce

94

00:03:28,789 --> 00:03:27,280

these patterns quite easily

95

00:03:30,309 --> 00:03:28,799

so that what you're working toward

96

00:03:33,190 --> 00:03:30,319

primarily right now

97

00:03:33,670 --> 00:03:33,200

is just fleshing that theory out making

98

00:03:36,710 --> 00:03:33,680

it

99

00:03:39,110 --> 00:03:36,720

does i mean

100

00:03:40,550 --> 00:03:39,120

making a match with current data yeah

101

00:03:41,990 --> 00:03:40,560

basically so i'm

102

00:03:43,589 --> 00:03:42,000

you know on the on the one side there's

103

00:03:44,869 --> 00:03:43,599

this question like how do you connect us

104

00:03:46,789 --> 00:03:44,879

with the data but they're

105

00:03:48,309 --> 00:03:46,799

also on the theoretical side they are

106

00:03:51,910 --> 00:03:48,319

just things that are

107

00:03:54,149 --> 00:03:51,920

have not been very well explored um so

108

00:03:55,350 --> 00:03:54,159

you know i'm a theoretical physicist i

109

00:03:59,030 --> 00:03:55,360

work more on

110

00:04:00,869 --> 00:03:59,040

understanding the theory part and um

111

00:04:03,270 --> 00:04:00,879

you know but i i have a student and a

112

00:04:04,949 --> 00:04:03,280

collaborator um who are more on the

113

00:04:07,110 --> 00:04:04,959

observational side

114

00:04:08,550 --> 00:04:07,120

so of course we're hoping to connect the

115

00:04:10,630 --> 00:04:08,560

two

116

00:04:12,229 --> 00:04:10,640

and what's your youtube channel what's

117

00:04:15,830 --> 00:04:12,239

the goal

118

00:04:17,990 --> 00:04:15,840

watching this you should check out

119

00:04:19,349 --> 00:04:18,000

i'll include a link to your youtube

120

00:04:22,230 --> 00:04:19,359

channel in the description

121

00:04:23,909 --> 00:04:22,240

check out her channel because if you're

122

00:04:25,749 --> 00:04:23,919

someone who's interested in physics and

123

00:04:27,030 --> 00:04:25,759

if you're an undergrad in physics

124

00:04:28,710 --> 00:04:27,040

even if you're a graduate of physics

125

00:04:29,189 --> 00:04:28,720

you'll have plenty to learn from her

126
00:04:31,189 --> 00:04:29,199
channel

127
00:04:32,870 --> 00:04:31,199
she has music videos as well as far as i

128
00:04:34,230 --> 00:04:32,880
know sabine you've moved your music

129
00:04:35,670 --> 00:04:34,240
videos to another channel though some of

130
00:04:38,550 --> 00:04:35,680
the old ones remain

131
00:04:40,070 --> 00:04:38,560
and yeah so what the heck is why are you

132
00:04:41,749 --> 00:04:40,080
doing the youtube channel

133
00:04:43,189 --> 00:04:41,759
maybe it's self-explanatory but i want

134
00:04:44,950 --> 00:04:43,199
to hear it from you and then

135
00:04:46,790 --> 00:04:44,960
second what's the deal with the music

136
00:04:50,230 --> 00:04:46,800
videos

137
00:04:51,430 --> 00:04:50,240
well so um i've been in science

138
00:04:54,390 --> 00:04:51,440

communication like

139

00:04:55,189 --> 00:04:54,400

for almost 15 years now and i used to

140

00:04:58,230 --> 00:04:55,199

mostly do

141

00:05:00,390 --> 00:04:58,240

writing as you probably know i've

142

00:05:02,070 --> 00:05:00,400

written this blog called back reaction

143

00:05:05,350 --> 00:05:02,080

for quite a long time

144

00:05:08,870 --> 00:05:05,360

and i've just found in the long run that

145

00:05:10,469 --> 00:05:08,880

writing doesn't appeal to a pretty big

146

00:05:13,830 --> 00:05:10,479

group of people

147

00:05:16,870 --> 00:05:13,840

and there's generally an issue with um

148

00:05:18,550 --> 00:05:16,880

blogging which is that the audience is

149

00:05:20,390 --> 00:05:18,560

pretty much self-selecting

150

00:05:22,150 --> 00:05:20,400

so after you've written on a particular

151

00:05:24,150 --> 00:05:22,160

topic for some time which in

152

00:05:25,909 --> 00:05:24,160

my case is mostly particle physics

153

00:05:27,510 --> 00:05:25,919

you're you're pretty much stuck

154

00:05:28,950 --> 00:05:27,520

with a certain group of people so you

155

00:05:30,310 --> 00:05:28,960

live in this bubble

156

00:05:31,830 --> 00:05:30,320

and then if you get interested in

157

00:05:32,870 --> 00:05:31,840

something else like it's been the case

158

00:05:35,189 --> 00:05:32,880

with we

159

00:05:36,950 --> 00:05:35,199

um you you totally talk past your

160

00:05:40,310 --> 00:05:36,960

audience so no one gives a

161

00:05:42,550 --> 00:05:40,320

basically um i see and um

162

00:05:43,510 --> 00:05:42,560

in so you developed too narrow of an

163

00:05:45,990 --> 00:05:43,520

audience over time

164

00:05:46,950 --> 00:05:46,000

with blogs yeah right and and now the

165

00:05:50,310 --> 00:05:46,960

thing is that

166

00:05:51,430 --> 00:05:50,320

um search engine um optimization has

167

00:05:53,749 --> 00:05:51,440

been going

168

00:05:55,350 --> 00:05:53,759

um in a way that doesn't really help

169

00:05:58,790 --> 00:05:55,360

this so people don't just

170

00:06:00,550 --> 00:05:58,800

go online and search for

171

00:06:02,550 --> 00:06:00,560

something on a blog that just doesn't

172

00:06:04,950 --> 00:06:02,560

exist and now the interesting thing

173

00:06:07,990 --> 00:06:04,960

about youtube is that

174

00:06:09,189 --> 00:06:08,000

they will try to find an audience for

175

00:06:11,270 --> 00:06:09,199

your content

176

00:06:12,309 --> 00:06:11,280

that's what the search algorithm does

177

00:06:13,270 --> 00:06:12,319

and now you know there's a long

178

00:06:16,309 --> 00:06:13,280

conversation to be

179

00:06:17,189 --> 00:06:16,319

uh have had about how well this actually

180

00:06:19,350 --> 00:06:17,199

works but

181

00:06:21,189 --> 00:06:19,360

in principle the idea is good you know

182

00:06:22,790 --> 00:06:21,199

they take your content and they

183

00:06:24,790 --> 00:06:22,800

they try to find people who may be

184

00:06:26,150 --> 00:06:24,800

interested in it and i think this has

185

00:06:29,029 --> 00:06:26,160

really helped me

186

00:06:30,790 --> 00:06:29,039

um to get the stuff that i've more

187

00:06:33,110 --> 00:06:30,800

recently been interested in which leads

188

00:06:36,390 --> 00:06:33,120

more towards philosophy foundations of

189

00:06:39,110 --> 00:06:36,400

quantum mechanics and more generally the

190

00:06:40,950 --> 00:06:39,120

um sometimes not very well working

191

00:06:42,070 --> 00:06:40,960

connection between science and science

192

00:06:45,110 --> 00:06:42,080

policy

193

00:06:47,909 --> 00:06:45,120

um so so this is all stuff um that

194

00:06:49,430 --> 00:06:47,919

i found gets a quote across much better

195

00:06:52,070 --> 00:06:49,440

on youtube and i mean then there are

196

00:06:54,150 --> 00:06:52,080

obvious things like that it's easier to

197

00:06:55,430 --> 00:06:54,160

um explain some things if you can use

198

00:06:58,469 --> 00:06:55,440

graphics

199

00:06:59,749 --> 00:06:58,479

right right and when you say that you're

200

00:07:01,510 --> 00:06:59,759

interested in the philosophy of the

201
00:07:02,309 --> 00:07:01,520
foundations of quantum mechanics are you

202
00:07:03,830 --> 00:07:02,319
referring to

203
00:07:06,469 --> 00:07:03,840
the different interpretations of quantum

204
00:07:09,990 --> 00:07:09,029
well um i'm you know i said i'm a

205
00:07:12,150 --> 00:07:10,000
theorist but

206
00:07:13,909 --> 00:07:12,160
uh i'm actually more strictly speaking

207
00:07:16,070 --> 00:07:13,919
i'm a phenomenologist

208
00:07:17,430 --> 00:07:16,080
it's just that i try to avoid the word

209
00:07:18,790 --> 00:07:17,440
because a lot of people don't know what

210
00:07:21,029 --> 00:07:18,800
it means

211
00:07:22,150 --> 00:07:21,039
yeah so actually a quick aside

212
00:07:23,909 --> 00:07:22,160
phenomenology

213
00:07:25,749 --> 00:07:23,919

for the majority of our audience they

214

00:07:28,309 --> 00:07:25,759

might be familiar with the philosophy

215

00:07:30,230 --> 00:07:28,319

that comes from husserl exactly and

216

00:07:30,870 --> 00:07:30,240

phenomenology particle phenomenology

217

00:07:33,029 --> 00:07:30,880

sounds like oh

218

00:07:34,629 --> 00:07:33,039

are you talking about the Umwelt of a

219

00:07:36,870 --> 00:07:34,639

quark i don't know if you are

220

00:07:38,710 --> 00:07:36,880

aware of the philosophical phenomenology

221

00:07:41,990 --> 00:07:38,720

but if you if you are can you delineate

222

00:07:45,110 --> 00:07:42,000

it between the particle phenomenology

223

00:07:46,869 --> 00:07:45,120

yes so the phenomenology um in particle

224

00:07:49,670 --> 00:07:46,879

physics has nothing to do with the

225

00:07:50,150 --> 00:07:49,680

philosophical area of phenomenology but

226

00:07:53,270 --> 00:07:50,160

it's

227

00:07:56,950 --> 00:07:53,280

um it basically sits in the middle

228

00:07:59,110 --> 00:07:56,960

between theory and experiment so you're

229

00:08:02,070 --> 00:07:59,120

trying to develop

230

00:08:04,550 --> 00:08:02,080

a model that you can connect to what is

231

00:08:06,309 --> 00:08:04,560

actually measurable

232

00:08:08,390 --> 00:08:06,319

so the the theoretical side in

233

00:08:08,869 --> 00:08:08,400

particular in particle physics tends to

234

00:08:11,350 --> 00:08:08,879

be

235

00:08:12,869 --> 00:08:11,360

pretty much only math right that that

236

00:08:14,390 --> 00:08:12,879

that's what you do

237

00:08:17,110 --> 00:08:14,400

and then on the experimental side you

238

00:08:19,990 --> 00:08:17,120

measure and the phenomenology

239

00:08:22,869 --> 00:08:20,000

um is that group of people where we are

240

00:08:25,270 --> 00:08:22,879

making a connection between the two

241

00:08:26,469 --> 00:08:25,280

so it would be as if newton came up with

242

00:08:28,070 --> 00:08:26,479

the theory of gravity

243

00:08:29,749 --> 00:08:28,080

and then someone said well here's how we

244

00:08:31,350 --> 00:08:29,759

can test the theory of gravity that's

245

00:08:33,190 --> 00:08:31,360

the phenomenologist and then the

246

00:08:36,550 --> 00:08:33,200

experimentalists go out and do the

247

00:08:39,350 --> 00:08:36,560

actual testing is that the divide

248

00:08:41,110 --> 00:08:39,360

um yeah roughly speaking except that

249

00:08:42,630 --> 00:08:41,120

normally it's the case that you have a

250

00:08:44,630 --> 00:08:42,640

theory which is much much more

251
00:08:45,990 --> 00:08:44,640
complicated than newtonian gravity so

252
00:08:47,269 --> 00:08:46,000
you have to coax

253
00:08:49,990 --> 00:08:47,279
something out of it that you can

254
00:08:51,509 --> 00:08:50,000
actually go and measure i see i see

255
00:08:52,949 --> 00:08:51,519
and i'm sure you've heard of some of

256
00:08:54,630 --> 00:08:52,959
these new theories of everything that

257
00:08:55,350 --> 00:08:54,640
have been developed recently two major

258
00:08:58,790 --> 00:08:55,360
ones

259
00:09:02,389 --> 00:08:58,800
and for example weinsteins and wolframs

260
00:09:04,230 --> 00:09:02,399
and i'm i want to know if you're

261
00:09:05,190 --> 00:09:04,240
familiar with it and if you see as a

262
00:09:08,949 --> 00:09:05,200
phenomenologist

263
00:09:10,949 --> 00:09:08,959

any clear way of getting a prediction

264

00:09:14,070 --> 00:09:10,959

from them

265

00:09:16,310 --> 00:09:14,080

uh no i don't see such a

266

00:09:17,110 --> 00:09:16,320

way i'm sure that they both have been

267

00:09:20,470 --> 00:09:17,120

thinking about

268

00:09:21,030 --> 00:09:20,480

it uh but it's a you know this is a

269

00:09:24,550 --> 00:09:21,040

really

270

00:09:27,670 --> 00:09:24,560

complicated process

271

00:09:30,230 --> 00:09:27,680

um i'm not even

272

00:09:31,590 --> 00:09:30,240

sorry i'm not even one to say that a

273

00:09:34,310 --> 00:09:31,600

prediction is necessary

274

00:09:35,110 --> 00:09:34,320

in the short term when you're exploring

275

00:09:37,829 --> 00:09:35,120

i know that i

276

00:09:39,670 --> 00:09:37,839

in your book lost in math it's it's like

277

00:09:40,230 --> 00:09:39,680

hey there's been 20 years with string

278

00:09:44,070 --> 00:09:40,240

theory

279

00:09:46,630 --> 00:09:44,080

maybe more and it's it seems like

280

00:09:47,670 --> 00:09:46,640

right right well these two new theories

281

00:09:50,389 --> 00:09:47,680

don't have that

282

00:09:51,910 --> 00:09:50,399

long of a history so it's not such a

283

00:09:53,350 --> 00:09:51,920

detriment at least in my

284

00:09:55,030 --> 00:09:53,360

estimation that they don't have

285

00:09:57,350 --> 00:09:55,040

prediction predictions associated with

286

00:09:58,790 --> 00:09:57,360

it even a fineman said that

287

00:10:03,750 --> 00:09:58,800

feynman had this great talk i don't know

288

00:10:09,910 --> 00:10:07,750

prematurely throw out a new physics

289

00:10:11,350 --> 00:10:09,920

theory just because it doesn't comport

290

00:10:11,990 --> 00:10:11,360

with the data and doesn't make

291

00:10:14,310 --> 00:10:12,000

experiments

292

00:10:16,310 --> 00:10:14,320

and he gave a great analogy imagine the

293

00:10:20,150 --> 00:10:16,320

mayans 500 600 years ago

294

00:10:22,870 --> 00:10:20,160

and they had wonderful predictions

295

00:10:24,790 --> 00:10:22,880

it was based on a wrong model but it all

296

00:10:25,829 --> 00:10:24,800

fit with the data of how the sun of when

297

00:10:27,430 --> 00:10:25,839

the sun is going to come out

298

00:10:29,509 --> 00:10:27,440

and then someone says hey i think that

299

00:10:30,870 --> 00:10:29,519

the sun actually revolves that the earth

300

00:10:33,110 --> 00:10:30,880

revolves around the sun

301

00:10:34,470 --> 00:10:33,120

and and then they say well can you

302

00:10:35,910 --> 00:10:34,480

predict when the moon is going to have

303

00:10:36,630 --> 00:10:35,920

an eclipse and that person i know i

304

00:10:41,430 --> 00:10:36,640

haven't

305

00:10:45,990 --> 00:10:44,550

yeah certainly i mean um it can take a

306

00:10:49,030 --> 00:10:46,000

long time to

307

00:10:51,590 --> 00:10:49,040

understand a theory on a depth

308

00:10:52,310 --> 00:10:51,600

so that you can reliably make a

309

00:10:53,910 --> 00:10:52,320

prediction

310

00:10:55,829 --> 00:10:53,920

so and and that certainly that's

311

00:10:58,710 --> 00:10:55,839

certainly a problem that

312

00:10:59,509 --> 00:10:58,720

we see in the foundations with a lot of

313

00:11:01,590 --> 00:10:59,519

people who

314

00:11:02,710 --> 00:11:01,600
are working alone or in very small

315

00:11:05,190 --> 00:11:02,720
groups

316

00:11:06,069 --> 00:11:05,200
uh it can take like a really long time

317

00:11:09,110 --> 00:11:06,079
to get anywhere

318

00:11:11,190 --> 00:11:09,120
and uh as long as they don't have

319

00:11:12,230 --> 00:11:11,200
as long as they have nothing to show for

320

00:11:14,310 --> 00:11:12,240
everyone else is like

321

00:11:15,750 --> 00:11:14,320
yeah no i don't want to even think about

322

00:11:18,389 --> 00:11:15,760
it right

323

00:11:19,670 --> 00:11:18,399
so it's kind of it's a process where the

324

00:11:21,910 --> 00:11:19,680
rich get richer

325

00:11:24,310 --> 00:11:21,920
and the poorer never get anywhere have

326

00:11:27,670 --> 00:11:24,320

you read lee smolin's book on

327

00:11:29,910 --> 00:11:27,680

the trouble with physics yes i read that

328

00:11:31,670 --> 00:11:29,920

it seems like there's plenty of

329

00:11:33,670 --> 00:11:31,680

parallels between lost and math and

330

00:11:35,030 --> 00:11:33,680

and the trouble with physics do you see

331

00:11:37,670 --> 00:11:35,040

any disagreements with

332

00:11:39,190 --> 00:11:37,680

your point of view and lisa mullins in

333

00:11:42,949 --> 00:11:39,200

the theory of

334

00:11:45,670 --> 00:11:42,959

sorry in the trouble with physics

335

00:11:46,470 --> 00:11:45,680

well there are some parallels of course

336

00:11:50,230 --> 00:11:46,480

in that

337

00:11:52,790 --> 00:11:50,240

i think we're both concerned about

338

00:11:53,910 --> 00:11:52,800

where the foundations of physics are

339

00:11:56,870 --> 00:11:53,920

headed

340

00:11:57,670 --> 00:11:56,880

and that there are there's too much

341

00:12:01,670 --> 00:11:57,680

emphasis

342

00:12:04,629 --> 00:12:01,680

on some few research directions

343

00:12:06,550 --> 00:12:04,639

um my book is more broadly about the

344

00:12:08,310 --> 00:12:06,560

foundations of physics

345

00:12:09,750 --> 00:12:08,320

why lee's book is more specifically

346

00:12:11,269 --> 00:12:09,760

about string theory

347

00:12:13,350 --> 00:12:11,279

what's the difference you ask i think

348

00:12:14,470 --> 00:12:13,360

i'm far less critical of string theory

349

00:12:17,590 --> 00:12:14,480

um than the years

350

00:12:19,430 --> 00:12:17,600

um but i'm somewhat more critical of low

351

00:12:23,110 --> 00:12:19,440

quantum gravity

352

00:12:26,470 --> 00:12:23,120

than he is right so you know um

353

00:12:27,430 --> 00:12:26,480

there are differences so how do you

354

00:12:29,670 --> 00:12:27,440

define a theory

355

00:12:33,910 --> 00:12:29,680

of everything is it simply unifying

356

00:12:36,949 --> 00:12:33,920

gravity with the other three forces or

357

00:12:39,190 --> 00:12:36,959

or is there something more

358

00:12:40,310 --> 00:12:39,200

well you want to unify it so that that

359

00:12:41,829 --> 00:12:40,320

it's consistent

360

00:12:44,710 --> 00:12:41,839

you know if you just take the standard

361

00:12:46,629 --> 00:12:44,720

model and you lump gravity on top of it

362

00:12:48,870 --> 00:12:46,639

that's kind of a theory which describes

363

00:12:51,350 --> 00:12:48,880

both particle physics as

364

00:12:53,509 --> 00:12:51,360

we use it today and general relativity

365

00:12:55,590 --> 00:12:53,519

but it's internally inconsistent

366

00:12:57,990 --> 00:12:55,600

so what people mean with the theory of

367

00:12:59,350 --> 00:12:58,000

everything is a theory that combines all

368

00:13:02,790 --> 00:12:59,360

these four forces

369

00:13:04,629 --> 00:13:02,800

but is mathematically consistent and it

370

00:13:07,590 --> 00:13:04,639

is widely believed that

371

00:13:09,509 --> 00:13:07,600

this will require quantizing gravity so

372

00:13:12,069 --> 00:13:09,519

quantum gravity is kind of part

373

00:13:12,790 --> 00:13:12,079

um of the picture should a theory of

374

00:13:15,670 --> 00:13:12,800

everything

375

00:13:17,350 --> 00:13:15,680

have as one of its ingredients an

376

00:13:20,310 --> 00:13:17,360

explanation for dark matter

377

00:13:21,670 --> 00:13:20,320

or dark energy or is that unnecessary

378

00:13:26,230 --> 00:13:21,680

it's just purely about

379

00:13:27,750 --> 00:13:26,240

grand unified theory unifying these well

380

00:13:30,230 --> 00:13:27,760

you definitely need to do something

381

00:13:32,310 --> 00:13:30,240

about dark matter um

382

00:13:33,670 --> 00:13:32,320

because you need some resolution to that

383

00:13:36,150 --> 00:13:33,680

um i mean

384

00:13:38,230 --> 00:13:36,160

look dark matter makes up like 85

385

00:13:41,110 --> 00:13:38,240

percent of the matter in the universe

386

00:13:41,990 --> 00:13:41,120

um so if your theory of everything does

387

00:13:43,590 --> 00:13:42,000

not describe

388

00:13:45,829 --> 00:13:43,600

most of what's in the universe that's a

389

00:13:48,870 --> 00:13:45,839

pretty poor theory of everything i'd say

390

00:13:52,230 --> 00:13:48,880

it's a theory of a few of a minority

391

00:13:54,310 --> 00:13:52,240

yeah basically so when it comes to

392

00:13:56,470 --> 00:13:54,320

dark energy um there really isn't

393

00:13:57,030 --> 00:13:56,480

anything to explain you know you can

394

00:13:59,670 --> 00:13:57,040

just

395

00:14:01,189 --> 00:13:59,680

fit all the observations that we have uh

396

00:14:02,949 --> 00:14:01,199

quite well by just saying well it's a

397

00:14:04,310 --> 00:14:02,959

cosmological constant and that's just a

398

00:14:05,110 --> 00:14:04,320

constant of nature and here we have

399

00:14:07,590 --> 00:14:05,120

measured it

400

00:14:09,990 --> 00:14:07,600

and that's the value so there's uh

401
00:14:12,069 --> 00:14:10,000
there's nothing wrong with that

402
00:14:13,829 --> 00:14:12,079
so in the theory of everything in your

403
00:14:15,430 --> 00:14:13,839
eyes the

404
00:14:17,030 --> 00:14:15,440
there are some constants that simply

405
00:14:19,350 --> 00:14:17,040
need to be measured

406
00:14:20,629 --> 00:14:19,360
they can be taken for granted they don't

407
00:14:23,990 --> 00:14:20,639
need to be explained

408
00:14:26,790 --> 00:14:24,000
by some other fundamental process

409
00:14:29,030 --> 00:14:26,800
they don't need to be explained no but

410
00:14:31,430 --> 00:14:29,040
you know it would certainly be nice

411
00:14:32,310 --> 00:14:31,440
if we were able to reduce the number of

412
00:14:34,230 --> 00:14:32,320
um

413
00:14:35,430 --> 00:14:34,240

constants that that we have right now so

414

00:14:37,110 --> 00:14:35,440

this is certainly something that a lot

415

00:14:38,870 --> 00:14:37,120

of people hope for

416

00:14:41,189 --> 00:14:38,880

but strictly speaking it's not necessary

417

00:14:42,069 --> 00:14:41,199

you know do you think it's in principle

418

00:14:44,550 --> 00:14:42,079

possible

419

00:14:45,829 --> 00:14:44,560

to r to actually reduce all the physical

420

00:14:50,069 --> 00:14:45,839

constants to something else that's

421

00:14:54,710 --> 00:14:53,110

um well it it kind of depends on how you

422

00:14:58,150 --> 00:14:54,720

would define that because

423

00:15:00,310 --> 00:14:58,160

um i mean so i

424

00:15:01,509 --> 00:15:00,320

depends on what you mean by constants

425

00:15:03,750 --> 00:15:01,519

the thing is that

426
00:15:05,110 --> 00:15:03,760
we have in our physical theories uh we

427
00:15:07,829 --> 00:15:05,120
don't just have

428
00:15:10,550 --> 00:15:07,839
numbers like numbers without units but

429
00:15:12,389 --> 00:15:10,560
we also have dimensionful constants

430
00:15:13,670 --> 00:15:12,399
and you need these to come from

431
00:15:15,110 --> 00:15:13,680
somewhere

432
00:15:16,790 --> 00:15:15,120
like i mean i'm talking about things

433
00:15:17,829 --> 00:15:16,800
like uh the speed of light planck's

434
00:15:21,350 --> 00:15:17,839
constant

435
00:15:24,829 --> 00:15:21,360
kind of stuff

436
00:15:28,069 --> 00:15:24,839
and and i don't really see how um you

437
00:15:31,030 --> 00:15:28,079
can get around actually measuring them

438
00:15:34,389 --> 00:15:31,040

like how can we possibly derive them

439

00:15:35,990 --> 00:15:34,399

yes um which is also something that

440

00:15:37,350 --> 00:15:36,000

i think most people don't have in mind

441

00:15:38,069 --> 00:15:37,360

when they're talking about the theory of

442

00:15:40,230 --> 00:15:38,079

everything

443

00:15:41,670 --> 00:15:40,240

you know this i mean theoretical

444

00:15:43,670 --> 00:15:41,680

physicists like to just set all these

445

00:15:46,150 --> 00:15:43,680

constants equal to one

446

00:15:47,430 --> 00:15:46,160

all right so just to ease the

447

00:15:50,470 --> 00:15:47,440

calculation

448

00:15:53,030 --> 00:15:50,480

um so these are not the constants that

449

00:15:55,189 --> 00:15:53,040

they normally talk about um when they

450

00:15:56,949 --> 00:15:55,199

say we want to derive this but

451

00:16:00,069 --> 00:15:56,959

usually what they talk about are

452

00:16:02,470 --> 00:16:00,079

constants that do not have any units

453

00:16:04,230 --> 00:16:02,480

so this may be for example the ratio

454

00:16:05,829 --> 00:16:04,240

between the masses of

455

00:16:07,590 --> 00:16:05,839

uh i don't know the higgs boson at the

456

00:16:08,949 --> 00:16:07,600

electron or something like this so so

457

00:16:12,389 --> 00:16:08,959

this would be a typical

458

00:16:14,310 --> 00:16:12,399

example for a number that you would hope

459

00:16:17,670 --> 00:16:14,320

you can actually derive

460

00:16:20,550 --> 00:16:17,680

from your theory of everything and then

461

00:16:21,990 --> 00:16:20,560

that theory may well maybe only require

462

00:16:25,749 --> 00:16:22,000

one constant

463

00:16:28,550 --> 00:16:25,759

i don't see why this would be impossible

464

00:16:30,230 --> 00:16:28,560

but no one has managed to actually do

465

00:16:31,910 --> 00:16:30,240

that

466

00:16:33,990 --> 00:16:31,920

is there some current theory of

467

00:16:35,749 --> 00:16:34,000

everything that you feel like is

468

00:16:40,150 --> 00:16:35,759

on the right track is there one that in

469

00:16:40,160 --> 00:16:44,550

well i mean there there are

470

00:16:49,430 --> 00:16:47,350

so um so we didn't settle before i

471

00:16:50,949 --> 00:16:49,440

answered the question uh if by theory of

472

00:16:55,189 --> 00:16:50,959

everything

473

00:16:58,949 --> 00:16:55,199

you want to include a grand unification

474

00:17:01,990 --> 00:16:58,959

so the grand unification is a

475

00:17:04,630 --> 00:17:02,000

certain kind of symmetry for the

476

00:17:05,829 --> 00:17:04,640

the other three known forces besides

477

00:17:07,669 --> 00:17:05,839

gravity

478

00:17:09,750 --> 00:17:07,679

the forces in the standard model like

479

00:17:11,510 --> 00:17:09,760

there's electromagnetism and the strong

480

00:17:14,630 --> 00:17:11,520

and the weak nuclear force

481

00:17:16,949 --> 00:17:14,640

so um what

482

00:17:18,549 --> 00:17:16,959

physicists usually call a grand unified

483

00:17:21,189 --> 00:17:18,559

theory is one that

484

00:17:22,069 --> 00:17:21,199

combines these three forces and you

485

00:17:24,069 --> 00:17:22,079

could say well they

486

00:17:25,750 --> 00:17:24,079

are already in the standard model so

487

00:17:26,789 --> 00:17:25,760

what's wrong with that and the answer is

488

00:17:30,310 --> 00:17:26,799

well nothing really

489

00:17:31,029 --> 00:17:30,320

but um you know it would be nicer if we

490

00:17:33,830 --> 00:17:31,039

could

491

00:17:35,909 --> 00:17:33,840

combine them to only one force which in

492

00:17:38,870 --> 00:17:35,919

a certain limit gives rise to these

493

00:17:40,549 --> 00:17:38,880

three forces and so normally when people

494

00:17:44,070 --> 00:17:40,559

talk about the theory of everything

495

00:17:44,549 --> 00:17:44,080

they um include grand unification in

496

00:17:47,430 --> 00:17:44,559

that

497

00:17:50,230 --> 00:17:47,440

so the theory of everything is this

498

00:17:53,350 --> 00:17:50,240

combination of quantum gravity with

499

00:17:57,029 --> 00:17:53,360

um the gut the

500

00:18:00,390 --> 00:17:57,039

grand unified uh theory and um

501
00:18:03,990 --> 00:18:00,400
so there are very few

502
00:18:06,070 --> 00:18:04,000
theories um that do that um

503
00:18:07,669 --> 00:18:06,080
for example and we were talking about uh

504
00:18:09,190 --> 00:18:07,679
look quantum gravity a loop quantum

505
00:18:11,029 --> 00:18:09,200
gravity doesn't really say anything

506
00:18:14,150 --> 00:18:11,039
about the particle sector

507
00:18:15,430 --> 00:18:14,160
so it does not it does not have a grand

508
00:18:17,590 --> 00:18:15,440
unification

509
00:18:19,350 --> 00:18:17,600
so i think and this is always a matter

510
00:18:20,870 --> 00:18:19,360
of definition of course but i think

511
00:18:22,549 --> 00:18:20,880
a lot of physicists would not call it a

512
00:18:25,669 --> 00:18:22,559
theory of everything they would just say

513
00:18:28,789 --> 00:18:25,679

it's a theory of quantum gravity

514

00:18:29,669 --> 00:18:28,799

um and so string theory uh is a theory

515

00:18:32,789 --> 00:18:29,679

of everything

516

00:18:36,230 --> 00:18:32,799

um that um because

517

00:18:37,669 --> 00:18:36,240

both gravity and all these forces come

518

00:18:39,029 --> 00:18:37,679

out of the same thing so it's all

519

00:18:42,310 --> 00:18:39,039

strings basically so

520

00:18:43,110 --> 00:18:42,320

that's the idea um and then um there are

521

00:18:46,549 --> 00:18:43,120

some other

522

00:18:48,070 --> 00:18:46,559

um approaches where um people say that's

523

00:18:50,310 --> 00:18:48,080

what they do but it's

524

00:18:52,310 --> 00:18:50,320

you know it's difficult as i said

525

00:18:54,230 --> 00:18:52,320

because um these tend to be pursued by

526

00:18:55,590 --> 00:18:54,240

very few people so

527

00:18:57,110 --> 00:18:55,600

they never seem to really be getting

528

00:18:59,029 --> 00:18:57,120

anywhere and i have some of these

529

00:19:00,230 --> 00:18:59,039

examples in my book like garrett lisey

530

00:19:02,789 --> 00:19:00,240

for example with his

531

00:19:04,310 --> 00:19:02,799

uh e8 um theory in principle that's

532

00:19:05,830 --> 00:19:04,320

something that could be a theory of

533

00:19:07,510 --> 00:19:05,840

everything but it

534

00:19:09,190 --> 00:19:07,520

it you know he's pretty much working

535

00:19:11,830 --> 00:19:09,200

alone and and so

536

00:19:12,710 --> 00:19:11,840

it's it's a very long tedious process

537

00:19:14,150 --> 00:19:12,720

and then

538

00:19:15,990 --> 00:19:14,160

you know there are things like causal

539

00:19:16,630 --> 00:19:16,000

fermion models and you might may put on

540

00:19:19,669 --> 00:19:16,640

this list

541

00:19:20,470 --> 00:19:19,679

eric weinstein and um you know maybe

542

00:19:23,990 --> 00:19:20,480

maybe

543

00:19:25,430 --> 00:19:24,000

from um things like that and the word

544

00:19:26,950 --> 00:19:25,440

from actually

545

00:19:28,710 --> 00:19:26,960

what my understanding is he doesn't say

546

00:19:29,510 --> 00:19:28,720

anything about the unification of of the

547

00:19:31,430 --> 00:19:29,520

interaction

548

00:19:32,710 --> 00:19:31,440

um on the other hand he claims he has to

549

00:19:33,669 --> 00:19:32,720

say something about the foundations of

550

00:19:36,549 --> 00:19:33,679

quantum mechanics

551
00:19:37,990 --> 00:19:36,559
so you know you get into the details uh

552
00:19:41,909 --> 00:19:38,000
very very quickly

553
00:19:43,990 --> 00:19:41,919
um there's also um asymptotically safe

554
00:19:45,430 --> 00:19:44,000
gravity which a lot of people

555
00:19:48,950 --> 00:19:45,440
seem to be missing and i would say

556
00:19:51,990 --> 00:19:48,960
that's a proper theory of everything

557
00:19:55,270 --> 00:19:52,000
because you can very well combined that

558
00:19:58,150 --> 00:19:55,280
with uh grand unification and people

559
00:19:59,590 --> 00:19:58,160
have studied that kind of thing and it

560
00:20:01,990 --> 00:19:59,600
basically removes

561
00:20:04,070 --> 00:20:02,000
the discrepancy between the standard

562
00:20:07,190 --> 00:20:04,080
model and the classical theory

563
00:20:09,350 --> 00:20:07,200

of gravity so um you know

564

00:20:10,630 --> 00:20:09,360

i i don't have very strong opinions

565

00:20:12,230 --> 00:20:10,640

about which one of those

566

00:20:13,990 --> 00:20:12,240

is the best as i said i'm i'm a

567

00:20:14,789 --> 00:20:14,000

phenomenologist you know for for me

568

00:20:16,870 --> 00:20:14,799

that's just

569

00:20:19,590 --> 00:20:16,880

uh there are different approaches and

570

00:20:21,750 --> 00:20:19,600

the question is how can you test them

571

00:20:23,590 --> 00:20:21,760

so so that that's the question that i'm

572

00:20:26,310 --> 00:20:23,600

most interested in

573

00:20:28,070 --> 00:20:26,320

i see i see do you mind outlining for

574

00:20:29,990 --> 00:20:28,080

our audience your views on strong

575

00:20:33,110 --> 00:20:30,000

emergence you had a great paper

576

00:20:36,630 --> 00:20:33,120

and from my understanding of it it was

577

00:20:39,990 --> 00:20:36,640

first defining what strong emergence is

578

00:20:43,190 --> 00:20:40,000

and then refuting it but then

579

00:20:44,310 --> 00:20:43,200

at the end you save it and i i could be

580

00:20:50,149 --> 00:20:44,320

incorrect

581

00:20:53,750 --> 00:20:52,549

so i i think that the the definition of

582

00:20:56,149 --> 00:20:53,760

strong emergence that

583

00:20:58,310 --> 00:20:56,159

uh i'm using there so so there's strong

584

00:21:02,230 --> 00:20:58,320

weak emergence and i'm just using the

585

00:21:06,789 --> 00:21:02,240

the common definition um so if um

586

00:21:10,070 --> 00:21:06,799

you have a system um which is made of

587

00:21:12,789 --> 00:21:10,080

small entities so it's uh composed of

588

00:21:13,270 --> 00:21:12,799

some smaller stuff roughly speaking um

589

00:21:15,750 --> 00:21:13,280

then

590

00:21:18,470 --> 00:21:15,760

you can observe some behavior on

591

00:21:21,830 --> 00:21:18,480

macroscopic scales

592

00:21:23,750 --> 00:21:21,840

which you would say is emergent from

593

00:21:25,110 --> 00:21:23,760

the behavior of the underlying

594

00:21:29,110 --> 00:21:25,120

macroscopic

595

00:21:31,830 --> 00:21:29,120

things and this

596

00:21:33,830 --> 00:21:31,840

is a weak emergence if you can actually

597

00:21:36,470 --> 00:21:33,840

derive

598

00:21:38,549 --> 00:21:36,480

from the interactions and the properties

599

00:21:39,270 --> 00:21:38,559

of these microscopic constituents what

600

00:21:42,310 --> 00:21:39,280

is happening

601
00:21:45,110 --> 00:21:42,320
happening on the macroscopic level so

602
00:21:46,149 --> 00:21:45,120
you know a typical example would be that

603
00:21:49,110 --> 00:21:46,159
you can derive

604
00:21:49,669 --> 00:21:49,120
say the properties of molecules uh if

605
00:21:52,390 --> 00:21:49,679
you know

606
00:21:52,870 --> 00:21:52,400
if you have a theory of atoms because

607
00:21:56,630 --> 00:21:52,880
the

608
00:21:58,710 --> 00:21:56,640
follow from

609
00:22:00,310 --> 00:21:58,720
what the atoms do and you know the

610
00:22:01,190 --> 00:22:00,320
electro orbitals and all that kind of

611
00:22:03,270 --> 00:22:01,200
stuff

612
00:22:04,470 --> 00:22:03,280
and what you're describing is so far it

613
00:22:07,350 --> 00:22:04,480

sounds synonymous with

614

00:22:09,350 --> 00:22:07,360

reductionism um well it's kind of well

615

00:22:11,830 --> 00:22:09,360

reductionism goes the other way around

616

00:22:13,110 --> 00:22:11,840

right so so weak emergence is kind of so

617

00:22:15,750 --> 00:22:13,120

reductionism you dig

618

00:22:19,350 --> 00:22:15,760

into the smaller scales weak emergence

619

00:22:22,630 --> 00:22:19,360

you derive the microscopic scales

620

00:22:25,590 --> 00:22:22,640

and and so weak emergence is compatible

621

00:22:25,990 --> 00:22:25,600

with this reductionist picture and a

622

00:22:30,149 --> 00:22:26,000

strong

623

00:22:33,669 --> 00:22:30,159

emergence says that no you can have

624

00:22:34,870 --> 00:22:33,679

entirely new phenomena on larger scales

625

00:22:37,750 --> 00:22:34,880

that you cannot

626

00:22:39,110 --> 00:22:37,760

derive from the properties of the

627

00:22:40,950 --> 00:22:39,120

constituents of the system

628

00:22:42,630 --> 00:22:40,960

so there's something really new coming

629

00:22:45,909 --> 00:22:42,640

into into play there

630

00:22:48,549 --> 00:22:45,919

and this um reductionism um hierarchy

631

00:22:51,830 --> 00:22:48,559

basically breaks down somewhere

632

00:22:55,029 --> 00:22:51,840

and now um as a particle physicist

633

00:22:55,830 --> 00:22:55,039

who um has dealt with reductionism all

634

00:22:57,830 --> 00:22:55,840

the time

635

00:22:59,190 --> 00:22:57,840

of course it's a question that i'm very

636

00:23:01,510 --> 00:22:59,200

interested in like

637

00:23:02,630 --> 00:23:01,520

can you actually make strong emergence

638

00:23:05,830 --> 00:23:02,640

work

639

00:23:07,990 --> 00:23:05,840

because um if you know

640

00:23:09,430 --> 00:23:08,000

that stuff is made of particles and we

641

00:23:11,909 --> 00:23:09,440

have the laws

642

00:23:14,710 --> 00:23:11,919

for these particles then in principle

643

00:23:16,630 --> 00:23:14,720

everything derives from that

644

00:23:19,029 --> 00:23:16,640

so that brings up the question like is

645

00:23:22,070 --> 00:23:19,039

there some place where this derivation

646

00:23:24,070 --> 00:23:22,080

can go wrong um

647

00:23:25,909 --> 00:23:24,080

that's actually that's really really

648

00:23:28,710 --> 00:23:25,919

hard to make sense of

649

00:23:29,430 --> 00:23:28,720

theoretically and people have tried for

650

00:23:31,430 --> 00:23:29,440

some time

651
00:23:32,470 --> 00:23:31,440
um there there is a very interesting

652
00:23:35,510 --> 00:23:32,480
paper by

653
00:23:37,430 --> 00:23:35,520
um michael newton and

654
00:23:38,870 --> 00:23:37,440
someone else i've forgotten the name of

655
00:23:42,390 --> 00:23:38,880
the co-author

656
00:23:45,350 --> 00:23:42,400
which is called um more really is

657
00:23:46,470 --> 00:23:45,360
different you know that's an echo of

658
00:23:49,669 --> 00:23:46,480
anderson's paper

659
00:23:50,230 --> 00:23:49,679
uh more is different and so they try to

660
00:23:53,669 --> 00:23:50,240
show

661
00:23:55,830 --> 00:23:53,679
um that there are certain systems um

662
00:23:56,710 --> 00:23:55,840
so so they use a very simplified system

663
00:23:59,510 --> 00:23:56,720

with with uh

664

00:24:00,549 --> 00:23:59,520

it's kind of like a um a board with

665

00:24:03,590 --> 00:24:00,559

spins

666

00:24:04,390 --> 00:24:03,600

um where you can define certain

667

00:24:06,390 --> 00:24:04,400

quantities

668

00:24:08,310 --> 00:24:06,400

in the example that they use is the

669

00:24:11,350 --> 00:24:08,320

overall magnetization

670

00:24:12,390 --> 00:24:11,360

um but you cannot derive them from the

671

00:24:14,470 --> 00:24:12,400

properties

672

00:24:15,909 --> 00:24:14,480

of the underlying system so this this

673

00:24:18,230 --> 00:24:15,919

would be an example where you could

674

00:24:21,350 --> 00:24:18,240

really speak of strong emergence

675

00:24:23,350 --> 00:24:21,360

but you know the fine print on this

676

00:24:26,149 --> 00:24:23,360

example which they use is

677

00:24:26,789 --> 00:24:26,159

that it only becomes impossible to

678

00:24:29,269 --> 00:24:26,799

actually

679

00:24:31,190 --> 00:24:29,279

calculate this if you have a system that

680

00:24:34,149 --> 00:24:31,200

is really infinitely large

681

00:24:35,669 --> 00:24:34,159

so it's this infinity um that brings up

682

00:24:37,430 --> 00:24:35,679

this impossibility

683

00:24:38,950 --> 00:24:37,440

and of course nothing in nature is

684

00:24:40,710 --> 00:24:38,960

really ever infinite

685

00:24:41,990 --> 00:24:40,720

um so it's not a particularly good

686

00:24:43,990 --> 00:24:42,000

example and there are some other

687

00:24:46,950 --> 00:24:44,000

examples that that people have played

688

00:24:47,990 --> 00:24:46,960

with and so um with my background in

689

00:24:50,070 --> 00:24:48,000

particle physics

690

00:24:51,990 --> 00:24:50,080

i was trying to look more directly at

691

00:24:53,110 --> 00:24:52,000

the theories that we're actually using

692

00:24:54,950 --> 00:24:53,120

and particle physics

693

00:24:56,149 --> 00:24:54,960

so in the standard model just to be

694

00:24:59,190 --> 00:24:56,159

concrete

695

00:25:01,269 --> 00:24:59,200

that's a quantum field theory and in

696

00:25:05,190 --> 00:25:01,279

quantum field theory we have

697

00:25:08,470 --> 00:25:05,200

um a well-defined process of deriving

698

00:25:11,990 --> 00:25:08,480

a theory on larger scales

699

00:25:13,909 --> 00:25:12,000

from the theory on shorter scales

700

00:25:15,750 --> 00:25:13,919

that's called effective field theory and

701

00:25:18,310 --> 00:25:15,760

it's just a mathematical thing

702

00:25:20,149 --> 00:25:18,320

um it's fairly new in a sense that i

703

00:25:20,710 --> 00:25:20,159

mean it's been around for half a century

704

00:25:23,590 --> 00:25:20,720

but it

705

00:25:24,230 --> 00:25:23,600

it has really only entered uh i would

706

00:25:25,990 --> 00:25:24,240

say you know

707

00:25:28,149 --> 00:25:26,000

the consciousness of the community in

708

00:25:28,870 --> 00:25:28,159

the in the past 20 years uh or something

709

00:25:30,950 --> 00:25:28,880

like this

710

00:25:32,390 --> 00:25:30,960

it's just technically there have been

711

00:25:34,470 --> 00:25:32,400

some things that were not very well

712

00:25:36,149 --> 00:25:34,480

understood in the early days but

713

00:25:38,149 --> 00:25:36,159

uh today is kind of something that

714

00:25:39,590 --> 00:25:38,159

everyone uh pretty much uses so you have

715

00:25:43,029 --> 00:25:39,600

these equations that you can

716

00:25:45,510 --> 00:25:43,039

just use to derive

717

00:25:49,110 --> 00:25:45,520

in principle what happens on the

718

00:25:51,830 --> 00:25:49,120

macroscopic scales from the underlying

719

00:25:53,750 --> 00:25:51,840

physics now in many cases of course you

720

00:25:56,070 --> 00:25:53,760

can't actually solve the equations

721

00:25:57,029 --> 00:25:56,080

but they are but they are there so if

722

00:25:59,029 --> 00:25:57,039

you think that

723

00:26:00,950 --> 00:25:59,039

strong emergence is a real thing these

724

00:26:02,710 --> 00:26:00,960

equations have to break down

725

00:26:03,990 --> 00:26:02,720

at some point you know something has to

726

00:26:06,710 --> 00:26:04,000

go wrong and

727

00:26:08,870 --> 00:26:06,720

um the only way that um you can actually

728

00:26:12,230 --> 00:26:08,880

have really new laws

729

00:26:13,830 --> 00:26:12,240

on um large scales

730

00:26:16,390 --> 00:26:13,840

is if something goes wrong in this

731

00:26:17,990 --> 00:26:16,400

derivation and so in in this paper

732

00:26:19,990 --> 00:26:18,000

i was making this argument you know

733

00:26:22,710 --> 00:26:20,000

first i was explaining um

734

00:26:24,230 --> 00:26:22,720

why we don't actually have something

735

00:26:26,870 --> 00:26:24,240

like strong emergence

736

00:26:27,669 --> 00:26:26,880

why all these examples that people have

737

00:26:29,750 --> 00:26:27,679

come up with

738

00:26:30,870 --> 00:26:29,760

are not realistic because they all draw

739

00:26:32,630 --> 00:26:30,880

on um

740

00:26:33,909 --> 00:26:32,640

something being infinitely large in one

741

00:26:37,110 --> 00:26:33,919

way or the other

742

00:26:38,950 --> 00:26:37,120

and then to say but look if you if you

743

00:26:41,029 --> 00:26:38,960

look at effective field theory there is

744

00:26:41,750 --> 00:26:41,039

a way in which this duration can go

745

00:26:44,549 --> 00:26:41,760

wrong

746

00:26:46,710 --> 00:26:44,559

and loosely speaking it's because there

747

00:26:49,269 --> 00:26:46,720

are certain functions

748

00:26:51,269 --> 00:26:49,279

that connect the theory on short

749

00:26:54,549 --> 00:26:51,279

distances with the theory on

750

00:26:57,190 --> 00:26:54,559

long distances that can run into

751
00:26:58,070 --> 00:26:57,200
a singular point and let me be clear

752
00:26:59,909 --> 00:26:58,080
that

753
00:27:01,590 --> 00:26:59,919
just because the point is singular does

754
00:27:02,230 --> 00:27:01,600
not mean that it's actually infinitely

755
00:27:05,110 --> 00:27:02,240
large

756
00:27:05,990 --> 00:27:05,120
but it it can be a point where the

757
00:27:07,909 --> 00:27:06,000
function is actually

758
00:27:10,549 --> 00:27:07,919
zero and all the derivatives are also

759
00:27:10,950 --> 00:27:10,559
zero the thing is that if you're trying

760
00:27:14,470 --> 00:27:10,960
to

761
00:27:16,390 --> 00:27:14,480
continue

762
00:27:18,630 --> 00:27:16,400
from the short distances to the long

763
00:27:20,950 --> 00:27:18,640

distances you can't

764

00:27:22,710 --> 00:27:20,960

so and this is exactly what you would

765

00:27:23,430 --> 00:27:22,720

need for strong emergence to be a real

766

00:27:25,510 --> 00:27:23,440

thing

767

00:27:26,549 --> 00:27:25,520

uh because in that case you would not be

768

00:27:30,149 --> 00:27:26,559

able to derive

769

00:27:31,669 --> 00:27:30,159

anything past that point

770

00:27:33,190 --> 00:27:31,679

and i think that's a theoretical

771

00:27:35,269 --> 00:27:33,200

possibility and that's what i

772

00:27:37,590 --> 00:27:35,279

uh what i wrote this paper about which

773

00:27:40,070 --> 00:27:37,600

is called a case for strong immersions

774

00:27:40,710 --> 00:27:40,080

um this was one of the fpxi essay

775

00:27:42,549 --> 00:27:40,720

contests

776
00:27:45,029 --> 00:27:42,559
uh by the way if someone wants to look

777
00:27:48,070 --> 00:27:45,039
that up um

778
00:27:50,310 --> 00:27:48,080
but um i i don't know

779
00:27:51,430 --> 00:27:50,320
any physical system that would actually

780
00:27:53,269 --> 00:27:51,440
have this property

781
00:27:54,470 --> 00:27:53,279
so it's theoretically i think it's

782
00:27:57,110 --> 00:27:54,480
possible

783
00:27:58,230 --> 00:27:57,120
uh but i i i don't have any reason to

784
00:28:00,549 --> 00:27:58,240
think that it is actually

785
00:28:04,389 --> 00:28:00,559
realized in nature have you heard of lee

786
00:28:07,990 --> 00:28:06,789
uh probably is that the thing that kind

787
00:28:10,710 --> 00:28:08,000
of sounds like

788
00:28:14,230 --> 00:28:10,720

leibniz principle of what's it called

789

00:28:19,269 --> 00:28:17,430

i believe it's that

790

00:28:21,669 --> 00:28:19,279

somewhere in the universe let's say

791

00:28:23,190 --> 00:28:21,679

electrons have conglomerated to form

792

00:28:25,190 --> 00:28:23,200

some property by chance

793

00:28:28,389 --> 00:28:25,200

well then other in other parts of the

794

00:28:30,230 --> 00:28:28,399

universe the electrons know about this

795

00:28:31,990 --> 00:28:30,240

rupert sheldrick if you were to be more

796

00:28:32,870 --> 00:28:32,000

mystical he would call this morphic

797

00:28:35,029 --> 00:28:32,880

resonate

798

00:28:37,830 --> 00:28:35,039

morphic resonance i'm actually speaking

799

00:28:40,789 --> 00:28:37,840

with him in a few hours i'm gonna

800

00:28:42,870 --> 00:28:40,799

probe him on this but if this is true

801
00:28:44,710 --> 00:28:42,880
this to me sounds like a case for strong

802
00:28:47,909 --> 00:28:44,720
emergence as well

803
00:28:50,149 --> 00:28:47,919
am i incorrect so

804
00:28:51,990 --> 00:28:50,159
first i confuse these principles you

805
00:28:54,070 --> 00:28:52,000
know lee likes to introduce

806
00:28:55,029 --> 00:28:54,080
definitions and principles and they're

807
00:28:57,909 --> 00:28:55,039
they're easy to

808
00:28:59,590 --> 00:28:57,919
mix up and i think you're talking about

809
00:29:00,789 --> 00:28:59,600
what he calls like the ensemble

810
00:29:02,389 --> 00:29:00,799
interpretation

811
00:29:04,549 --> 00:29:02,399
okay i could be wrong with my

812
00:29:06,710 --> 00:29:04,559
terminology um

813
00:29:10,830 --> 00:29:06,720

so he wrote a book about this recently

814

00:29:13,510 --> 00:29:12,470

um i never thought about whether this

815

00:29:16,549 --> 00:29:13,520

would be

816

00:29:19,909 --> 00:29:16,559

emergence

817

00:29:21,990 --> 00:29:19,919

um so i i sorry i just okay that's fine

818

00:29:24,830 --> 00:29:22,000

that's fine what does this what does

819

00:29:26,149 --> 00:29:24,840

strong emergence have to say about free

820

00:29:30,870 --> 00:29:26,159

will

821

00:29:34,789 --> 00:29:30,880

well um so as long as you only have

822

00:29:38,070 --> 00:29:34,799

weak emergence um free will

823

00:29:38,789 --> 00:29:38,080

does not exist uh for the simple reason

824

00:29:45,269 --> 00:29:38,799

that

825

00:29:46,549 --> 00:29:45,279

in particular physics they are all

826

00:29:48,470 --> 00:29:46,559

deterministic

827

00:29:50,630 --> 00:29:48,480

you know you you give me an initial

828

00:29:52,389 --> 00:29:50,640

state of the universe at some time i

829

00:29:54,470 --> 00:29:52,399

apply my equations to it

830

00:29:56,710 --> 00:29:54,480

and i can calculate the state of the

831

00:29:58,950 --> 00:29:56,720

universe at any later time

832

00:30:00,549 --> 00:29:58,960

it's it's kind of the same thing with as

833

00:30:02,630 --> 00:30:00,559

with laplace's demon

834

00:30:03,750 --> 00:30:02,640

the one difference is that we know of

835

00:30:06,149 --> 00:30:03,760

quantum mechanics

836

00:30:07,430 --> 00:30:06,159

so in addition to this deterministic

837

00:30:08,950 --> 00:30:07,440

time evolution

838

00:30:10,710 --> 00:30:08,960

there's an element of randomness

839

00:30:12,630 --> 00:30:10,720

sprinkled over this which comes from the

840

00:30:14,710 --> 00:30:12,640

measurement in quantum mechanics

841

00:30:16,870 --> 00:30:14,720

so you have a combination of this

842

00:30:18,230 --> 00:30:16,880

deterministic time evolution and then

843

00:30:18,710 --> 00:30:18,240

every once in a while there's something

844

00:30:21,990 --> 00:30:18,720

which

845

00:30:25,830 --> 00:30:22,000

is unpredictable and neither

846

00:30:29,590 --> 00:30:25,840

of which uh is anything like what we

847

00:30:31,750 --> 00:30:29,600

normally kind of intuitively uh refer to

848

00:30:32,710 --> 00:30:31,760

as free will and now i know of course

849

00:30:35,510 --> 00:30:32,720

that there are a lot of

850

00:30:35,990 --> 00:30:35,520

philosophers who have you know bend over

851

00:30:38,710 --> 00:30:36,000

backwards

852

00:30:40,950 --> 00:30:38,720

to try and find a definition for free

853

00:30:42,630 --> 00:30:40,960

will that would be compatible with that

854

00:30:45,110 --> 00:30:42,640

um you know this is this whole idea of

855

00:30:46,789 --> 00:30:45,120

compatibilism and i don't really like to

856

00:30:49,669 --> 00:30:46,799

argue about

857

00:30:51,350 --> 00:30:49,679

you know the use of words but i you know

858

00:30:52,710 --> 00:30:51,360

i would think that this notion of free

859

00:30:54,389 --> 00:30:52,720

will that the philosophers are

860

00:30:55,110 --> 00:30:54,399

discussing it's not a notion of free

861

00:30:57,990 --> 00:30:55,120

will that

862

00:30:58,470 --> 00:30:58,000

uh you know someone on the street uh

863

00:31:00,149 --> 00:30:58,480

would

864

00:31:01,990 --> 00:31:00,159

remotely understand you know you're

865

00:31:03,350 --> 00:31:02,000

referring to the philosophers who say

866

00:31:04,470 --> 00:31:03,360

that free will can be saved under

867

00:31:05,830 --> 00:31:04,480

compatibilism

868

00:31:07,509 --> 00:31:05,840

but their definition of free will

869

00:31:08,870 --> 00:31:07,519

doesn't comport with people's intuitive

870

00:31:11,029 --> 00:31:08,880

definition of free will

871

00:31:12,710 --> 00:31:11,039

and the intuitive definition of free

872

00:31:15,430 --> 00:31:12,720

will is called libertarianism

873

00:31:16,070 --> 00:31:15,440

libertarian free will but it doesn't

874

00:31:18,630 --> 00:31:16,080

matter

875

00:31:19,350 --> 00:31:18,640

so yeah i'm not i i don't know so in

876

00:31:22,549 --> 00:31:19,360

your opinion

877

00:31:24,470 --> 00:31:22,559

do you believe that so i i think like

878

00:31:26,389 --> 00:31:24,480

intuitively the idea that people have

879

00:31:28,630 --> 00:31:26,399

is that there are like they're different

880

00:31:29,590 --> 00:31:28,640

futures and you're using this thing you

881

00:31:31,350 --> 00:31:29,600

call free will

882

00:31:33,029 --> 00:31:31,360

which is basically you and you pick one

883

00:31:36,549 --> 00:31:33,039

of these futures

884

00:31:38,630 --> 00:31:36,559

and you know what i just said about

885

00:31:40,470 --> 00:31:38,640

the underlying fundamental laws is that

886

00:31:41,590 --> 00:31:40,480

it's a combination of determinism and

887

00:31:43,110 --> 00:31:41,600

randomness

888

00:31:45,350 --> 00:31:43,120

it doesn't leave place for anything like

889

00:31:52,470 --> 00:31:45,360

that

890

00:31:54,630 --> 00:31:52,480

um have this breakdown of the connection

891

00:31:58,470 --> 00:31:54,640

between the underlying law

892

00:31:59,350 --> 00:31:58,480

and um the the law on larger states like

893

00:32:01,350 --> 00:31:59,360

human beings

894

00:32:02,789 --> 00:32:01,360

you and i stuff like that or maybe

895

00:32:06,070 --> 00:32:02,799

already at the level of

896

00:32:07,750 --> 00:32:06,080

viruses of god knows what um then in

897

00:32:10,710 --> 00:32:07,760

principle you can have

898

00:32:11,830 --> 00:32:10,720

entirely different laws and of course

899

00:32:13,110 --> 00:32:11,840

that would bring up the question well

900

00:32:15,190 --> 00:32:13,120

what are these laws but

901
00:32:16,470 --> 00:32:15,200
well nobody knows but at least in

902
00:32:18,389 --> 00:32:16,480
principle um

903
00:32:20,630 --> 00:32:18,399
you know if you have strong emergence

904
00:32:24,549 --> 00:32:20,640
there's room for that

905
00:32:30,070 --> 00:32:24,559
do you believe in free will personally

906
00:32:33,830 --> 00:32:30,080
no do you believe in god

907
00:32:36,789 --> 00:32:33,840
no okay

908
00:32:38,389 --> 00:32:36,799
let's move on then why why not agnostic

909
00:32:39,830 --> 00:32:38,399
so that sounds like atheism yeah

910
00:32:42,070 --> 00:32:39,840
i was about to say that it kind of

911
00:32:44,389 --> 00:32:42,080
depends on whether you're asking me

912
00:32:45,590 --> 00:32:44,399
in my profession as a scientist i would

913
00:32:47,190 --> 00:32:45,600

say i'm agnostic

914

00:32:48,950 --> 00:32:47,200

i don't care one way or the other if you

915

00:32:50,070 --> 00:32:48,960

ask me personally you know the way that

916

00:32:52,149 --> 00:32:50,080

i arrange my life

917

00:32:53,990 --> 00:32:52,159

the way that i think about things i just

918

00:32:55,909 --> 00:32:54,000

don't believe it

919

00:32:57,830 --> 00:32:55,919

there's one way of getting around

920

00:32:58,710 --> 00:32:57,840

belle's inequality and it's called super

921

00:33:01,669 --> 00:32:58,720

determinism

922

00:33:03,190 --> 00:33:01,679

and i'm i'm curious if you heard of it

923

00:33:04,870 --> 00:33:03,200

and if you don't mind

924

00:33:06,230 --> 00:33:04,880

explaining it to our audience and then

925

00:33:09,350 --> 00:33:06,240

giving what your thoughts are

926

00:33:11,909 --> 00:33:09,360

on it yes i've heard of it

927

00:33:13,750 --> 00:33:11,919

um as i said in the very beginning i'm

928

00:33:15,750 --> 00:33:13,760

partly working in the foundations

929

00:33:18,070 --> 00:33:15,760

of quantum mechanics and and that's what

930

00:33:22,789 --> 00:33:18,080

i'm working on

931

00:33:27,590 --> 00:33:22,799

um so as you correctly say

932

00:33:30,230 --> 00:33:27,600

super determinism is one of the ways to

933

00:33:30,870 --> 00:33:30,240

get around the conclusions of bell's

934

00:33:33,909 --> 00:33:30,880

theorem

935

00:33:37,029 --> 00:33:33,919

which could be summarized as

936

00:33:40,310 --> 00:33:37,039

if you have um a

937

00:33:42,310 --> 00:33:40,320

local and deterministic theory like

938

00:33:43,830 --> 00:33:42,320

roughly speaking you know very roughly

939

00:33:45,269 --> 00:33:43,840

like the way that we are used to from

940

00:33:47,190 --> 00:33:45,279

newtonian mechanics

941

00:33:48,389 --> 00:33:47,200

you know um there's no randomness in

942

00:33:50,230 --> 00:33:48,399

that it's all

943

00:33:51,590 --> 00:33:50,240

deterministic there's no spooky action

944

00:33:54,630 --> 00:33:51,600

at the

945

00:33:58,630 --> 00:33:54,640

that kind of stuff in which

946

00:34:02,070 --> 00:33:58,640

the outcomes of quantum mechanics are

947

00:34:03,350 --> 00:34:02,080

actually determined but you cannot

948

00:34:06,549 --> 00:34:03,360

predict them just

949

00:34:09,829 --> 00:34:06,559

information

950

00:34:11,829 --> 00:34:09,839

um so in this case the

951
00:34:13,669 --> 00:34:11,839
quantum mechanics would be probabilistic

952
00:34:15,990 --> 00:34:13,679
for the exact same reason

953
00:34:17,669 --> 00:34:16,000
that you normally have probabilistic

954
00:34:19,190 --> 00:34:17,679
predictions if you're throwing dice or

955
00:34:21,829 --> 00:34:19,200
something this you just don't you're

956
00:34:23,430 --> 00:34:21,839
you're missing information and so

957
00:34:26,550 --> 00:34:23,440
belle's theorem tells you

958
00:34:28,470 --> 00:34:26,560
um you can't do that

959
00:34:30,310 --> 00:34:28,480
because any theory that has these

960
00:34:33,270 --> 00:34:30,320
properties

961
00:34:34,950 --> 00:34:33,280
will be in conflict with certain

962
00:34:36,950 --> 00:34:34,960
experiments that have been done

963
00:34:37,990 --> 00:34:36,960

so that's the thing that's called bells

964

00:34:39,829 --> 00:34:38,000

inequality

965

00:34:41,349 --> 00:34:39,839

and all theories of the type that i was

966

00:34:45,750 --> 00:34:41,359

just talking about

967

00:34:47,669 --> 00:34:45,760

um tell you have to obey this inequality

968

00:34:49,270 --> 00:34:47,679

but experimentally you know that it can

969

00:34:51,990 --> 00:34:49,280

be violated

970

00:34:52,629 --> 00:34:52,000

so this this just rules out um this type

971

00:34:55,669 --> 00:34:52,639

of

972

00:34:59,829 --> 00:34:55,679

to mean

973

00:35:02,870 --> 00:34:59,839

that um you know quantum mechanics is

974

00:35:06,150 --> 00:35:02,880

a non-local and it's a non-realist

975

00:35:06,870 --> 00:35:06,160

theory and so on now um there is one

976

00:35:09,589 --> 00:35:06,880

assumption of

977

00:35:12,870 --> 00:35:09,599

inbound theorem which is called

978

00:35:15,109 --> 00:35:12,880

statistical independence

979

00:35:16,950 --> 00:35:15,119

and this is really really essential to

980

00:35:19,990 --> 00:35:16,960

arrive at this conclusion

981

00:35:22,230 --> 00:35:20,000

so if you throw out this assumption of

982

00:35:23,510 --> 00:35:22,240

statistical independence you can very

983

00:35:26,310 --> 00:35:23,520

well have a theory

984

00:35:26,790 --> 00:35:26,320

that is deterministic and local and

985

00:35:30,630 --> 00:35:26,800

still

986

00:35:31,829 --> 00:35:30,640

violates um belt's inequalities and is

987

00:35:34,550 --> 00:35:31,839

therefore compatible

988

00:35:35,670 --> 00:35:34,560

with all observations and personally i

989

00:35:38,950 --> 00:35:35,680

think that this is

990

00:35:40,230 --> 00:35:38,960

much more reasonable to than to buy into

991

00:35:43,829 --> 00:35:40,240

all this

992

00:35:45,750 --> 00:35:43,839

you know philosophically uh

993

00:35:48,230 --> 00:35:45,760

stuff about having a non-realist

994

00:35:50,710 --> 00:35:48,240

interpretation that is somehow

995

00:35:53,190 --> 00:35:50,720

you know always drawing on microscopic

996

00:35:55,270 --> 00:35:53,200

concepts like detector measurements or

997

00:35:56,470 --> 00:35:55,280

agents and the knowledge and that kind

998

00:35:58,230 --> 00:35:56,480

of stuff and yet

999

00:36:00,790 --> 00:35:58,240

still somehow compatible with

1000

00:36:03,589 --> 00:36:00,800

reductionism

1001

00:36:05,030 --> 00:36:03,599

the only thing that this requires is

1002

00:36:08,470 --> 00:36:05,040

that you give up on this

1003

00:36:10,310 --> 00:36:08,480

rather mathematical assumption of

1004

00:36:13,270 --> 00:36:10,320

statistical independence

1005

00:36:13,990 --> 00:36:13,280

now you may ask but what does it mean to

1006

00:36:16,390 --> 00:36:14,000

give up on

1007

00:36:18,069 --> 00:36:16,400

statistical independence so just

1008

00:36:21,670 --> 00:36:18,079

technically it means

1009

00:36:25,190 --> 00:36:21,680

that the outcome of the measurement

1010

00:36:28,150 --> 00:36:25,200

depends on the setting of the detector

1011

00:36:30,150 --> 00:36:28,160

and if you want to interpret this more

1012

00:36:31,109 --> 00:36:30,160

broadly it basically means that there

1013

00:36:35,750 --> 00:36:31,119

are

1014

00:36:37,430 --> 00:36:35,760

entirely

1015

00:36:39,109 --> 00:36:37,440

disconnected from each other so

1016

00:36:41,829 --> 00:36:39,119

basically everything

1017

00:36:43,270 --> 00:36:41,839

is connected with everything else in in

1018

00:36:46,230 --> 00:36:43,280

very very subtle ways

1019

00:36:46,710 --> 00:36:46,240

so that you don't normally notice it

1020

00:36:50,150 --> 00:36:46,720

like

1021

00:36:51,829 --> 00:36:50,160

uh in in you know everyday life

1022

00:36:53,349 --> 00:36:51,839

we don't notice quantum effects and so

1023

00:36:56,069 --> 00:36:53,359

we also don't notice

1024

00:36:57,430 --> 00:36:56,079

these subtle correlations but if you do

1025

00:37:00,710 --> 00:36:57,440

a bell-type

1026

00:37:04,550 --> 00:37:00,720

test or some other quantum experiment uh

1027

00:37:06,390 --> 00:37:04,560

then um you become sensitive to that

1028

00:37:08,550 --> 00:37:06,400

how's this congruent with special

1029

00:37:10,069 --> 00:37:08,560

relativity that is that you can't break

1030

00:37:13,270 --> 00:37:10,079

the speed of light how is it that

1031

00:37:17,270 --> 00:37:13,280

we can be connected to what is

1032

00:37:18,630 --> 00:37:17,280

outside the the cone

1033

00:37:21,030 --> 00:37:18,640

well you you can have in special

1034

00:37:24,630 --> 00:37:21,040

relativity you can very well have

1035

00:37:27,589 --> 00:37:24,640

um correlations between um

1036

00:37:29,349 --> 00:37:27,599

you know distant points um they they

1037

00:37:30,310 --> 00:37:29,359

will be within some light cone of

1038

00:37:32,870 --> 00:37:30,320

something

1039

00:37:33,430 --> 00:37:32,880

um it just you know just because they're

1040

00:37:36,710 --> 00:37:33,440

in

1041

00:37:38,950 --> 00:37:36,720

were

1042

00:37:40,230 --> 00:37:38,960

created at a distance you know they can

1043

00:37:43,430 --> 00:37:40,240

have been

1044

00:37:43,990 --> 00:37:43,440

created locally right right do you have

1045

00:37:47,109 --> 00:37:44,000

any

1046

00:37:48,870 --> 00:37:47,119

thoughts on the emergence of possible

1047

00:37:53,349 --> 00:37:48,880

emergence of consciousness or whether or

1048

00:37:57,510 --> 00:37:56,069

well um i don't think there's that

1049

00:38:01,270 --> 00:37:57,520

consciousness is all that

1050

00:38:02,790 --> 00:38:01,280

mysterious um so you know i'm a particle

1051
00:38:04,870 --> 00:38:02,800
for this is i'm a reductionist of course

1052
00:38:05,990 --> 00:38:04,880
i think that consciousness is weakly

1053
00:38:10,390 --> 00:38:06,000
emergent

1054
00:38:13,990 --> 00:38:10,400
as i guess most people in my discipline

1055
00:38:17,349 --> 00:38:14,000
you know it's it's it comes from

1056
00:38:20,390 --> 00:38:17,359
the way that complex systems

1057
00:38:22,150 --> 00:38:20,400
process information i would say and at

1058
00:38:24,470 --> 00:38:22,160
some level

1059
00:38:26,230 --> 00:38:24,480
it becomes beneficial for the system in

1060
00:38:29,030 --> 00:38:26,240
terms of natural selection to have a

1061
00:38:30,870 --> 00:38:29,040
self-monitoring process

1062
00:38:32,550 --> 00:38:30,880
so that's a peculiar thing about

1063
00:38:33,589 --> 00:38:32,560

consciousness is that most of the time

1064

00:38:35,270 --> 00:38:33,599

we're actually

1065

00:38:36,790 --> 00:38:35,280

not really aware of a lot of stuff

1066

00:38:38,390 --> 00:38:36,800

that's going on

1067

00:38:40,150 --> 00:38:38,400

so that that's all the stuff that we put

1068

00:38:42,790 --> 00:38:40,160

into the subconsciousness

1069

00:38:43,990 --> 00:38:42,800

um which basically frees up i guess some

1070

00:38:47,270 --> 00:38:44,000

processing power

1071

00:38:50,230 --> 00:38:47,280

uh on the higher levels and

1072

00:38:51,589 --> 00:38:50,240

um i i don't think that consciousness is

1073

00:38:54,950 --> 00:38:51,599

specific to

1074

00:38:57,270 --> 00:38:54,960

um you know biological forms of life

1075

00:38:59,589 --> 00:38:57,280

um but that sooner or later there will

1076

00:39:01,670 --> 00:38:59,599

be some computers that will reach some

1077

00:39:03,990 --> 00:39:01,680

levels of consciousness

1078

00:39:04,790 --> 00:39:04,000

so that is the sun even has a level of

1079

00:39:07,829 --> 00:39:04,800

consciousness

1080

00:39:11,109 --> 00:39:07,839

and the planets do

1081

00:39:13,589 --> 00:39:11,119

well you know there's there's

1082

00:39:14,230 --> 00:39:13,599

some it depends on exactly how you

1083

00:39:20,790 --> 00:39:14,240

define

1084

00:39:21,589 --> 00:39:20,800

consciousness um by information

1085

00:39:24,630 --> 00:39:21,599

processing

1086

00:39:28,710 --> 00:39:24,640

uh capacity uh together with some

1087

00:39:31,829 --> 00:39:28,720

level of self-awareness um then

1088

00:39:35,190 --> 00:39:31,839

you may find that pretty much any system

1089

00:39:37,750 --> 00:39:35,200

has a very very small level of uh

1090

00:39:38,390 --> 00:39:37,760

consciousness at some point uh but it's

1091

00:39:42,069 --> 00:39:38,400

rather

1092

00:39:43,910 --> 00:39:42,079

meaningless you know it's i guess that

1093

00:39:45,510 --> 00:39:43,920

you would have to pretty arbitrarily at

1094

00:39:46,710 --> 00:39:45,520

some point just say okay we call it

1095

00:39:48,230 --> 00:39:46,720

consciousness

1096

00:39:49,990 --> 00:39:48,240

if it's larger then i don't know

1097

00:39:51,990 --> 00:39:50,000

something right

1098

00:39:53,430 --> 00:39:52,000

now how do we test that i i can see that

1099

00:39:55,670 --> 00:39:53,440

we can come up with a measurement for

1100

00:39:58,150 --> 00:39:55,680

consciousness but it's not as if we can

1101

00:40:01,589 --> 00:39:58,160

it sounds like we're simply defining

1102

00:40:07,270 --> 00:40:04,710

a certain level of self monitoring

1103

00:40:08,710 --> 00:40:07,280

information processing but it's not well

1104

00:40:10,790 --> 00:40:08,720

you know on this verbal level

1105

00:40:12,069 --> 00:40:10,800

of course you can't test it you actually

1106

00:40:14,550 --> 00:40:12,079

need to write down

1107

00:40:16,150 --> 00:40:14,560

a particular model that you know

1108

00:40:19,510 --> 00:40:16,160

quantifies

1109

00:40:21,109 --> 00:40:19,520

just what it takes um what's what

1110

00:40:22,150 --> 00:40:21,119

exactly needs to be happening in the

1111

00:40:24,870 --> 00:40:22,160

brain

1112

00:40:26,470 --> 00:40:24,880

um and and so on and so forth and uh

1113

00:40:30,150 --> 00:40:26,480

then i think you can very well go and

1114

00:40:33,910 --> 00:40:32,950

okay well what i'm saying is that if you

1115

00:40:37,430 --> 00:40:33,920

measure it

1116

00:40:39,190 --> 00:40:37,440

let's imagine there's someone who has

1117

00:40:40,950 --> 00:40:39,200

a low level of what we would predict to

1118

00:40:41,349 --> 00:40:40,960

be consciousness so let's just give it a

1119

00:40:42,870 --> 00:40:41,359

number

1120

00:40:44,390 --> 00:40:42,880

they have consciousness we would predict

1121

00:40:45,750 --> 00:40:44,400

that they have we can

1122

00:40:47,990 --> 00:40:45,760

we can figure out their brain state

1123

00:40:51,349 --> 00:40:48,000

almost exactly and we can

1124

00:40:52,309 --> 00:40:51,359

imagine that from our data from our

1125

00:40:55,109 --> 00:40:52,319

theory that they should have

1126

00:40:57,030 --> 00:40:55,119

consciousness at level 10. but they say

1127

00:40:58,150 --> 00:40:57,040

and somehow we have to get we have to

1128

00:40:59,510 --> 00:40:58,160

have a way of

1129

00:41:02,470 --> 00:40:59,520

saying this they're like no no i have

1130

00:41:04,390 --> 00:41:02,480

consciousness at level 20.

1131

00:41:05,670 --> 00:41:04,400

or someone who we predict at level 10

1132

00:41:07,349 --> 00:41:05,680

said no no i'm i'm actually

1133

00:41:13,750 --> 00:41:07,359

consciousness level 5.

1134

00:41:18,790 --> 00:41:17,109

it just sounds like a definition yes

1135

00:41:20,950 --> 00:41:18,800

there's probably something fishy about

1136

00:41:22,550 --> 00:41:20,960

your definition is what i would say

1137

00:41:25,109 --> 00:41:22,560

look of course you want you want a

1138

00:41:28,309 --> 00:41:25,119

definition that actually agrees

1139

00:41:31,109 --> 00:41:28,319

you know to quite some extent with um

1140

00:41:33,190 --> 00:41:31,119

what we normally mean by consciousness

1141

00:41:34,870 --> 00:41:33,200

right i mean we have we have an idea of

1142

00:41:37,829 --> 00:41:34,880

consciousness like

1143

00:41:39,670 --> 00:41:37,839

you're conscious i i am conscious uh you

1144

00:41:42,950 --> 00:41:39,680

know other people are conscious

1145

00:41:44,470 --> 00:41:42,960

um my computer is not conscious at least

1146

00:41:46,150 --> 00:41:44,480

not on a noticeable level

1147

00:41:48,550 --> 00:41:46,160

you know you could say that maybe the

1148

00:41:51,750 --> 00:41:48,560

the task manager or something is

1149

00:41:52,790 --> 00:41:51,760

some level of self-awareness but it's so

1150

00:41:55,750 --> 00:41:52,800

tiny that

1151
00:41:57,750 --> 00:41:55,760
um you know i i can't have a meaningful

1152
00:41:58,710 --> 00:41:57,760
conversation with my computer let me put

1153
00:42:02,309 --> 00:41:58,720
it like this

1154
00:42:05,190 --> 00:42:02,319
and so um if we managed to come up with

1155
00:42:05,990 --> 00:42:05,200
some definition of consciousness we will

1156
00:42:09,670 --> 00:42:06,000
wanted

1157
00:42:13,829 --> 00:42:09,680
to agree with our

1158
00:42:16,390 --> 00:42:13,839
our intuition basically for our audience

1159
00:42:18,309 --> 00:42:16,400
do you mind explaining i know that

1160
00:42:19,589 --> 00:42:18,319
wolfram's theory is not

1161
00:42:21,990 --> 00:42:19,599
it's not something you've studied

1162
00:42:24,790 --> 00:42:22,000
immensely but wolfram does say that the

1163
00:42:28,230 --> 00:42:24,800

universe is inherently computational

1164

00:42:30,230 --> 00:42:28,240

what does that mean well

1165

00:42:31,990 --> 00:42:30,240

i think you should ask a word from about

1166

00:42:35,750 --> 00:42:32,000

this not me okay

1167

00:42:36,230 --> 00:42:35,760

okay so your you would say that the mind

1168

00:42:37,670 --> 00:42:36,240

body

1169

00:42:38,870 --> 00:42:37,680

you know in philosophy there's something

1170

00:42:40,309 --> 00:42:38,880

called the mind body problem the mind

1171

00:42:44,550 --> 00:42:40,319

body problem itself it's just

1172

00:42:47,190 --> 00:42:44,560

body and then no i i don't know i didn't

1173

00:42:48,550 --> 00:42:47,200

i said it's solvable it's there seem to

1174

00:42:49,349 --> 00:42:48,560

be a lot of people who have this kind of

1175

00:42:51,349 --> 00:42:49,359

this

1176
00:42:53,030 --> 00:42:51,359
mystic attitude like there's there's

1177
00:42:54,870 --> 00:42:53,040
something

1178
00:42:56,790 --> 00:42:54,880
so special about consciousness we'll

1179
00:42:58,630 --> 00:42:56,800
never be able to

1180
00:42:59,990 --> 00:42:58,640
figure out how it works with science and

1181
00:43:01,430 --> 00:43:00,000
i'm like

1182
00:43:03,109 --> 00:43:01,440
you know let's talk about this again in

1183
00:43:04,550 --> 00:43:03,119
100 years and i'll tell you we'll have

1184
00:43:07,349 --> 00:43:04,560
figured it out

1185
00:43:09,270 --> 00:43:07,359
i see i see okay let's get to your music

1186
00:43:12,470 --> 00:43:09,280
what does

1187
00:43:14,550 --> 00:43:12,480
you have this creative

1188
00:43:16,470 --> 00:43:14,560

urge this itch inside you that you have

1189

00:43:20,069 --> 00:43:16,480

to just get it out there

1190

00:43:21,750 --> 00:43:20,079

or or you just do it for fun or or what

1191

00:43:24,550 --> 00:43:21,760

there's not many physicists that i know

1192

00:43:26,950 --> 00:43:24,560

that post music videos

1193

00:43:28,870 --> 00:43:26,960

both i would say um you know i i

1194

00:43:31,030 --> 00:43:28,880

definitely have some

1195

00:43:33,030 --> 00:43:31,040

need for creative outlet for a long time

1196

00:43:33,510 --> 00:43:33,040

i used to paint actually i used to paint

1197

00:43:36,550 --> 00:43:33,520

and then

1198

00:43:39,190 --> 00:43:36,560

um you know i had kids and uh you know

1199

00:43:40,710 --> 00:43:39,200

oil colors and small children don't mix

1200

00:43:42,950 --> 00:43:40,720

well

1201
00:43:44,230 --> 00:43:42,960
uh so i had to find something else and

1202
00:43:46,150 --> 00:43:44,240
that's when i started

1203
00:43:48,069 --> 00:43:46,160
writing songs and you know the the i

1204
00:43:49,750 --> 00:43:48,079
i'll admit like the first five years

1205
00:43:52,630 --> 00:43:49,760
probably the output was pretty terrible

1206
00:43:55,349 --> 00:43:52,640
but you know i've learned something sin

1207
00:43:57,030 --> 00:43:55,359
since and i really enjoy it you know i i

1208
00:43:58,630 --> 00:43:57,040
sometimes feel like if i'm

1209
00:44:00,630 --> 00:43:58,640
thinking too much about physics i get a

1210
00:44:02,550 --> 00:44:00,640
headache like literally

1211
00:44:03,670 --> 00:44:02,560
i i find it really stressful and the

1212
00:44:06,870 --> 00:44:03,680
good thing about

1213
00:44:08,150 --> 00:44:06,880

um creative enterprise is that it clears

1214

00:44:10,230 --> 00:44:08,160

out your mind

1215

00:44:13,109 --> 00:44:10,240

you know you get something else in there

1216

00:44:15,510 --> 00:44:13,119

and um so i do music

1217

00:44:17,430 --> 00:44:15,520

i've uh tried to teach myself how to

1218

00:44:18,550 --> 00:44:17,440

sing something that youtube is really

1219

00:44:20,150 --> 00:44:18,560

good for by the way

1220

00:44:22,230 --> 00:44:20,160

you know right did you also learning

1221

00:44:23,670 --> 00:44:22,240

something new did you teach yourself how

1222

00:44:24,630 --> 00:44:23,680

to edit or does someone else edit those

1223

00:44:27,430 --> 00:44:24,640

music videos

1224

00:44:27,829 --> 00:44:27,440

do you use after effects or what oh the

1225

00:44:33,510 --> 00:44:27,839

so

1226
00:44:37,030 --> 00:44:36,150
and yeah it's pretty much learning by

1227
00:44:39,270 --> 00:44:37,040
doing

1228
00:44:40,790 --> 00:44:39,280
i guess i've just made every possible

1229
00:44:42,710 --> 00:44:40,800
mistake that you can make

1230
00:44:43,990 --> 00:44:42,720
and at some point it starts looking kind

1231
00:44:46,550 --> 00:44:44,000
of okayish

1232
00:44:47,670 --> 00:44:46,560
you know in the sense that if you watch

1233
00:44:50,390 --> 00:44:47,680
it on your phone

1234
00:44:51,270 --> 00:44:50,400
um you won't be able to see most of the

1235
00:44:54,550 --> 00:44:51,280
glitches

1236
00:44:55,109 --> 00:44:54,560
so that's kind of i mean i sometimes i

1237
00:44:57,510 --> 00:44:55,119
watch

1238
00:44:59,990 --> 00:44:57,520

like professionally made videos and i'm

1239

00:45:00,790 --> 00:45:00,000

always odd i'm like this is so great you

1240

00:45:06,950 --> 00:45:00,800

know

1241

00:45:07,990 --> 00:45:06,960

autofocus and sometimes it goes wrong

1242

00:45:09,910 --> 00:45:08,000

and focuses on the

1243

00:45:11,349 --> 00:45:09,920

on the wrong thing or you know stuff

1244

00:45:13,510 --> 00:45:11,359

like i forget to plug in the

1245

00:45:15,349 --> 00:45:13,520

the microphone cable or stupid things

1246

00:45:15,990 --> 00:45:15,359

and then i talk for like an hour and in

1247

00:45:18,950 --> 00:45:16,000

the end

1248

00:45:20,470 --> 00:45:18,960

i haven't recorded stupid and it can get

1249

00:45:24,470 --> 00:45:20,480

really frustrating but

1250

00:45:25,510 --> 00:45:24,480

um yeah um you know after after doing

1251
00:45:28,150 --> 00:45:25,520
this for a while

1252
00:45:28,870 --> 00:45:28,160
you you kind of develop a work routine

1253
00:45:31,349 --> 00:45:28,880
and

1254
00:45:33,270 --> 00:45:31,359
so so i really do it all myself also the

1255
00:45:34,710 --> 00:45:33,280
music videos i mean every once in a

1256
00:45:36,309 --> 00:45:34,720
while you know i need someone to hold

1257
00:45:38,309 --> 00:45:36,319
the camera

1258
00:45:39,910 --> 00:45:38,319
my husband or my brother or my mother

1259
00:45:41,990 --> 00:45:39,920
usually um

1260
00:45:43,990 --> 00:45:42,000
but other than that i i do it all myself

1261
00:45:45,270 --> 00:45:44,000
you know i i write the songs i record

1262
00:45:49,270 --> 00:45:45,280
them

1263
00:45:50,309 --> 00:45:49,280

i do the mixing um i i do the videos i

1264

00:45:53,990 --> 00:45:50,319

do the makeup

1265

00:45:57,190 --> 00:45:54,000

the clothing the editing

1266

00:45:58,470 --> 00:45:57,200

um everything pretty much yeah do you

1267

00:46:02,069 --> 00:45:58,480

find that

1268

00:46:03,670 --> 00:46:02,079

your days are are structured where

1269

00:46:05,270 --> 00:46:03,680

at the institute you don't have to teach

1270

00:46:06,950 --> 00:46:05,280

as far as i know so you pretty much do

1271

00:46:09,430 --> 00:46:06,960

research do you

1272

00:46:10,790 --> 00:46:09,440

do you wake up at a specific time and

1273

00:46:12,309 --> 00:46:10,800

then you

1274

00:46:13,990 --> 00:46:12,319

go to bed at a specific time and you

1275

00:46:17,190 --> 00:46:14,000

read papers from a certain time

1276

00:46:19,190 --> 00:46:17,200

or is it is every day chaotic no

1277

00:46:21,190 --> 00:46:19,200

i i'm very much a routine person you

1278

00:46:23,670 --> 00:46:21,200

know am i my days

1279

00:46:25,430 --> 00:46:23,680

look kind of really yeah yeah but it's

1280

00:46:26,550 --> 00:46:25,440

also it's not just me it's because you

1281

00:46:29,349 --> 00:46:26,560

know i have two children

1282

00:46:30,630 --> 00:46:29,359

uh who normally would go to school so

1283

00:46:31,829 --> 00:46:30,640

right now of course the schools are

1284

00:46:33,829 --> 00:46:31,839

close but

1285

00:46:35,109 --> 00:46:33,839

you know you just you get this routine

1286

00:46:36,470 --> 00:46:35,119

because you have to

1287

00:46:38,069 --> 00:46:36,480

wake them up and get them to school and

1288

00:46:38,550 --> 00:46:38,079

then they come back at a certain time

1289

00:46:40,870 --> 00:46:38,560

and

1290

00:46:42,870 --> 00:46:40,880

by then you have better done your your

1291

00:46:44,630 --> 00:46:42,880

job right

1292

00:46:47,109 --> 00:46:44,640

what does your day look like then in

1293

00:46:47,990 --> 00:46:47,119

terms of how much time you spend working

1294

00:46:49,510 --> 00:46:48,000

and what do you

1295

00:46:51,270 --> 00:46:49,520

specifically work on are you reading

1296

00:46:52,069 --> 00:46:51,280

papers most of the time are you sitting

1297

00:46:53,990 --> 00:46:52,079

with a pen

1298

00:46:57,510 --> 00:46:54,000

looking at the wall like i'm i'm

1299

00:47:00,150 --> 00:46:57,520

actually interested in the specifics

1300

00:47:01,349 --> 00:47:00,160

well so i should probably say that right

1301
00:47:03,990 --> 00:47:01,359
now everything is just

1302
00:47:04,630 --> 00:47:04,000
different you know normally i would be

1303
00:47:08,630 --> 00:47:04,640
at

1304
00:47:10,950 --> 00:47:08,640
been working for

1305
00:47:11,829 --> 00:47:10,960
from home for three months with the kids

1306
00:47:14,150 --> 00:47:11,839
in the background

1307
00:47:15,750 --> 00:47:14,160
and a lot of stuff didn't really get

1308
00:47:17,190 --> 00:47:15,760
done because

1309
00:47:19,190 --> 00:47:17,200
you know they're just other things that

1310
00:47:20,870 --> 00:47:19,200
keep getting in the way i have to remind

1311
00:47:23,510 --> 00:47:20,880
them to do their homework i have to cook

1312
00:47:26,150 --> 00:47:23,520
for them that that kind of stuff

1313
00:47:27,190 --> 00:47:26,160

so it's not it's not normal the way that

1314

00:47:30,230 --> 00:47:27,200

it is right now but

1315

00:47:31,990 --> 00:47:30,240

um normally um i mean

1316

00:47:33,910 --> 00:47:32,000

so there are there are many different

1317

00:47:35,750 --> 00:47:33,920

aspects of um

1318

00:47:37,589 --> 00:47:35,760

being a theoretical physicist as you

1319

00:47:38,069 --> 00:47:37,599

already pointed out so i work at the

1320

00:47:41,349 --> 00:47:38,079

research

1321

00:47:43,510 --> 00:47:41,359

institute i don't have teaching duties

1322

00:47:44,470 --> 00:47:43,520

and that of course is also part of the

1323

00:47:47,910 --> 00:47:44,480

reason why

1324

00:47:51,349 --> 00:47:47,920

i'm active in public outreach is kind of

1325

00:47:54,069 --> 00:47:51,359

filling in this educational part that

1326

00:47:54,710 --> 00:47:54,079

i don't have in my job so i kind of feel

1327

00:47:57,910 --> 00:47:54,720

like

1328

00:48:00,150 --> 00:47:57,920

i need to give back something to society

1329

00:48:01,430 --> 00:48:00,160

because i know some professors they love

1330

00:48:03,109 --> 00:48:01,440

research and they

1331

00:48:05,190 --> 00:48:03,119

dislike teaching now some are the

1332

00:48:06,549 --> 00:48:05,200

opposite i think feynman actually

1333

00:48:08,710 --> 00:48:06,559

left the institute because he's like i

1334

00:48:09,510 --> 00:48:08,720

gotta teach i can't i have to be in the

1335

00:48:11,270 --> 00:48:09,520

field

1336

00:48:14,470 --> 00:48:11,280

but many professors that i know they

1337

00:48:18,069 --> 00:48:14,480

don't particularly like teaching

1338

00:48:20,950 --> 00:48:18,079

it seems like you have

1339

00:48:21,670 --> 00:48:20,960

a need to teach a need to give back is

1340

00:48:30,309 --> 00:48:21,680

that

1341

00:48:33,349 --> 00:48:31,829

well it's kind of it's it's a very

1342

00:48:35,349 --> 00:48:33,359

different audience you know the

1343

00:48:36,549 --> 00:48:35,359

youtube videos are not talking to

1344

00:48:40,309 --> 00:48:36,559

students

1345

00:48:43,670 --> 00:48:40,319

they're not meant to prepare people for

1346

00:48:46,390 --> 00:48:43,680

work in a professional discipline

1347

00:48:48,150 --> 00:48:46,400

they're more to generally communicate

1348

00:48:51,270 --> 00:48:48,160

what are we actually doing

1349

00:48:54,390 --> 00:48:51,280

and personally i find this more relevant

1350

00:48:55,589 --> 00:48:54,400

um i guess mostly it's because there are

1351

00:48:57,430 --> 00:48:55,599

a lot of people who teach

1352

00:48:59,430 --> 00:48:57,440

but i think there are too few people who

1353

00:49:02,069 --> 00:48:59,440

do science communication

1354

00:49:03,430 --> 00:49:02,079

and so so this is why it's i it's

1355

00:49:04,870 --> 00:49:03,440

important to me and

1356

00:49:07,430 --> 00:49:04,880

i like doing it even though i'm

1357

00:49:11,430 --> 00:49:07,440

technically not getting paid for it

1358

00:49:14,069 --> 00:49:11,440

um and um so i would not

1359

00:49:15,829 --> 00:49:14,079

describe my outreach activities as

1360

00:49:17,030 --> 00:49:15,839

actually being part of my job you know

1361

00:49:19,670 --> 00:49:17,040

it's it's something that i

1362

00:49:20,549 --> 00:49:19,680

i do on the side for what my research is

1363

00:49:24,390 --> 00:49:20,559

concerned

1364

00:49:26,630 --> 00:49:24,400

um you know it's indeed mostly reading

1365

00:49:27,430 --> 00:49:26,640

you know it's a lot of it the biggest

1366

00:49:29,190 --> 00:49:27,440

part is

1367

00:49:31,349 --> 00:49:29,200

finding out and understanding what other

1368

00:49:31,829 --> 00:49:31,359

people have done including you know the

1369

00:49:33,750 --> 00:49:31,839

stuff you

1370

00:49:35,109 --> 00:49:33,760

go go to seminars you give seminars

1371

00:49:37,750 --> 00:49:35,119

yourself and and

1372

00:49:40,309 --> 00:49:37,760

uh that whole game and then of course

1373

00:49:41,990 --> 00:49:40,319

you get to a point where you feel like

1374

00:49:43,510 --> 00:49:42,000

you've read everything that was to read

1375

00:49:46,790 --> 00:49:43,520

on a particular topic

1376

00:49:48,710 --> 00:49:46,800

now can i add my own thing um

1377

00:49:50,950 --> 00:49:48,720

and that's where you have to sit down

1378

00:49:53,349 --> 00:49:50,960

and actually write down equations

1379

00:49:54,150 --> 00:49:53,359

uh and see if there's a problem you can

1380

00:49:57,510 --> 00:49:54,160

solve or

1381

00:49:57,990 --> 00:49:57,520

if there's a new twist you can turn on

1382

00:50:03,030 --> 00:49:58,000

um

1383

00:50:04,230 --> 00:50:03,040

stuff like this then of course i also

1384

00:50:06,549 --> 00:50:04,240

have a postdoc and i

1385

00:50:08,230 --> 00:50:06,559

have a student um who have their own

1386

00:50:11,270 --> 00:50:08,240

projects that i have to look at

1387

00:50:11,990 --> 00:50:11,280

and see that they they get to where i

1388

00:50:14,950 --> 00:50:12,000

think they should be

1389

00:50:15,910 --> 00:50:14,960

getting um and you know there are other

1390

00:50:18,470 --> 00:50:15,920

things like i

1391

00:50:19,589 --> 00:50:18,480

um organize workshops conferences i have

1392

00:50:21,990 --> 00:50:19,599

to review papers

1393

00:50:23,589 --> 00:50:22,000

i have to review grant proposals um i

1394

00:50:25,430 --> 00:50:23,599

have to write grant proposals this

1395

00:50:26,549 --> 00:50:25,440

actually sucks up a dramatic amount of

1396

00:50:28,470 --> 00:50:26,559

time

1397

00:50:29,990 --> 00:50:28,480

um there's some administrative stuff

1398

00:50:31,829 --> 00:50:30,000

that i have to do like if you're getting

1399

00:50:33,750 --> 00:50:31,839

grants there's always some overhead that

1400

00:50:35,190 --> 00:50:33,760

comes with it that you have to

1401
00:50:37,589 --> 00:50:35,200
you know you have to keep track of where

1402
00:50:39,510 --> 00:50:37,599
the money goes and fill in reports and

1403
00:50:41,030 --> 00:50:39,520
it sounds like that's that's there's so

1404
00:50:43,589 --> 00:50:41,040
much extra

1405
00:50:45,829 --> 00:50:43,599
on top of the actual research that how

1406
00:50:48,309 --> 00:50:45,839
much of your time do you get to spend on

1407
00:50:49,750 --> 00:50:48,319
research with you like you said sitting

1408
00:50:51,109 --> 00:50:49,760
at your desk with your paper thinking

1409
00:50:52,710 --> 00:50:51,119
how can you twist

1410
00:50:54,230 --> 00:50:52,720
how can you add your own how can you

1411
00:50:55,750 --> 00:50:54,240
contribute to a field

1412
00:50:58,470 --> 00:50:55,760
how much of your time do you get to

1413
00:51:01,109 --> 00:50:58,480

spend doing that

1414

00:51:01,990 --> 00:51:01,119

let's say let's say per day an hour or

1415

00:51:05,750 --> 00:51:02,000

two hours

1416

00:51:09,190 --> 00:51:07,430

you know i i would have to think about

1417

00:51:12,069 --> 00:51:09,200

this more deeply so

1418

00:51:13,109 --> 00:51:12,079

the problem is that um the way that i

1419

00:51:18,150 --> 00:51:13,119

work

1420

00:51:21,270 --> 00:51:18,160

have a phase where i pretty much only do

1421

00:51:23,349 --> 00:51:21,280

research like i've been doing now i've

1422

00:51:25,030 --> 00:51:23,359

been working on the super determinism

1423

00:51:27,430 --> 00:51:25,040

stuff like every day

1424

00:51:29,270 --> 00:51:27,440

for 10 hours basically i wake up it's on

1425

00:51:31,349 --> 00:51:29,280

my mind you know there's this stuff and

1426

00:51:33,829 --> 00:51:31,359

then maybe i can do it this way and you

1427

00:51:35,349 --> 00:51:33,839

you know you know down an equation then

1428

00:51:36,069 --> 00:51:35,359

you figure out okay i don't know this i

1429

00:51:37,750 --> 00:51:36,079

have to look this

1430

00:51:39,270 --> 00:51:37,760

up you know then you try this and it

1431

00:51:40,549 --> 00:51:39,280

doesn't work and you try to something

1432

00:51:41,750 --> 00:51:40,559

else and it goes like this the whole day

1433

00:51:42,950 --> 00:51:41,760

until i go to bed

1434

00:51:45,109 --> 00:51:42,960

then i wake up in the middle of the

1435

00:51:46,630 --> 00:51:45,119

night with an idea and

1436

00:51:48,390 --> 00:51:46,640

i'm like oh i have to write this down

1437

00:51:49,990 --> 00:51:48,400

okay so then i sleep some more hours and

1438

00:51:50,950 --> 00:51:50,000

then i wake up again and i'm like now i

1439

00:51:53,190 --> 00:51:50,960

have to look this up

1440

00:51:55,510 --> 00:51:53,200

and it may go like this for several

1441

00:51:57,589 --> 00:51:55,520

weeks or maybe one two months

1442

00:51:59,589 --> 00:51:57,599

and then at some point i'm like i'm like

1443

00:52:00,710 --> 00:51:59,599

either totally frustrated and stressed

1444

00:52:03,589 --> 00:52:00,720

out and everything and just

1445

00:52:03,990 --> 00:52:03,599

have to stop it or something else comes

1446

00:52:07,030 --> 00:52:04,000

up

1447

00:52:09,030 --> 00:52:07,040

um that just has to be done um you know

1448

00:52:10,470 --> 00:52:09,040

conference organization what have you

1449

00:52:12,470 --> 00:52:10,480

the proposal deadline

1450

00:52:13,510 --> 00:52:12,480

is approaching uh and then something

1451

00:52:15,030 --> 00:52:13,520

else takes over

1452

00:52:16,950 --> 00:52:15,040

so then for someone i'll be doing

1453

00:52:18,790 --> 00:52:16,960

something else and then

1454

00:52:21,109 --> 00:52:18,800

i'll be getting back to research so it

1455

00:52:24,630 --> 00:52:21,119

makes it very difficult for me to answer

1456

00:52:27,430 --> 00:52:24,640

the question in terms of hours per day

1457

00:52:27,990 --> 00:52:27,440

um you know i it i guess it's something

1458

00:52:31,270 --> 00:52:28,000

between

1459

00:52:33,670 --> 00:52:31,280

30 and 50 roughly speaking

1460

00:52:35,349 --> 00:52:33,680

that i get to actually work on that's

1461

00:52:38,630 --> 00:52:35,359

pretty much yeah i know that

1462

00:52:42,710 --> 00:52:38,640

i i'm in a very lucky position

1463

00:52:44,790 --> 00:52:42,720

um i know that a lot of

1464

00:52:46,630 --> 00:52:44,800

my colleagues especially those who work

1465

00:52:51,109 --> 00:52:46,640

in teaching you know have have a lot

1466

00:52:54,230 --> 00:52:51,119

more duties um that take time away

1467

00:52:56,230 --> 00:52:54,240

from from their research um you know

1468

00:52:57,750 --> 00:52:56,240

on the downside though i have to say i

1469

00:52:58,390 --> 00:52:57,760

don't have a permanent position you know

1470

00:53:02,470 --> 00:52:58,400

i sit on

1471

00:53:04,630 --> 00:53:02,480

run out in two years

1472

00:53:06,150 --> 00:53:04,640

i was talking to stephen pinker and i

1473

00:53:07,750 --> 00:53:06,160

was asking him well how much of your

1474

00:53:09,589 --> 00:53:07,760

time is spent

1475

00:53:10,950 --> 00:53:09,599

actually writing versus researching and

1476

00:53:12,630 --> 00:53:10,960

i think he said it's 90

1477

00:53:14,870 --> 00:53:12,640

research that is in your case it would

1478

00:53:18,150 --> 00:53:14,880

be the equivalent of reading papers

1479

00:53:20,150 --> 00:53:18,160

and then 10 writing for you

1480

00:53:23,430 --> 00:53:20,160

how much of how what does that split

1481

00:53:28,470 --> 00:53:25,910

well between the between the reading and

1482

00:53:31,750 --> 00:53:28,480

the writing there's the calculation part

1483

00:53:34,790 --> 00:53:31,760

right so um

1484

00:53:36,150 --> 00:53:34,800

for me the writing is kind of the the

1485

00:53:38,069 --> 00:53:36,160

least amount of effort

1486

00:53:40,150 --> 00:53:38,079

you know it's what i do at the very end

1487

00:53:41,510 --> 00:53:40,160

if i have everything together

1488

00:53:42,950 --> 00:53:41,520

i sit down right that's what i mean

1489

00:53:44,390 --> 00:53:42,960

sorry i'm i'm also including the

1490

00:53:47,430 --> 00:53:44,400

calculation in the writing

1491

00:53:50,230 --> 00:53:47,440

so the reading and then calculating and

1492

00:53:52,069 --> 00:53:50,240

slash writing so it depends on whether

1493

00:53:52,549 --> 00:53:52,079

it's a field that i'm already familiar

1494

00:53:55,109 --> 00:53:52,559

with

1495

00:53:56,870 --> 00:53:55,119

um like if if it's a field like for

1496

00:53:57,990 --> 00:53:56,880

example the superfluid dark matter stuff

1497

00:53:59,750 --> 00:53:58,000

okay i've been

1498

00:54:01,349 --> 00:53:59,760

following the literature on that for

1499

00:54:02,870 --> 00:54:01,359

five years

1500

00:54:05,109 --> 00:54:02,880

so now the thing is if something new

1501
00:54:06,470 --> 00:54:05,119
comes out i only have to read the new

1502
00:54:08,470 --> 00:54:06,480
part

1503
00:54:10,870 --> 00:54:08,480
so which reduces the amount of

1504
00:54:13,030 --> 00:54:10,880
literature that i have to digest

1505
00:54:14,230 --> 00:54:13,040
so in any case like this you know it may

1506
00:54:17,109 --> 00:54:14,240
be something like

1507
00:54:18,630 --> 00:54:17,119
50 50. but if it's if it's a topic that

1508
00:54:21,990 --> 00:54:18,640
i'm really new to

1509
00:54:23,109 --> 00:54:22,000
um as it was the case up until recently

1510
00:54:25,510 --> 00:54:23,119
with the foundations of quantum

1511
00:54:26,150 --> 00:54:25,520
mechanics and there's just such a huge

1512
00:54:28,710 --> 00:54:26,160
amount

1513
00:54:31,109 --> 00:54:28,720

of literature that you first have to get

1514

00:54:31,750 --> 00:54:31,119

in and digest that it shifts more to

1515

00:54:34,950 --> 00:54:31,760

like

1516

00:54:36,150 --> 00:54:34,960

it's 95 uh reading and then there's this

1517

00:54:38,789 --> 00:54:36,160

little bit of extra

1518

00:54:40,390 --> 00:54:38,799

that you may be able to add i remember

1519

00:54:41,990 --> 00:54:40,400

one of your videos and i'm paraphrasing

1520

00:54:43,510 --> 00:54:42,000

so please let me know if i'm

1521

00:54:45,829 --> 00:54:43,520

mischaracterizing you i don't mean to

1522

00:54:47,670 --> 00:54:45,839

you said something along the lines of

1523

00:54:48,950 --> 00:54:47,680

that's not you're referring to something

1524

00:54:49,589 --> 00:54:48,960

i wish i could remember but he said

1525

00:54:50,789 --> 00:54:49,599

that's not a

1526

00:54:52,150 --> 00:54:50,799

that's not something i'm interested in

1527

00:54:53,349 --> 00:54:52,160

that's not a question that can be

1528

00:54:54,230 --> 00:54:53,359

answered with science so i'm not

1529

00:54:55,750 --> 00:54:54,240

interested

1530

00:54:58,390 --> 00:54:55,760

now you can tell me if i'm wrong there

1531

00:55:03,990 --> 00:54:58,400

but i'm curious is all that matters

1532

00:55:10,549 --> 00:55:06,870

um so i have no idea what i may have

1533

00:55:14,069 --> 00:55:12,230

it sounds like something that that that

1534

00:55:17,270 --> 00:55:14,079

i may have said

1535

00:55:19,589 --> 00:55:17,280

in the context of the video probably

1536

00:55:21,349 --> 00:55:19,599

you know i was trying to discuss a

1537

00:55:23,270 --> 00:55:21,359

scientific question

1538

00:55:24,549 --> 00:55:23,280

and then i may have said something uh to

1539

00:55:26,549 --> 00:55:24,559

the extent

1540

00:55:27,910 --> 00:55:26,559

um but i don't want to talk about this

1541

00:55:29,030 --> 00:55:27,920

because it's not a question that science

1542

00:55:31,589 --> 00:55:29,040

can answer

1543

00:55:33,109 --> 00:55:31,599

um so but this doesn't mean that science

1544

00:55:33,990 --> 00:55:33,119

is the only thing that's interesting

1545

00:55:37,109 --> 00:55:34,000

like we were already

1546

00:55:40,230 --> 00:55:37,119

talking about creative outlets right and

1547

00:55:42,309 --> 00:55:40,240

um i i don't think that this is merely

1548

00:55:43,589 --> 00:55:42,319

you know something that's unimportant

1549

00:55:45,750 --> 00:55:43,599

you know i don't

1550

00:55:47,349 --> 00:55:45,760

see myself as a professional artist and

1551

00:55:48,950 --> 00:55:47,359

i you know i have no aspirations to

1552

00:55:50,230 --> 00:55:48,960

become one to me it's kind of something

1553

00:55:53,190 --> 00:55:50,240

that i

1554

00:55:54,470 --> 00:55:53,200

need to function properly as a human

1555

00:55:56,789 --> 00:55:54,480

basically

1556

00:55:58,230 --> 00:55:56,799

but uh i mean there are professional

1557

00:56:00,829 --> 00:55:58,240

artists and i think that they

1558

00:56:01,990 --> 00:56:00,839

fulfill a very important function in our

1559

00:56:04,710 --> 00:56:02,000

society

1560

00:56:06,309 --> 00:56:04,720

you know by um giving pleasure to

1561

00:56:06,630 --> 00:56:06,319

people's life you know that's something

1562

00:56:10,870 --> 00:56:06,640

that

1563

00:56:11,990 --> 00:56:10,880

science is is definitely not the only

1564

00:56:13,589 --> 00:56:12,000

thing that matters

1565

00:56:15,190 --> 00:56:13,599

or maybe i should add you know but also

1566

00:56:17,030 --> 00:56:15,200

but to make people

1567

00:56:18,710 --> 00:56:17,040

think you know art is not only about

1568

00:56:22,950 --> 00:56:18,720

what is pretty of course

1569

00:56:25,750 --> 00:56:22,960

are there truths that are non-scientific

1570

00:56:27,430 --> 00:56:25,760

um yes they're mathematical truths okay

1571

00:56:30,470 --> 00:56:27,440

are the truths that are non-mathematical

1572

00:56:31,829 --> 00:56:30,480

and non-scientific

1573

00:56:33,510 --> 00:56:31,839

well it depends on what you mean by

1574

00:56:36,470 --> 00:56:33,520

truth i would say no

1575

00:56:37,109 --> 00:56:36,480

because for me a truth is an absolute

1576

00:56:39,990 --> 00:56:37,119

truth

1577

00:56:41,270 --> 00:56:40,000

you know something that is unshakable

1578

00:56:42,789 --> 00:56:41,280

and

1579

00:56:44,630 --> 00:56:42,799

you basically only find this in

1580

00:56:46,150 --> 00:56:44,640

mathematics if you can actually prove

1581

00:56:48,870 --> 00:56:46,160

something like two plus two

1582

00:56:49,910 --> 00:56:48,880

equals four so already when you come to

1583

00:56:52,230 --> 00:56:49,920

science

1584

00:56:53,190 --> 00:56:52,240

um the best you can do is say that

1585

00:56:55,190 --> 00:56:53,200

something is

1586

00:56:57,030 --> 00:56:55,200

almost certainly correct you know with

1587

00:57:00,150 --> 00:56:57,040

with a certain arrow bar

1588

00:57:01,910 --> 00:57:00,160

at uh to be almost certainly but

1589

00:57:03,270 --> 00:57:01,920

colloquially i guess most people would

1590

00:57:04,950 --> 00:57:03,280

at some point

1591

00:57:06,710 --> 00:57:04,960

just say it's true you know if the

1592

00:57:08,710 --> 00:57:06,720

uncertainty is so small that

1593

00:57:10,069 --> 00:57:08,720

uh nothing's going to change about it

1594

00:57:11,430 --> 00:57:10,079

almost certainly in their lifetime or

1595

00:57:13,030 --> 00:57:11,440

something they would just say it's true

1596

00:57:14,870 --> 00:57:13,040

are there truths in fiction

1597

00:57:16,309 --> 00:57:14,880

so for example if you watch a movie that

1598

00:57:18,710 --> 00:57:16,319

was made up by someone

1599

00:57:19,670 --> 00:57:18,720

and you say there's there's truth in

1600

00:57:22,870 --> 00:57:19,680

that i mean

1601
00:57:25,030 --> 00:57:22,880
i don't know would is there truth in

1602
00:57:27,030 --> 00:57:25,040
fiction

1603
00:57:28,470 --> 00:57:27,040
well again i i think that's something

1604
00:57:31,109 --> 00:57:28,480
which people would say

1605
00:57:31,910 --> 00:57:31,119
colloquially but they wouldn't literally

1606
00:57:35,109 --> 00:57:31,920
mean

1607
00:57:37,310 --> 00:57:35,119
it's true they they would say it um

1608
00:57:38,630 --> 00:57:37,320
maybe to mean um

1609
00:57:41,190 --> 00:57:38,640
[Music]

1610
00:57:43,190 --> 00:57:41,200
this captures something that i have also

1611
00:57:44,549 --> 00:57:43,200
experienced or something like that

1612
00:57:48,309 --> 00:57:44,559
what's the difference in your eyes

1613
00:57:51,829 --> 00:57:50,710

and just delineate it for the audience

1614

00:57:54,630 --> 00:57:51,839

well

1615

00:57:55,190 --> 00:57:54,640

i think my if my greek doesn't fail me i

1616

00:57:58,309 --> 00:57:55,200

think

1617

00:58:00,470 --> 00:57:58,319

the word matter just means beyond so the

1618

00:58:01,190 --> 00:58:00,480

the metaphysics or after or something

1619

00:58:02,950 --> 00:58:01,200

like this

1620

00:58:04,470 --> 00:58:02,960

like it's what what comes after the

1621

00:58:06,470 --> 00:58:04,480

physics if you're done with the physics

1622

00:58:09,430 --> 00:58:06,480

then there's metaphysics

1623

00:58:11,589 --> 00:58:09,440

um but the way that uh it's it's been

1624

00:58:14,309 --> 00:58:11,599

mostly used by philosophers

1625

00:58:15,990 --> 00:58:14,319

um is to say that in physics you have

1626
00:58:16,870 --> 00:58:16,000
certain assumptions that are not

1627
00:58:19,910 --> 00:58:16,880
themselves

1628
00:58:23,670 --> 00:58:19,920
empirically um testable

1629
00:58:27,030 --> 00:58:23,680
but that physicists use nevertheless

1630
00:58:29,670 --> 00:58:27,040
um just because they have to

1631
00:58:30,390 --> 00:58:29,680
um otherwise nothing works you have to

1632
00:58:34,230 --> 00:58:30,400
start with

1633
00:58:37,589 --> 00:58:34,240
uh something um and i i guess i'm

1634
00:58:39,750 --> 00:58:37,599
i'm i'm hoping that i'm using the word

1635
00:58:40,710 --> 00:58:39,760
uh in the same way um that the

1636
00:58:44,069 --> 00:58:40,720
philosophers

1637
00:58:47,670 --> 00:58:44,079
do like i mean for example

1638
00:58:48,829 --> 00:58:47,680

a metaphysical assumption is the idea

1639

00:58:50,010 --> 00:58:48,839

that

1640

00:58:52,390 --> 00:58:50,020

um

1641

00:58:55,510 --> 00:58:52,400

[Music]

1642

00:58:57,829 --> 00:58:55,520

theories have to um

1643

00:58:59,109 --> 00:58:57,839

fulfill a certain type of beauty that's

1644

00:59:01,510 --> 00:58:59,119

what my book is about

1645

00:59:04,069 --> 00:59:01,520

um right there's certain types of beauty

1646

00:59:08,150 --> 00:59:04,079

that physicists have

1647

00:59:10,309 --> 00:59:08,160

been using extensively and

1648

00:59:12,309 --> 00:59:10,319

you know i i say that these are ideals

1649

00:59:15,910 --> 00:59:12,319

of beauty but what they actually are

1650

00:59:18,789 --> 00:59:15,920

are metaphysical criteria it's just that

1651
00:59:19,910 --> 00:59:18,799
you know if it's it's not particularly

1652
00:59:21,910 --> 00:59:19,920
catchy to talk about

1653
00:59:23,510 --> 00:59:21,920
metaphysical criteria so so that's not

1654
00:59:26,549 --> 00:59:23,520
what i call it i just say their

1655
00:59:27,990 --> 00:59:26,559
appeals to beauty i have a somewhat

1656
00:59:30,309 --> 00:59:28,000
technical question

1657
00:59:33,270 --> 00:59:30,319
weinstein eric weinstein was talking

1658
00:59:35,030 --> 00:59:33,280
about the einstein field equations

1659
00:59:36,710 --> 00:59:35,040
dirac equations and then the yang mills

1660
00:59:38,630 --> 00:59:36,720
equations and he said

1661
00:59:39,829 --> 00:59:38,640
that they are provably the simplest in

1662
00:59:41,990 --> 00:59:39,839
their class and

1663
00:59:43,190 --> 00:59:42,000

as far as i know there's no theorem in

1664

00:59:44,549 --> 00:59:43,200

the field of physics that says that

1665

00:59:46,630 --> 00:59:44,559

they're probably the simplest

1666

00:59:48,549 --> 00:59:46,640

is there and like what the heck what

1667

00:59:51,670 --> 00:59:48,559

does that mean that they're

1668

00:59:55,670 --> 00:59:51,680

provably of their kind do you

1669

00:59:56,069 --> 00:59:55,680

know well so it's hard to say what what

1670

01:00:01,270 --> 00:59:56,079

he

1671

01:00:03,030 --> 01:00:01,280

you

1672

01:00:04,470 --> 01:00:03,040

because it depends on exactly which

1673

01:00:06,470 --> 01:00:04,480

assumptions

1674

01:00:08,390 --> 01:00:06,480

uh you make like let let's take for

1675

01:00:11,990 --> 01:00:08,400

example general relativity

1676

01:00:15,349 --> 01:00:12,000

you can just um general relativity

1677

01:00:18,470 --> 01:00:15,359

is a simple theory in the sense that um

1678

01:00:21,589 --> 01:00:18,480

it takes only like five assumptions

1679

01:00:23,270 --> 01:00:21,599

um to derive it uh

1680

01:00:25,349 --> 01:00:23,280

and these five assumptions are kind of

1681

01:00:26,950 --> 01:00:25,359

like uh gravity is described by the

1682

01:00:28,870 --> 01:00:26,960

curvature of space and time

1683

01:00:30,789 --> 01:00:28,880

it couples to the stress energy tensor

1684

01:00:32,630 --> 01:00:30,799

which is the conserved quantity uh it

1685

01:00:35,829 --> 01:00:32,640

reproduces neutron and gravity

1686

01:00:37,349 --> 01:00:35,839

uh in a suitable limit and uh

1687

01:00:38,950 --> 01:00:37,359

i think that two more which i've which

1688

01:00:42,069 --> 01:00:38,960

i've now forgotten and

1689

01:00:43,270 --> 01:00:42,079

then you can show that uh general

1690

01:00:46,710 --> 01:00:43,280

relativity

1691

01:00:49,109 --> 01:00:46,720

is the simple theory that does that

1692

01:00:49,910 --> 01:00:49,119

where the word simple becomes relevant

1693

01:00:52,069 --> 01:00:49,920

because

1694

01:00:53,430 --> 01:00:52,079

you can you can make the theory more

1695

01:00:56,870 --> 01:00:53,440

complicated if you want to

1696

01:00:58,710 --> 01:00:56,880

um by adding higher order terms

1697

01:01:00,549 --> 01:00:58,720

but but then you just say no i take the

1698

01:01:04,789 --> 01:01:00,559

simplest one

1699

01:01:06,710 --> 01:01:04,799

i see and uh and i guess that um

1700

01:01:08,789 --> 01:01:06,720

it with young myths theory the drock

1701

01:01:11,109 --> 01:01:08,799

equation it may be something

1702

01:01:12,870 --> 01:01:11,119

similar but again it depends on exactly

1703

01:01:15,349 --> 01:01:12,880

how you phrase the assumptions like if

1704

01:01:18,710 --> 01:01:15,359

for example with the dirac equation

1705

01:01:20,150 --> 01:01:18,720

um dirac made this

1706

01:01:22,470 --> 01:01:20,160

assumption that the theory has to be

1707

01:01:25,589 --> 01:01:22,480

linear um

1708

01:01:27,349 --> 01:01:25,599

which um is something that you may

1709

01:01:29,190 --> 01:01:27,359

wonder if you can do it without

1710

01:01:31,750 --> 01:01:29,200

so the direct equation is basically

1711

01:01:34,870 --> 01:01:31,760

you're trying to take the square root

1712

01:01:36,789 --> 01:01:34,880

of um einstein's equation e

1713

01:01:38,150 --> 01:01:36,799

$e^2 - p^2 = m$

1714

01:01:40,230 --> 01:01:38,160

squared

1715

01:01:41,670 --> 01:01:40,240

and so the peculiar thing about the

1716

01:01:42,870 --> 01:01:41,680

derog equation is that you take the

1717

01:01:43,829 --> 01:01:42,880

square root but you get a linear

1718

01:01:45,430 --> 01:01:43,839

equation

1719

01:01:48,150 --> 01:01:45,440

and the only way you can do that is by

1720

01:01:50,309 --> 01:01:48,160

using these weird matrices

1721

01:01:52,789 --> 01:01:50,319

but in principle you can take a square

1722

01:01:54,309 --> 01:01:52,799

root of an operator

1723

01:01:56,390 --> 01:01:54,319

that's something which exists and you

1724

01:01:59,109 --> 01:01:56,400

you can define that uh by

1725

01:02:00,069 --> 01:01:59,119

using the spectral uh decomposition and

1726

01:02:02,069 --> 01:02:00,079

i've no idea why

1727

01:02:03,430 --> 01:02:02,079

why dirk didn't try that or maybe he did

1728

01:02:05,829 --> 01:02:03,440

and you know

1729

01:02:06,950 --> 01:02:05,839

he didn't like it or whatever people

1730

01:02:10,710 --> 01:02:06,960

tried it later

1731

01:02:13,109 --> 01:02:10,720

their papers about this um and

1732

01:02:14,390 --> 01:02:13,119

you know then you you can i don't know

1733

01:02:16,230 --> 01:02:14,400

how

1734

01:02:18,390 --> 01:02:16,240

is one of these solutions simpler than

1735

01:02:20,069 --> 01:02:18,400

the other i don't know but one is wrong

1736

01:02:21,510 --> 01:02:20,079

and the other one isn't

1737

01:02:23,109 --> 01:02:21,520

like i mean wrong in the sense that

1738

01:02:24,710 --> 01:02:23,119

derek's equation actually describes

1739

01:02:25,349 --> 01:02:24,720

reality well if you do it the other way

1740

01:02:27,910 --> 01:02:25,359

around

1741

01:02:29,910 --> 01:02:27,920

you also get a theory that kind of

1742

01:02:31,589 --> 01:02:29,920

solves the problem that derock posed

1743

01:02:34,549 --> 01:02:31,599

like how do i take the square root of

1744

01:02:37,670 --> 01:02:36,630

doesn't describe what we observe so i

1745

01:02:40,230 --> 01:02:37,680

see this

1746

01:02:42,309 --> 01:02:40,240

question doesn't make much sense but

1747

01:02:44,630 --> 01:02:42,319

it's fun to think about

1748

01:02:45,670 --> 01:02:44,640

imagine you're a photon how do you

1749

01:02:48,390 --> 01:02:45,680

experience time

1750

01:02:50,069 --> 01:02:48,400

now i know time is defined as the length

1751

01:02:54,069 --> 01:02:50,079

the path length

1752

01:02:55,910 --> 01:02:54,079

in space time but proper time is so

1753

01:02:57,910 --> 01:02:55,920

that means that the photon experiences

1754

01:02:59,670 --> 01:02:57,920

zero time which is

1755

01:03:01,589 --> 01:02:59,680

imagining you're the photon it's it's

1756

01:03:03,910 --> 01:03:01,599

like you you're emerging and then you

1757

01:03:05,670 --> 01:03:03,920

die instantaneously

1758

01:03:08,309 --> 01:03:05,680

what does the experience of a photon

1759

01:03:11,510 --> 01:03:10,150

i have no idea i don't know what it

1760

01:03:13,510 --> 01:03:11,520

means to talk about the

1761

01:03:15,270 --> 01:03:13,520

experience of a photon like we were

1762

01:03:17,750 --> 01:03:15,280

talking about um

1763

01:03:18,789 --> 01:03:17,760

consciousness earlier and i think that

1764

01:03:22,470 --> 01:03:18,799

you can

1765

01:03:24,230 --> 01:03:22,480

define experience in a similar way but

1766

01:03:26,150 --> 01:03:24,240

it requires that you have a certain

1767

01:03:28,549 --> 01:03:26,160

amount of particles that are able to

1768

01:03:30,390 --> 01:03:28,559

actually exchange information

1769

01:03:31,910 --> 01:03:30,400

and so i would say a single photon just

1770

01:03:33,029 --> 01:03:31,920

doesn't have any experiences i have no

1771

01:03:36,309 --> 01:03:33,039

idea what that's

1772

01:03:36,630 --> 01:03:36,319

supposed to mean so uh yeah i'm not sure

1773

01:03:37,990 --> 01:03:36,640

that

1774

01:03:40,390 --> 01:03:38,000

answers your question but yeah i mean

1775

01:03:40,950 --> 01:03:40,400

the canonical answer to the question is

1776

01:03:43,910 --> 01:03:40,960

that uh

1777

01:03:44,230 --> 01:03:43,920

photons um don't can't have a sense of

1778

01:03:46,710 --> 01:03:44,240

time

1779

01:03:47,270 --> 01:03:46,720

basically exactly because of this issue

1780

01:03:50,789 --> 01:03:47,280

that

1781

01:03:54,150 --> 01:03:50,799

length of the curve

1782

01:03:55,670 --> 01:03:54,160

on which the photon moves is zero and uh

1783

01:03:57,190 --> 01:03:55,680

the length of this curve is usually what

1784

01:04:00,230 --> 01:03:57,200

you mean by time

1785

01:04:01,349 --> 01:04:00,240

sabine what's next for you and

1786

01:04:03,430 --> 01:04:01,359

why don't you tell our audience where

1787

01:04:06,870 --> 01:04:03,440

they can find out more about you

1788

01:04:09,910 --> 01:04:06,880

your youtube link will be included well

1789

01:04:12,549 --> 01:04:09,920

so um i'm lucky in that

1790

01:04:13,829 --> 01:04:12,559

for all i know i'm the only person on

1791

01:04:15,190 --> 01:04:13,839

this planet with the names of being a

1792

01:04:15,910 --> 01:04:15,200

hostenfelder so the only thing you have

1793

01:04:17,829 --> 01:04:15,920

to do is

1794

01:04:19,910 --> 01:04:17,839

enter my name in some search engine and

1795

01:04:20,870 --> 01:04:19,920

you will find out more about me than you

1796

01:04:24,710 --> 01:04:20,880

ever wanted to know

1797

01:04:27,109 --> 01:04:24,720

trust me um so that's the easy part um

1798

01:04:28,150 --> 01:04:27,119

the complicated part is uh what i'm

1799

01:04:31,750 --> 01:04:28,160

going to do

1800

01:04:33,910 --> 01:04:31,760

so um like the next two years are

1801

01:04:35,670 --> 01:04:33,920

pretty straightforward because i'm

1802

01:04:38,630 --> 01:04:35,680

working on this research project

1803

01:04:39,670 --> 01:04:38,640

on superfluid dark matter so that's what

1804

01:04:41,190 --> 01:04:39,680

i'll be doing

1805

01:04:43,270 --> 01:04:41,200

i also have this running research

1806

01:04:46,789 --> 01:04:43,280

project on super determinism

1807

01:04:48,950 --> 01:04:46,799

um that we talked about um and i'm also

1808

01:04:50,710 --> 01:04:48,960

you know i i was in the process of

1809

01:04:52,789 --> 01:04:50,720

organizing a workshop on that

1810

01:04:54,950 --> 01:04:52,799

um which was supposed to take place in

1811

01:04:56,150 --> 01:04:54,960

may but then we had to cancel everything

1812

01:04:57,829 --> 01:04:56,160

i'm glad because when i wrote that

1813

01:04:59,670 --> 01:04:57,839

question i wasn't sure if you were

1814

01:05:00,950 --> 01:04:59,680

familiar with the term super determinism

1815

01:05:01,990 --> 01:05:00,960

and it turns out you're a specialist in

1816

01:05:04,549 --> 01:05:02,000

the field

1817

01:05:05,829 --> 01:05:04,559

yeah you know it was lucky because as i

1818

01:05:07,029 --> 01:05:05,839

keep joking the only

1819

01:05:08,870 --> 01:05:07,039

three people on the planet who

1820

01:05:09,270 --> 01:05:08,880

understand what super determinism is so

1821

01:05:12,710 --> 01:05:09,280

that's

1822

01:05:14,870 --> 01:05:12,720

palmer

1823

01:05:16,150 --> 01:05:14,880

so you're talking to exactly the right

1824

01:05:19,430 --> 01:05:16,160

person

1825

01:05:21,029 --> 01:05:19,440

um yes uh and i'll

1826

01:05:23,349 --> 01:05:21,039

i'll keep on doing the youtube thing for

1827

01:05:25,910 --> 01:05:23,359

some more time definitely

1828

01:05:28,069 --> 01:05:25,920

i'm kind of getting into it you know the

1829

01:05:30,309 --> 01:05:28,079

the more practice you have the easier it

1830

01:05:33,430 --> 01:05:30,319

gets because you become more efficient

1831

01:05:33,910 --> 01:05:33,440

um with producing content if you don't

1832

01:05:36,950 --> 01:05:33,920

make

1833

01:05:38,710 --> 01:05:36,960

as many mistakes um

1834

01:05:40,870 --> 01:05:38,720

but beyond this i really don't know

1835

01:05:42,789 --> 01:05:40,880

because i'm i'm sitting on this

1836

01:05:44,230 --> 01:05:42,799

short-term contract and there's always

1837

01:05:47,109 --> 01:05:44,240

the question like uh

1838

01:05:48,150 --> 01:05:47,119

will i get another research grant or if

1839

01:05:50,470 --> 01:05:48,160

not then

1840

01:05:52,309 --> 01:05:50,480

what am i supposed to do so your future

1841

01:05:53,750 --> 01:05:52,319

in the next five years if this was a job

1842

01:05:54,870 --> 01:05:53,760

interview what does your future look

1843

01:05:56,309 --> 01:05:54,880

like

1844

01:05:58,470 --> 01:05:56,319

you're not clear in the next five years

1845

01:06:00,789 --> 01:05:58,480

you hopefully yeah i failed

1846

01:06:01,589 --> 01:06:00,799

i failed the interview so what if

1847

01:06:03,510 --> 01:06:01,599

someone gave you

1848

01:06:05,349 --> 01:06:03,520

a million dollars and said i want you to

1849

01:06:05,670 --> 01:06:05,359

spend this and just make music videos or

1850

01:06:08,549 --> 01:06:05,680

just

1851
01:06:09,990 --> 01:06:08,559
pursue music would you say yes or no is

1852
01:06:15,990 --> 01:06:10,000
it that much of a passion

1853
01:06:20,309 --> 01:06:18,950
well you know i i wouldn't want to give

1854
01:06:23,910 --> 01:06:20,319
up my research

1855
01:06:24,390 --> 01:06:23,920
um on the other hand i could put it on

1856
01:06:27,029 --> 01:06:24,400
pause

1857
01:06:27,670 --> 01:06:27,039
for some time uh so i guess it depends

1858
01:06:30,150 --> 01:06:27,680
on how many

1859
01:06:32,710 --> 01:06:30,160
of the right incentives yeah it it's

1860
01:06:35,990 --> 01:06:32,720
it's a matter of time period that

1861
01:06:37,190 --> 01:06:36,000
um he or she would expect me to spend

1862
01:06:39,190 --> 01:06:37,200
away from research

1863
01:06:41,270 --> 01:06:39,200

it's not really amount about the amount

1864

01:06:43,349 --> 01:06:41,280

of money oh okay okay

1865

01:06:44,870 --> 01:06:43,359

all right thank you so much sabine

1866

01:06:47,670 --> 01:06:44,880

appreciate this

1867

01:06:48,309 --> 01:06:47,680

and have a great day everyone go visit

1868

01:06:52,309 --> 01:06:48,319

her channel

1869

01:06:57,270 --> 01:06:55,029

are you aware of any other logical

1870

01:07:00,470 --> 01:06:57,280

approaches to

1871

01:07:03,270 --> 01:07:00,480

of any other logics that are used in

1872

01:07:03,910 --> 01:07:03,280

the building of physical theory so for

1873

01:07:05,430 --> 01:07:03,920

example

1874

01:07:07,510 --> 01:07:05,440

most of physical theories are grounded

1875

01:07:09,270 --> 01:07:07,520

in classical logic that is p or not p

1876

01:07:11,029 --> 01:07:09,280

and you can't have both why else do you

1877

01:07:12,829 --> 01:07:11,039

have principle of explosion well that is

1878

01:07:15,190 --> 01:07:12,839

the principle

1879

01:07:16,789 --> 01:07:15,200

okay well

1880

01:07:18,630 --> 01:07:16,799

there is consistent logics and

1881

01:07:21,589 --> 01:07:18,640

intuitionist logics

1882

01:07:23,190 --> 01:07:21,599

there is something called quantum logic

1883

01:07:25,430 --> 01:07:23,200

so people have tried to

1884

01:07:27,270 --> 01:07:25,440

um i i never followed this in much

1885

01:07:30,150 --> 01:07:27,280

detail but i heard like one two talks

1886

01:07:32,549 --> 01:07:30,160

about it yeah as you say that they're

1887

01:07:36,390 --> 01:07:32,559

different

1888

01:07:38,630 --> 01:07:36,400

systems of logic and people have tried

1889

01:07:47,349 --> 01:07:42,710

use them to um

1890

01:07:49,910 --> 01:07:47,359

explain the puzzling aspects of quantum

1891

01:07:51,270 --> 01:07:49,920

theory as just being a different type of

1892

01:07:53,109 --> 01:07:51,280

logic

1893

01:07:54,549 --> 01:07:53,119

um where statements don't have to be

1894

01:07:58,309 --> 01:07:54,559

mutually exclusive

1895

01:07:59,190 --> 01:07:58,319

so no so um which is supposedly where

1896

01:08:02,230 --> 01:07:59,200

you get

1897

01:08:04,150 --> 01:08:02,240

um all this stuff from that uh you know

1898

01:08:06,870 --> 01:08:04,160

estate can be both here and there

1899

01:08:07,750 --> 01:08:06,880

because these options are not exclusive

1900

01:08:11,029 --> 01:08:07,760

so that's kind of

1901

01:08:13,589 --> 01:08:11,039

the vague idea um but

1902

01:08:15,750 --> 01:08:13,599

you know i don't know i i heard about

1903

01:08:17,269 --> 01:08:15,760

this first i think 10 years ago and not

1904

01:08:19,189 --> 01:08:17,279

all that much seems to have come out of

1905

01:08:20,709 --> 01:08:19,199

it but yeah i mean this would be the

1906

01:08:23,030 --> 01:08:20,719

first thing that comes to my mind

1907

01:08:24,950 --> 01:08:23,040

i'm curious if there are from the

1908

01:08:27,030 --> 01:08:24,960

popularizers of science much like

1909

01:08:29,030 --> 01:08:27,040

neil degrasse tyson and so on if there

1910

01:08:31,030 --> 01:08:29,040

are myths that you feel like

1911

01:08:32,390 --> 01:08:31,040

that they sell to the audience that that

1912

01:08:34,309 --> 01:08:32,400

is incorrect that you wish they wouldn't

1913

01:08:35,910 --> 01:08:34,319

so for example that the electron is both

1914

01:08:36,709 --> 01:08:35,920

up and down at the same time rather than

1915

01:08:38,950 --> 01:08:36,719

that being just

1916

01:08:39,829 --> 01:08:38,960

a method that we use mathematically to

1917

01:08:41,189 --> 01:08:39,839

calculate what

1918

01:08:43,110 --> 01:08:41,199

happened that's just part of the wave

1919

01:08:46,309 --> 01:08:43,120

function it's not necessarily that the

1920

01:08:48,229 --> 01:08:46,319

electron is both up and down do you

1921

01:08:52,309 --> 01:08:48,239

happen to know of any other

1922

01:08:55,910 --> 01:08:52,319

misconceptions that you want to dispel

1923

01:08:58,950 --> 01:08:55,920

so i i don't know i don't know about

1924

01:09:02,070 --> 01:08:58,960

uh tyson or yeah it doesn't sound

1925

01:09:04,309 --> 01:09:02,080

particular yeah

1926

01:09:05,749 --> 01:09:04,319

there are a few of these that sometimes

1927

01:09:08,630 --> 01:09:05,759

come up that

1928

01:09:10,229 --> 01:09:08,640

the problem is that i have a hard time

1929

01:09:11,030 --> 01:09:10,239

pulling them up now because i didn't

1930

01:09:13,110 --> 01:09:11,040

think about it

1931

01:09:14,309 --> 01:09:13,120

previously but one thing that would come

1932

01:09:17,030 --> 01:09:14,319

to my mind uh

1933

01:09:19,189 --> 01:09:17,040

immediately is this idea that the

1934

01:09:22,789 --> 01:09:19,199

observations on the bullet cluster

1935

01:09:24,950 --> 01:09:22,799

rule out modified gravity which is

1936

01:09:26,870 --> 01:09:24,960

which is wrong and i think everyone who

1937

01:09:28,390 --> 01:09:26,880

works in the field knows that it's wrong

1938

01:09:31,349 --> 01:09:28,400

but it's such a

1939

01:09:32,709 --> 01:09:31,359

simple and seemingly uh intuitive

1940

01:09:35,510 --> 01:09:32,719

explanation that

1941

01:09:36,470 --> 01:09:35,520

that science communicators draw on it um

1942

01:09:38,149 --> 01:09:36,480

all the time

1943

01:09:39,510 --> 01:09:38,159

and i find it really really misleading

1944

01:09:40,789 --> 01:09:39,520

and i think it's really bad for the

1945

01:09:42,709 --> 01:09:40,799

field because

1946

01:09:44,229 --> 01:09:42,719

a lot of people in physics who are not

1947

01:09:46,870 --> 01:09:44,239

really familiar with the with the

1948

01:09:49,590 --> 01:09:46,880

subject matter just believe it

1949

01:09:50,789 --> 01:09:49,600

and um yes so this is one example

1950

01:09:54,149 --> 01:09:50,799

another example

1951

01:09:54,709 --> 01:09:54,159

is that um i i often hear people say

1952

01:09:58,229 --> 01:09:54,719

that

1953

01:10:02,310 --> 01:09:58,239

um special relativity um

1954

01:10:05,110 --> 01:10:02,320

cannot deal with accelerated observers

1955

01:10:06,390 --> 01:10:05,120

which is which is wrong you can

1956

01:10:08,950 --> 01:10:06,400

perfectly

1957

01:10:10,870 --> 01:10:08,960

well deal with accelerated observers in

1958

01:10:12,950 --> 01:10:10,880

special relativity it's just that

1959

01:10:14,630 --> 01:10:12,960

a lot of you know popular science

1960

01:10:17,830 --> 01:10:14,640

textbooks only talk about

1961

01:10:18,790 --> 01:10:17,840

um non-accelerated observers the reason

1962

01:10:22,229 --> 01:10:18,800

this

1963

01:10:24,310 --> 01:10:22,239

annoys me is that if you believe that

1964

01:10:25,910 --> 01:10:24,320

you can't understand the equivalence

1965

01:10:27,990 --> 01:10:25,920

principle because the equivalence

1966

01:10:31,270 --> 01:10:28,000

principle says that

1967

01:10:34,709 --> 01:10:31,280

acceleration in flat space in

1968

01:10:38,709 --> 01:10:34,719

special relativity is locally equivalent

1969

01:10:39,189 --> 01:10:38,719

uh to um gravity uh in a curved space so

1970

01:10:42,310 --> 01:10:39,199

if you

1971

01:10:43,110 --> 01:10:42,320

special relativity makes no sense

1972

01:10:45,110 --> 01:10:43,120

whatsoever

1973

01:10:46,950 --> 01:10:45,120

so the whole point about general

1974

01:10:50,870 --> 01:10:46,960

relativity is that it uses

1975

01:10:52,470 --> 01:10:50,880

special relativity and generalizes it so

1976

01:10:53,990 --> 01:10:52,480

so that's another one of these things

1977

01:10:57,270 --> 01:10:54,000

another thing that

1978

01:10:58,229 --> 01:10:57,280

more recently upsets me is that you have

1979

01:11:01,669 --> 01:10:58,239

probably heard

1980

01:11:02,229 --> 01:11:01,679

that um there is a type of dark matter

1981

01:11:04,870 --> 01:11:02,239

that is

1982

01:11:07,750 --> 01:11:04,880

um increasing in popularity right now

1983

01:11:10,790 --> 01:11:07,760

which is called the axion

1984

01:11:11,910 --> 01:11:10,800

and the story that they always tell if

1985

01:11:14,149 --> 01:11:11,920

you read these

1986

01:11:15,510 --> 01:11:14,159

popular science articles is that the

1987

01:11:19,270 --> 01:11:15,520

axion was

1988

01:11:21,830 --> 01:11:19,280

proposed in the 1970s by frank wilczyk

1989

01:11:24,390 --> 01:11:21,840

and stephen weinberg independently

1990

01:11:25,750 --> 01:11:24,400

as a solution to a particular problem in

1991

01:11:27,430 --> 01:11:25,760

the standard model which is called the

1992

01:11:30,790 --> 01:11:27,440

strong cp problem

1993

01:11:33,110 --> 01:11:30,800

and that's true in that um

1994

01:11:34,709 --> 01:11:33,120

they proposed this particle in the 1970s

1995

01:11:37,430 --> 01:11:34,719

but what they don't tell you

1996

01:11:39,830 --> 01:11:37,440

is that this particle was ruled out two

1997

01:11:42,390 --> 01:11:39,840

years after it was proposed it's just

1998

01:11:45,030 --> 01:11:42,400

not compatible with observations

1999

01:11:45,510 --> 01:11:45,040

and the thing that they search for now

2000

01:11:59,350 --> 01:11:45,520

is

2001
01:12:00,550 --> 01:11:59,360
going on in the foundations of physics

2002
01:12:03,189 --> 01:12:00,560
more generally that

2003
01:12:04,870 --> 01:12:03,199
after a model has been ruled out

2004
01:12:05,350 --> 01:12:04,880
physicists don't give up on it and say

2005
01:12:07,270 --> 01:12:05,360
okay

2006
01:12:08,870 --> 01:12:07,280
this didn't work instead they will

2007
01:12:10,950 --> 01:12:08,880
fiddle with the model

2008
01:12:12,470 --> 01:12:10,960
uh until it's compatible with data again

2009
01:12:14,070 --> 01:12:12,480
then it will do another experiment and

2010
01:12:15,430 --> 01:12:14,080
it would rule it out again and then they

2011
01:12:17,430 --> 01:12:15,440
put it with the model again and and

2012
01:12:19,510 --> 01:12:17,440
that's been going on for 40 years

2013
01:12:20,709 --> 01:12:19,520

so i feel that by leaving out this part

2014

01:12:24,550 --> 01:12:20,719

of the history

2015

01:12:34,830 --> 01:12:24,560

people get a very wrong impression of