

## Usual Assumptions

- ⊗ Materialism/Realism
  - *things in space?*
  - *objects vs differences*
- ⊗ Reductionism (whole =  $\Sigma$  parts)
  - *parts + interactions*
- ⊗ Randomness (causeless events)
  - *quantum measurement*
- Cause and Effect (unidirectional)

1  
00:00:06,869 --> 00:00:04,950  
well i want to talk about

2  
00:00:08,470 --> 00:00:06,879  
where it all starts

3  
00:00:10,629 --> 00:00:08,480  
the foundations

4  
00:00:12,549 --> 00:00:10,639  
the the the deeper understanding that we

5  
00:00:13,990 --> 00:00:12,559  
would all like about what's going on in

6  
00:00:14,709 --> 00:00:14,000  
the world and particularly what's going

7  
00:00:16,950 --> 00:00:14,719  
on

8  
00:00:19,029 --> 00:00:16,960  
in the universe as a whole how it got

9  
00:00:21,269 --> 00:00:19,039  
this way and how

10  
00:00:23,029 --> 00:00:21,279  
uh any understanding that we might have

11  
00:00:25,590 --> 00:00:23,039  
of the universe as a whole could be

12  
00:00:27,349 --> 00:00:25,600  
applied locally to our own situations

13  
00:00:31,910 --> 00:00:27,359

and to some of the phenomenon that we're

14

00:00:36,549 --> 00:00:35,510

bernie talked about the constants

15

00:00:40,310 --> 00:00:36,559

of the

16

00:00:42,709 --> 00:00:40,320

universe and

17

00:00:45,270 --> 00:00:42,719

i won't say a whole lot more about that

18

00:00:47,830 --> 00:00:45,280

but it's worth just reflecting on the

19

00:00:50,549 --> 00:00:47,840

fact that it seems that there are a few

20

00:00:52,549 --> 00:00:50,559

numbers a few constants a few parameters

21

00:00:54,549 --> 00:00:52,559

that uh determine a great deal of what

22

00:00:56,470 --> 00:00:54,559

goes on in the universe and

23

00:00:58,709 --> 00:00:56,480

um

24

00:00:59,590 --> 00:00:58,719

the phenomenon that take place within it

25

00:01:02,549 --> 00:00:59,600

and these

26

00:01:04,310 --> 00:01:02,559

constants seem at least to be

27

00:01:07,030 --> 00:01:04,320

somewhat independent and rather

28

00:01:09,510 --> 00:01:07,040

arbitrary and yet we know that in

29

00:01:10,390 --> 00:01:09,520

several cases these constants

30

00:01:12,789 --> 00:01:10,400

um

31

00:01:14,390 --> 00:01:12,799

are very finely tuned to support the

32

00:01:16,630 --> 00:01:14,400

kind of universe that we see and the

33

00:01:18,310 --> 00:01:16,640

life that we experience here

34

00:01:19,830 --> 00:01:18,320

and if they were different uh the

35

00:01:21,270 --> 00:01:19,840

universe would have been different and

36

00:01:22,630 --> 00:01:21,280

we would not have evolved to have

37

00:01:24,710 --> 00:01:22,640

noticed this

38

00:01:26,070 --> 00:01:24,720

so um

39

00:01:28,550 --> 00:01:26,080

there's a question about how it got

40

00:01:30,469 --> 00:01:28,560

there how those constants got that way

41

00:01:33,429 --> 00:01:30,479

and by the way how did all that stuff

42

00:01:37,510 --> 00:01:33,439

get out there in particular places

43

00:01:40,710 --> 00:01:39,109

even if we knew what those constants

44

00:01:41,910 --> 00:01:40,720

those parameters were to determine the

45

00:01:43,910 --> 00:01:41,920

physical laws and the properties of

46

00:01:46,230 --> 00:01:43,920

matter and energy we would still have

47

00:01:47,830 --> 00:01:46,240

this question of the initial condition

48

00:01:50,630 --> 00:01:47,840

why is it that the

49

00:01:52,069 --> 00:01:50,640

cosmic background radiation the oldest

50

00:01:54,310 --> 00:01:52,079

thing we can measure

51  
00:01:56,950 --> 00:01:54,320  
is not uniform as a matter of fact it

52  
00:01:57,910 --> 00:01:56,960  
seems to have some pattern to it big big

53  
00:01:59,109 --> 00:01:57,920  
mystery

54  
00:02:01,109 --> 00:01:59,119  
um

55  
00:02:02,870 --> 00:02:01,119  
how did it how did it get that way and

56  
00:02:05,749 --> 00:02:02,880  
how are these parameters derived could

57  
00:02:07,670 --> 00:02:05,759  
the universe be some other way

58  
00:02:09,669 --> 00:02:07,680  
the constants could be determined a lot

59  
00:02:12,390 --> 00:02:09,679  
of different ways here are four of them

60  
00:02:13,910 --> 00:02:12,400  
by some supernatural being

61  
00:02:14,949 --> 00:02:13,920  
perhaps they're determined at random and

62  
00:02:16,710 --> 00:02:14,959  
there are a lot of different

63  
00:02:18,550 --> 00:02:16,720

subuniverses that have different values

64

00:02:20,390 --> 00:02:18,560

for these constants in which case we

65

00:02:22,550 --> 00:02:20,400

sort of invoke an anthropo

66

00:02:24,630 --> 00:02:22,560

anthropic principle

67

00:02:26,070 --> 00:02:24,640

um

68

00:02:27,830 --> 00:02:26,080

those constants and those laws could

69

00:02:30,390 --> 00:02:27,840

have been in some way determined by our

70

00:02:33,030 --> 00:02:30,400

interactions with them our observations

71

00:02:34,949 --> 00:02:33,040

we created all by observing uh somewhat

72

00:02:36,710 --> 00:02:34,959

like similar

73

00:02:39,110 --> 00:02:36,720

previous uh talk

74

00:02:41,190 --> 00:02:39,120

or the the case that i'm more interested

75

00:02:43,589 --> 00:02:41,200

in perhaps that these constant really

76

00:02:45,270 --> 00:02:43,599

aren't independent and arbitrary but

77

00:02:47,350 --> 00:02:45,280

rather are mathematically derived and

78

00:02:49,190 --> 00:02:47,360

related in some interesting way so i'll

79

00:02:52,390 --> 00:02:49,200

give a couple of thoughts about that i'm

80

00:02:54,869 --> 00:02:52,400

reminded of clark's third law and by the

81

00:02:56,229 --> 00:02:54,879

way he added a fourth law in 99 for

82

00:02:59,270 --> 00:02:56,239

every expert there's an equal and

83

00:03:02,710 --> 00:03:00,710

if you've ever been involved in patent

84

00:03:05,190 --> 00:03:02,720

litigation as i have

85

00:03:07,110 --> 00:03:05,200

this is very uh apropos

86

00:03:09,110 --> 00:03:07,120

so i think it's uh

87

00:03:11,190 --> 00:03:09,120

any sufficiently advanced technology is

88

00:03:14,229 --> 00:03:11,200

indistinguishable from god we're really

89

00:03:16,070 --> 00:03:14,239

not imaginative enough to think of what

90

00:03:17,509 --> 00:03:16,080

advanced technology really advanced

91

00:03:19,670 --> 00:03:17,519

technology could be

92

00:03:22,390 --> 00:03:19,680

like and

93

00:03:24,550 --> 00:03:22,400

to say as some would say that they can't

94

00:03:26,790 --> 00:03:24,560

be here because it would violate the

95

00:03:28,710 --> 00:03:26,800

speed of light and too much energy is

96

00:03:30,710 --> 00:03:28,720

involved and all that kind of stuff

97

00:03:33,270 --> 00:03:30,720

is nonsense they have complete

98

00:03:34,710 --> 00:03:33,280

control of time and space and a lot more

99

00:03:37,030 --> 00:03:34,720

things that we haven't even thought of

100

00:03:38,789 --> 00:03:37,040

yet so

101  
00:03:41,750 --> 00:03:38,799  
if you think you have a guardian angel

102  
00:03:43,910 --> 00:03:41,760  
or some interaction with god i don't see

103  
00:03:46,390 --> 00:03:43,920  
any way to rule out that as being

104  
00:03:48,789 --> 00:03:46,400  
interaction with really advanced beings

105  
00:03:50,710 --> 00:03:48,799  
in advanced technology

106  
00:03:52,710 --> 00:03:50,720  
but beside the point back to physical

107  
00:03:55,430 --> 00:03:52,720  
constants here are some of them

108  
00:03:57,429 --> 00:03:55,440  
um bernie gave a nice summary of

109  
00:03:59,190 --> 00:03:57,439  
of a particular list michi akaku thinks

110  
00:04:02,630 --> 00:03:59,200  
maybe there are 19 numbers enumerates

111  
00:04:04,309 --> 00:04:02,640  
those john baez counts 26 numbers

112  
00:04:06,149 --> 00:04:04,319  
martin reese's book just six numbers

113  
00:04:07,030 --> 00:04:06,159

which is a very nice read

114

00:04:09,030 --> 00:04:07,040

um

115

00:04:10,949 --> 00:04:09,040

uh derives the basis in an entirely

116

00:04:11,830 --> 00:04:10,959

different way using dimensionless

117

00:04:14,070 --> 00:04:11,840

numbers

118

00:04:16,229 --> 00:04:14,080

number of spatial dimensions and so on

119

00:04:18,229 --> 00:04:16,239

another interesting way of saying how

120

00:04:19,590 --> 00:04:18,239

many degrees of freedom are there

121

00:04:24,629 --> 00:04:19,600

maybe the real number is somewhere

122

00:04:26,230 --> 00:04:24,639

between 6 and 26 i don't i don't know

123

00:04:27,590 --> 00:04:26,240

the usual assumptions that are made

124

00:04:30,150 --> 00:04:27,600

before we start thinking about these

125

00:04:32,310 --> 00:04:30,160

things i have some trouble with

126  
00:04:34,469 --> 00:04:32,320  
not because the principles are

127  
00:04:35,749 --> 00:04:34,479  
necessarily invalid for any reason but

128  
00:04:36,950 --> 00:04:35,759  
because of the way they're usually

129  
00:04:39,430 --> 00:04:36,960  
thought about

130  
00:04:42,150 --> 00:04:39,440  
materialism usually means there's stuff

131  
00:04:44,070 --> 00:04:42,160  
out there there are things in space

132  
00:04:46,710 --> 00:04:44,080  
whether those things are particles and

133  
00:04:50,469 --> 00:04:46,720  
fields or whether they are strings or

134  
00:04:53,909 --> 00:04:52,550  
i'm much more tending these days toward

135  
00:04:56,310 --> 00:04:53,919  
thinking about differences and

136  
00:04:59,110 --> 00:04:56,320  
boundaries and transitions rather than

137  
00:05:00,870 --> 00:04:59,120  
the objects to me the

138  
00:05:02,310 --> 00:05:00,880

the differences define the objects not

139

00:05:04,629 --> 00:05:02,320

the other way around

140

00:05:06,230 --> 00:05:04,639

and there's some precedence for this so

141

00:05:07,590 --> 00:05:06,240

maybe be able to go into that a little

142

00:05:09,029 --> 00:05:07,600

bit more later

143

00:05:10,469 --> 00:05:09,039

reductionism

144

00:05:12,310 --> 00:05:10,479

the idea that the whole is equal to some

145

00:05:13,830 --> 00:05:12,320

of the parts people always say no no

146

00:05:15,830 --> 00:05:13,840

something emerges when you get all the

147

00:05:18,230 --> 00:05:15,840

parts together that wasn't there among

148

00:05:20,150 --> 00:05:18,240

the parts forgetting that if you know

149

00:05:22,070 --> 00:05:20,160

the parts and all their interactions you

150

00:05:23,590 --> 00:05:22,080

really do have the whole nevertheless

151

00:05:26,070 --> 00:05:23,600

reductionism is not the only way to

152

00:05:27,990 --> 00:05:26,080

understand things and i would like to

153

00:05:29,749 --> 00:05:28,000

promote more constructivism that is

154

00:05:31,909 --> 00:05:29,759

starting from first principles or no

155

00:05:34,070 --> 00:05:31,919

principles and building upwards as well

156

00:05:35,909 --> 00:05:34,080

as reductionism taking things apart and

157

00:05:38,469 --> 00:05:35,919

trying to figure out how they work

158

00:05:40,870 --> 00:05:38,479

so the usual interpretation of that

159

00:05:42,870 --> 00:05:40,880

bothers me a bit randomness and the idea

160

00:05:44,230 --> 00:05:42,880

that there are truly causeless events at

161

00:05:46,310 --> 00:05:44,240

the core of physics

162

00:05:47,830 --> 00:05:46,320

i've totally um

163

00:05:49,430 --> 00:05:47,840

bogus that one it seems to me that

164

00:05:50,629 --> 00:05:49,440

quantum measurement is not random at all

165

00:05:53,270 --> 00:05:50,639

and there's a big mistake that we've

166

00:05:54,790 --> 00:05:53,280

been making by making that assumption

167

00:05:56,550 --> 00:05:54,800

and it is an assumption in quantum

168

00:05:57,830 --> 00:05:56,560

mechanics it just happens to work very

169

00:05:59,430 --> 00:05:57,840

well so

170

00:06:01,110 --> 00:05:59,440

we believe it but

171

00:06:03,110 --> 00:06:01,120

i don't think anything is truly random

172

00:06:05,110 --> 00:06:03,120

in the sense of being a causeless event

173

00:06:06,469 --> 00:06:05,120

even at the core of physics cause and

174

00:06:09,029 --> 00:06:06,479

effects might might be the most

175

00:06:10,309 --> 00:06:09,039

pernicious about of these in the sense

176

00:06:12,390 --> 00:06:10,319

that everyone thinks about cause and

177

00:06:14,950 --> 00:06:12,400

effect as a unidirectional

178

00:06:16,710 --> 00:06:14,960

uh thing and uh this leads to the idea

179

00:06:18,309 --> 00:06:16,720

of time as a dimension and flowing in

180

00:06:20,070 --> 00:06:18,319

one direction and so on

181

00:06:21,270 --> 00:06:20,080

bad idea it seems to me that physics is

182

00:06:24,309 --> 00:06:21,280

telling us that everything is

183

00:06:26,469 --> 00:06:24,319

symmetrical in time and that

184

00:06:28,230 --> 00:06:26,479

all relationships of the causal nature

185

00:06:29,830 --> 00:06:28,240

are bi-directional

186

00:06:32,230 --> 00:06:29,840

and

187

00:06:34,230 --> 00:06:32,240

influence travels in both directions

188

00:06:35,909 --> 00:06:34,240

if we take these assumptions and

189

00:06:38,070 --> 00:06:35,919

formalize them in some way we usually

190

00:06:41,110 --> 00:06:38,080

get what's called a system of axioms you

191

00:06:42,870 --> 00:06:41,120

could say the standard model of

192

00:06:44,870 --> 00:06:42,880

physics is a kind of set of formal

193

00:06:46,790 --> 00:06:44,880

assumptions quantum theory in

194

00:06:49,029 --> 00:06:46,800

mathematics set theory and predicate

195

00:06:50,870 --> 00:06:49,039

calculus and so forth so we tend to

196

00:06:51,830 --> 00:06:50,880

formalize this and one might say that

197

00:06:53,270 --> 00:06:51,840

the

198

00:06:55,430 --> 00:06:53,280

more complex

199

00:06:57,670 --> 00:06:55,440

well let's say the less complex the set

200

00:06:59,110 --> 00:06:57,680

of axioms and beliefs are the more

201  
00:07:00,469 --> 00:06:59,120  
likely it is that we're close to the

202  
00:07:01,990 --> 00:07:00,479  
bottom that we're close to really

203  
00:07:04,710 --> 00:07:02,000  
understanding something or closer to

204  
00:07:06,950 --> 00:07:04,720  
bedrock and the more complex things are

205  
00:07:09,589 --> 00:07:06,960  
the reverse so here's an example from

206  
00:07:11,589 --> 00:07:09,599  
mathematics the zamelo frankel and the

207  
00:07:14,230 --> 00:07:11,599  
axiom of choice set theory

208  
00:07:16,550 --> 00:07:14,240  
eight axioms two of which at least are

209  
00:07:18,710 --> 00:07:16,560  
infinite axiom schema

210  
00:07:21,110 --> 00:07:18,720  
now i ask you does this look like we

211  
00:07:23,350 --> 00:07:21,120  
really understand the foundations of set

212  
00:07:25,510 --> 00:07:23,360  
theory or maybe sets are not such a good

213  
00:07:27,589 --> 00:07:25,520

idea in the first place which is where

214

00:07:29,510 --> 00:07:27,599

where it's where i go

215

00:07:31,510 --> 00:07:29,520

uh henry prank

216

00:07:33,270 --> 00:07:31,520

carre said later generations will regard

217

00:07:35,350 --> 00:07:33,280

set theory is a disease from which one

218

00:07:37,189 --> 00:07:35,360

has recovered well we haven't recovered

219

00:07:38,469 --> 00:07:37,199

yet this is really one of the most

220

00:07:41,110 --> 00:07:38,479

fundamental things that are taught in

221

00:07:43,270 --> 00:07:41,120

mathematics

222

00:07:45,510 --> 00:07:43,280

congruent versus deep

223

00:07:47,110 --> 00:07:45,520

models a congruent model is really a

224

00:07:50,550 --> 00:07:47,120

kind of a theory it's an abstract

225

00:07:51,909 --> 00:07:50,560

something another that we sometimes

226

00:07:54,150 --> 00:07:51,919

try to tune

227

00:07:56,710 --> 00:07:54,160

to be the same shape as whatever it is

228

00:07:59,430 --> 00:07:56,720

we're modeling and so the more tuning is

229

00:08:02,309 --> 00:07:59,440

necessary that added assumptions and fud

230

00:08:04,710 --> 00:08:02,319

factors show up and and this is not

231

00:08:07,110 --> 00:08:04,720

necessarily explaining things but merely

232

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

modeling them so we can do stuff and try

233

00:08:11,270 --> 00:08:08,560

things to the model

234

00:08:14,070 --> 00:08:11,280

that will then be reflected in the in

235

00:08:16,070 --> 00:08:14,080

the real world somehow whereas a deeper

236

00:08:18,230 --> 00:08:16,080

model has something that's simpler and

237

00:08:21,110 --> 00:08:18,240

is really more fundamental and more like

238

00:08:23,110 --> 00:08:21,120

how it really is how the the phenomenon

239

00:08:24,629 --> 00:08:23,120

or whatever it is is actually generated

240

00:08:26,869 --> 00:08:24,639

and tells us something more about its

241

00:08:28,950 --> 00:08:26,879

place in the world here are some

242

00:08:31,110 --> 00:08:28,960

discrete physical models that i think

243

00:08:33,350 --> 00:08:31,120

are really um becoming more and more

244

00:08:35,190 --> 00:08:33,360

interesting

245

00:08:37,589 --> 00:08:35,200

string theory hasn't quite paid off but

246

00:08:39,110 --> 00:08:37,599

still there's something very importantly

247

00:08:41,589 --> 00:08:39,120

correct about it even if it's not the

248

00:08:44,389 --> 00:08:41,599

whole story even in the standard model

249

00:08:46,949 --> 00:08:44,399

group symmetries as an abstract

250

00:08:49,190 --> 00:08:46,959

idea can model three of the four forces

251

00:08:50,949 --> 00:08:49,200

at least in some respects

252

00:08:53,110 --> 00:08:50,959

some of you may have seen causal

253

00:08:55,670 --> 00:08:53,120

dynamical triangulations