

Unlocking Zero-Point Energy

Garret Moddel



**SOCIETY
FOR
SCIENTIFIC
EXPLORATION**

1
00:00:07,829 --> 00:00:06,150

[Music]

2
00:00:09,589 --> 00:00:07,839

hello folks thank you for the

3
00:00:12,870 --> 00:00:09,599

opportunity to speak about what we've

4
00:00:15,749 --> 00:00:12,880

been working on for the last few years

5
00:00:18,230 --> 00:00:15,759

we've been looking at harvesting zero

6
00:00:21,830 --> 00:00:18,240

point energy and today what i'd like to

7
00:00:24,070 --> 00:00:21,840

do is talk to you not only about zero

8
00:00:27,269 --> 00:00:24,080

point energy and the technology that

9
00:00:30,870 --> 00:00:27,279

we've been working on but also about my

10
00:00:33,350 --> 00:00:30,880

journey and the scientific interactions

11
00:00:35,510 --> 00:00:33,360

that we've had in these organizations

12
00:00:37,590 --> 00:00:35,520

that we're in we tend to deal with

13
00:00:40,549 --> 00:00:37,600

skeptics and

14

00:00:43,350 --> 00:00:40,559

data and

15

00:00:45,430 --> 00:00:43,360

trying to convince people

16

00:00:47,990 --> 00:00:45,440

what i find interesting in this work

17

00:00:51,029 --> 00:00:48,000

we're doing now is that what we're doing

18

00:00:53,750 --> 00:00:51,039

is physics it's it's uh uh

19

00:00:56,549 --> 00:00:53,760

based upon standard physical principles

20

00:00:58,790 --> 00:00:56,559

and yet we're also interacting with the

21

00:01:01,110 --> 00:00:58,800

same sort of skepticism and doubt that

22

00:01:04,310 --> 00:01:01,120

we do in some of the more

23

00:01:07,270 --> 00:01:04,320

uh exotic topics that we deal with

24

00:01:08,950 --> 00:01:07,280

so let's take a look at the journey that

25

00:01:09,910 --> 00:01:08,960

we're going through

26

00:01:11,030 --> 00:01:09,920

uh

27

00:01:14,070 --> 00:01:11,040

in doing

28

00:01:15,270 --> 00:01:14,080

our in in working on our technology we

29

00:01:17,030 --> 00:01:15,280

have to

30

00:01:19,510 --> 00:01:17,040

uh deal with

31

00:01:21,749 --> 00:01:19,520

uh the second law of thermodynamics

32

00:01:23,270 --> 00:01:21,759

because the second law of thermodynamics

33

00:01:24,789 --> 00:01:23,280

among other things and we'll be getting

34

00:01:27,830 --> 00:01:24,799

into that

35

00:01:28,789 --> 00:01:27,840

says that you can't you can't harvest

36

00:01:31,510 --> 00:01:28,799

energy

37

00:01:33,910 --> 00:01:31,520

from uh the background uh that would

38

00:01:36,069 --> 00:01:33,920

that would violate the second law and so

39

00:01:37,590 --> 00:01:36,079

if in fact that's what we're doing it

40

00:01:39,030 --> 00:01:37,600

would appear to be a violation of the

41

00:01:40,789 --> 00:01:39,040

second law

42

00:01:43,109 --> 00:01:40,799

so we've been working on this for a

43

00:01:44,149 --> 00:01:43,119

number of years and i interacted with a

44

00:01:46,630 --> 00:01:44,159

colleague

45

00:01:49,590 --> 00:01:46,640

who is a very respected physicist and a

46

00:01:50,950 --> 00:01:49,600

nice guy and he looked through our data

47

00:01:51,749 --> 00:01:50,960

and he said

48

00:01:54,710 --> 00:01:51,759

uh

49

00:01:55,510 --> 00:01:54,720

this seems to be okay

50

00:01:58,069 --> 00:01:55,520

but

51
00:02:01,350 --> 00:01:58,079
and so we went back and forth by email

52
00:02:03,590 --> 00:02:01,360
and this is from one of the final emails

53
00:02:06,789 --> 00:02:03,600
that he sent to me

54
00:02:08,710 --> 00:02:06,799
he said hi garrett look most people are

55
00:02:10,869 --> 00:02:08,720
not going to believe your paper and

56
00:02:13,430 --> 00:02:10,879
that's with good reason it's almost

57
00:02:15,030 --> 00:02:13,440
certainly wrong like every other paper

58
00:02:16,150 --> 00:02:15,040
that has claimed to get something from

59
00:02:18,229 --> 00:02:16,160
nothing

60
00:02:21,190 --> 00:02:18,239
there have been many many people saying

61
00:02:22,470 --> 00:02:21,200
the second law is wrong so far they've

62
00:02:24,550 --> 00:02:22,480
all been wrong

63
00:02:26,710 --> 00:02:24,560

yours might after all the failures be

64

00:02:29,110 --> 00:02:26,720

the first success but that's not how the

65

00:02:31,190 --> 00:02:29,120

smart money is going to bet i'm not

66

00:02:33,589 --> 00:02:31,200

ignoring your data i'm just balancing

67

00:02:35,589 --> 00:02:33,599

your data against all the data that says

68

00:02:36,710 --> 00:02:35,599

the second law of thermodynamics isn't

69

00:02:39,270 --> 00:02:36,720

viable

70

00:02:42,070 --> 00:02:39,280

it's not a great statement

71

00:02:44,309 --> 00:02:42,080

and he he raises good points so let's

72

00:02:45,589 --> 00:02:44,319

see what this is all about

73

00:02:47,430 --> 00:02:45,599

so

74

00:02:50,470 --> 00:02:47,440

in this journey i'm first going to talk

75

00:02:53,190 --> 00:02:50,480

about zero point energy what it is where

76
00:02:54,630 --> 00:02:53,200
it came from and what in general we

77
00:02:56,949 --> 00:02:54,640
think uh

78
00:02:59,589 --> 00:02:56,959
it might be from

79
00:03:01,270 --> 00:02:59,599
uh then we'll talk about the challenges

80
00:03:04,390 --> 00:03:01,280
in harvesting it

81
00:03:05,910 --> 00:03:04,400
and ways to meet those challenges

82
00:03:07,990 --> 00:03:05,920
at that point we'll get into our

83
00:03:09,509 --> 00:03:08,000
technology and talk about the device and

84
00:03:11,270 --> 00:03:09,519
the results and

85
00:03:12,229 --> 00:03:11,280
everything we've been looking at

86
00:03:13,830 --> 00:03:12,239
and then

87
00:03:16,550 --> 00:03:13,840
step back a little bit and look at the

88
00:03:17,509 --> 00:03:16,560

implications of this technology for the

89

00:03:19,270 --> 00:03:17,519

world

90

00:03:20,869 --> 00:03:19,280

to step back again and look at the

91

00:03:23,990 --> 00:03:20,879

implications for the second law of

92

00:03:24,869 --> 00:03:24,000

thermodynamics and what issues we have

93

00:03:27,430 --> 00:03:24,879

there

94

00:03:28,390 --> 00:03:27,440

we'll take a look at the objections and

95

00:03:33,910 --> 00:03:28,400

uh

96

00:03:36,390 --> 00:03:33,920

and then finally we step back a little

97

00:03:39,270 --> 00:03:36,400

bit farther and say how do we make

98

00:03:41,509 --> 00:03:39,280

science work better is it working right

99

00:03:44,710 --> 00:03:41,519

how do you find the balance between

100

00:03:45,509 --> 00:03:44,720

skepticism and acceptance

101
00:03:47,750 --> 00:03:45,519
and

102
00:03:49,910 --> 00:03:47,760
could our results be valid or are we

103
00:03:52,949 --> 00:03:49,920
deluding ourselves

104
00:03:55,030 --> 00:03:52,959
okay so let's get going so the first

105
00:03:57,589 --> 00:03:55,040
issue that we're going to be looking at

106
00:03:58,390 --> 00:03:57,599
is zero point energy itself of what it

107
00:04:02,550 --> 00:03:58,400
is

108
00:04:04,789 --> 00:04:02,560
uh and its origins uh are twofold

109
00:04:08,470 --> 00:04:04,799
uh in uh

110
00:04:09,910 --> 00:04:08,480
in 1900 max planck uh

111
00:04:13,350 --> 00:04:09,920
developed

112
00:04:15,509 --> 00:04:13,360
the idea of what became known as the

113
00:04:18,069 --> 00:04:15,519

planck distribution function

114

00:04:20,710 --> 00:04:18,079

and he was trying to model the black

115

00:04:24,629 --> 00:04:20,720

body thermal distribution of energy

116

00:04:25,749 --> 00:04:24,639

that's all around us and he found that

117

00:04:27,749 --> 00:04:25,759

in fact

118

00:04:30,230 --> 00:04:27,759

there was a problem in the way that it

119

00:04:33,030 --> 00:04:30,240

had been modeled and he needed to model

120

00:04:35,350 --> 00:04:33,040

it with this parameter h

121

00:04:37,909 --> 00:04:35,360

which became known as planck's constant

122

00:04:39,990 --> 00:04:37,919

but more important from our perspective

123

00:04:41,430 --> 00:04:40,000

is that he found that it's temperature

124

00:04:43,749 --> 00:04:41,440

dependent and he put a temperature

125

00:04:46,870 --> 00:04:43,759

dependence into the blackbody

126

00:04:48,310 --> 00:04:46,880

distribution and this is what today is

127

00:04:49,830 --> 00:04:48,320

known as the planck distribution

128

00:04:51,430 --> 00:04:49,840

function

129

00:04:52,629 --> 00:04:51,440

and

130

00:04:56,629 --> 00:04:52,639

this was

131

00:04:57,830 --> 00:04:56,639

mechanics he was the grandfather of the

132

00:05:01,189 --> 00:04:57,840

whole field

133

00:05:05,029 --> 00:05:01,199

and it started off our new understanding

134

00:05:07,189 --> 00:05:05,039

but about 11 years later he'd been

135

00:05:09,510 --> 00:05:07,199

dealing with the fact that his theory

136

00:05:11,830 --> 00:05:09,520

didn't quite match

137

00:05:13,430 --> 00:05:11,840

the data and he found that he needed to

138

00:05:15,430 --> 00:05:13,440

add another term

139

00:05:18,629 --> 00:05:15,440

and so this other term

140

00:05:20,870 --> 00:05:18,639

is uh hf the blanks planck's constant

141

00:05:21,990 --> 00:05:20,880

times the frequency over two

142

00:05:24,469 --> 00:05:22,000

and

143

00:05:25,670 --> 00:05:24,479

it is not temperature dependent as you

144

00:05:29,749 --> 00:05:25,680

can see

145

00:05:32,870 --> 00:05:29,759

uh and this uh became known as zero

146

00:05:34,870 --> 00:05:32,880

point energy and he included it simply

147

00:05:38,790 --> 00:05:34,880

because it was

148

00:05:42,150 --> 00:05:38,800

uh necessary to uh match uh

149

00:05:44,950 --> 00:05:42,160

the experiment and uh his formula

150

00:05:46,550 --> 00:05:44,960

uh but it was largely ignored by the uh

151

00:05:50,390 --> 00:05:46,560

physics community

152

00:05:52,950 --> 00:05:50,400

until uh a a couple of decades later

153

00:05:54,550 --> 00:05:52,960

really when uh this zero point energy

154

00:05:55,749 --> 00:05:54,560

had a resurgence

155

00:05:57,110 --> 00:05:55,759

due to

156

00:05:59,189 --> 00:05:57,120

um

157

00:06:01,350 --> 00:05:59,199

the uncertainty principle and we'll be

158

00:06:04,629 --> 00:06:01,360

getting into that in a minute so what

159

00:06:07,749 --> 00:06:04,639

are the consequences of this uh

160

00:06:10,469 --> 00:06:07,759

zero point energy so here i have a plot

161

00:06:12,950 --> 00:06:10,479

of the density of energy of radiation

162

00:06:15,430 --> 00:06:12,960

all around us in the vacuum everywhere

163

00:06:18,309 --> 00:06:15,440

as a function of photon energy so photon

164

00:06:19,909 --> 00:06:18,319

energy is proportional to the frequency

165

00:06:22,710 --> 00:06:19,919

uh or inversely proportional to the

166

00:06:24,950 --> 00:06:22,720

wavelength this is the infrared light

167

00:06:27,350 --> 00:06:24,960

down here this is

168

00:06:30,469 --> 00:06:27,360

ultraviolet light and this is visible

169

00:06:32,629 --> 00:06:30,479

and so you see this rounded curve here

170

00:06:33,909 --> 00:06:32,639

is the thermal black body radiation

171

00:06:36,550 --> 00:06:33,919

curve

172

00:06:38,309 --> 00:06:36,560

it is the radiation coming from

173

00:06:40,790 --> 00:06:38,319

everything from the ambient that's all

174

00:06:42,550 --> 00:06:40,800

around us

175

00:06:45,510 --> 00:06:42,560

we don't see it

176

00:06:48,710 --> 00:06:45,520

at night for example because it's in the

177

00:06:51,110 --> 00:06:48,720

infrared so we don't have a vision in

178

00:06:53,510 --> 00:06:51,120

the infrared and if we did we would be

179

00:06:55,510 --> 00:06:53,520

able to see it

180

00:06:59,189 --> 00:06:55,520

but that's not what i want to talk about

181

00:07:02,870 --> 00:06:59,199

here there's also this other term and

182

00:07:05,029 --> 00:07:02,880

this is the hf over two term uh in the

183

00:07:07,670 --> 00:07:05,039

in the formula and this is the quantum

184

00:07:10,070 --> 00:07:07,680

vacuum or zero point energy radiation

185

00:07:12,629 --> 00:07:10,080

and it just goes up and up and up and up

186

00:07:15,510 --> 00:07:12,639

as you increase photon energy and

187

00:07:16,550 --> 00:07:15,520

there's a huge amount of energy density

188

00:07:19,830 --> 00:07:16,560

in

189

00:07:22,230 --> 00:07:19,840

space all around us because of this zero

190

00:07:25,749 --> 00:07:22,240

point energy radiation

191

00:07:28,070 --> 00:07:25,759

this is a fairly well established

192

00:07:31,029 --> 00:07:28,080

fact in

193

00:07:32,870 --> 00:07:31,039

quantum theory and there isn't too much

194

00:07:34,309 --> 00:07:32,880

debate about it

195

00:07:37,589 --> 00:07:34,319

um

196

00:07:41,510 --> 00:07:37,599

it comes about uh as i said two

197

00:07:44,469 --> 00:07:41,520

different ways it fills all space

198

00:07:45,830 --> 00:07:44,479

it was proposed originally by planck

199

00:07:47,430 --> 00:07:45,840

and

200

00:07:49,670 --> 00:07:47,440

then later from the uncertainty

201
00:07:52,150 --> 00:07:49,680
principle so the uncertainty principle

202
00:07:53,510 --> 00:07:52,160
says that you cannot know to absolute

203
00:07:55,189 --> 00:07:53,520
precision

204
00:07:57,029 --> 00:07:55,199
two

205
00:07:59,749 --> 00:07:57,039
different types of complementary

206
00:08:02,469 --> 00:07:59,759
variables at the same time for example

207
00:08:03,670 --> 00:08:02,479
you cannot know the absolute

208
00:08:05,990 --> 00:08:03,680
precision

209
00:08:09,029 --> 00:08:06,000
of where a particle is

210
00:08:11,270 --> 00:08:09,039
and its momentum or velocity at the same

211
00:08:13,029 --> 00:08:11,280
time either you know where it is or you

212
00:08:14,710 --> 00:08:13,039
know how fast it's moving but you can't

213
00:08:17,990 --> 00:08:14,720

know both

214

00:08:20,150 --> 00:08:18,000

therefore if a particle sat still it

215

00:08:22,390 --> 00:08:20,160

you'd know both and so no particle

216

00:08:25,270 --> 00:08:22,400

stands sit still so the uncertainty

217

00:08:27,110 --> 00:08:25,280

principle says nothing sits still

218

00:08:29,909 --> 00:08:27,120

and because nothing sits still it all

219

00:08:32,469 --> 00:08:29,919

wiggles that is zero point energy and

220

00:08:34,630 --> 00:08:32,479

not only do particles wiggle but free

221

00:08:36,949 --> 00:08:34,640

space itself wiggles and that's in the

222

00:08:38,389 --> 00:08:36,959

form of electromagnetic

223

00:08:39,829 --> 00:08:38,399

vibrations

224

00:08:41,509 --> 00:08:39,839

and also

225

00:08:43,750 --> 00:08:41,519

particles coming into and out of

226
00:08:44,710 --> 00:08:43,760
existence

227
00:08:46,070 --> 00:08:44,720
and so

228
00:08:48,949 --> 00:08:46,080
really the

229
00:08:51,590 --> 00:08:48,959
origin of zero point energy

230
00:08:53,110 --> 00:08:51,600
is intimately tied to the uncertainty

231
00:08:54,630 --> 00:08:53,120
principle

232
00:08:56,150 --> 00:08:54,640
there's another way of expressing the

233
00:08:59,670 --> 00:08:56,160
uncertainty principle and that is the

234
00:09:01,430 --> 00:08:59,680
uncertainty in the amount of time that

235
00:09:04,230 --> 00:09:01,440
something lives for

236
00:09:06,230 --> 00:09:04,240
is inversely proportional to the amount

237
00:09:08,949 --> 00:09:06,240
of energy that it has so you can

238
00:09:11,350 --> 00:09:08,959

actually violate conservation of energy

239

00:09:14,150 --> 00:09:11,360

for a very very short time and the

240

00:09:16,230 --> 00:09:14,160

shorter the time is the more energy you

241

00:09:18,630 --> 00:09:16,240

can have but then the energy blips away

242

00:09:21,110 --> 00:09:18,640

and it goes away again

243

00:09:25,350 --> 00:09:21,120

and uh so we're going to take a look at

244

00:09:27,030 --> 00:09:25,360

that okay so that's what a zero-point

245

00:09:29,350 --> 00:09:27,040

energy is

246

00:09:31,110 --> 00:09:29,360

all sorts of people have been thinking

247

00:09:32,710 --> 00:09:31,120

about harvesting it and some have

248

00:09:35,190 --> 00:09:32,720

claimed to

249

00:09:37,350 --> 00:09:35,200

but there are some fundamental issues in

250

00:09:39,509 --> 00:09:37,360

trying to harvest it so from my

251
00:09:42,470 --> 00:09:39,519
perspective it really boils down to

252
00:09:43,990 --> 00:09:42,480
three main issues that are problematic

253
00:09:46,470 --> 00:09:44,000
the first issue

254
00:09:49,190 --> 00:09:46,480
is that the zero point state is the

255
00:09:50,949 --> 00:09:49,200
universal ground state everything all

256
00:09:53,030 --> 00:09:50,959
matter all space

257
00:09:55,509 --> 00:09:53,040
has this unit this

258
00:09:58,710 --> 00:09:55,519
zero point energy everywhere so if

259
00:10:01,670 --> 00:09:58,720
something is universal and flat in its

260
00:10:03,590 --> 00:10:01,680
distribution how do you cause a flow how

261
00:10:05,750 --> 00:10:03,600
do you cause it to flow from one place

262
00:10:07,829 --> 00:10:05,760
to another you can't

263
00:10:09,990 --> 00:10:07,839

not if it's it's if it's a universal

264

00:10:11,590 --> 00:10:10,000

ground state and so that's a fundamental

265

00:10:13,990 --> 00:10:11,600

argument as to why you can't harvest

266

00:10:16,790 --> 00:10:14,000

syrup and energy

267

00:10:18,949 --> 00:10:16,800

another one has to do with this pesky

268

00:10:22,310 --> 00:10:18,959

second law of thermodynamics

269

00:10:24,949 --> 00:10:22,320

and so this is an equilibrium state

270

00:10:27,269 --> 00:10:24,959

where everything is in balance there's

271

00:10:30,630 --> 00:10:27,279

no net flows of anything

272

00:10:33,110 --> 00:10:30,640

and therefore how could you violate that

273

00:10:34,310 --> 00:10:33,120

to get a net flow of energy out of the

274

00:10:36,230 --> 00:10:34,320

vacuum

275

00:10:38,230 --> 00:10:36,240

and then the third problem is this one i

276

00:10:41,110 --> 00:10:38,240

mentioned about the very short

277

00:10:43,110 --> 00:10:41,120

fluctuation nature of zero point energy

278

00:10:45,990 --> 00:10:43,120

the fluctuations come into and out of

279

00:10:47,509 --> 00:10:46,000

existence very very quickly and so how

280

00:10:50,470 --> 00:10:47,519

could you possibly deal with them so

281

00:10:53,509 --> 00:10:50,480

let's talk about these three in turn

282

00:10:56,230 --> 00:10:53,519

first the issue of the universal ground

283

00:10:57,269 --> 00:10:56,240

state well can we modify the ground

284

00:11:00,710 --> 00:10:57,279

state

285

00:11:01,430 --> 00:11:00,720

and it turns out that we can

286

00:11:04,550 --> 00:11:01,440

and

287

00:11:06,389 --> 00:11:04,560

the way that we modify it is by using

288

00:11:09,750 --> 00:11:06,399

the fact that it's an enter that it's a

289

00:11:10,630 --> 00:11:09,760

geometry dependent ground state so that

290

00:11:13,750 --> 00:11:10,640

means

291

00:11:15,750 --> 00:11:13,760

that the physical geometry of the system

292

00:11:21,030 --> 00:11:15,760

which we'll talk about in a moment can

293

00:11:22,550 --> 00:11:21,040

be used to create kind of a a a avoid a

294

00:11:25,190 --> 00:11:22,560

region with lower

295

00:11:27,910 --> 00:11:25,200

uh um zero point energy so it's an

296

00:11:29,430 --> 00:11:27,920

analogous to the ocean if the ocean is

297

00:11:32,550 --> 00:11:29,440

flat everywhere

298

00:11:36,150 --> 00:11:32,560

uh then imagine if we could just make a

299

00:11:39,509 --> 00:11:36,160

dip out a region of the ocean which uh

300

00:11:42,710 --> 00:11:39,519

in which the the surface were lower

301
00:11:45,030 --> 00:11:42,720
so it's analogous to that and this is by

302
00:11:46,630 --> 00:11:45,040
using a casimir cavity so what is the

303
00:11:47,509 --> 00:11:46,640
casimir cavity

304
00:11:50,710 --> 00:11:47,519
um

305
00:11:53,030 --> 00:11:50,720
in 1948 hendrick casimir

306
00:11:56,069 --> 00:11:53,040
developed a theory in which he said that

307
00:11:57,910 --> 00:11:56,079
if you have two closely split placed

308
00:12:00,870 --> 00:11:57,920
mirrors

309
00:12:03,430 --> 00:12:00,880
there are wavelengths electromagnetic

310
00:12:04,629 --> 00:12:03,440
wavelengths light within it

311
00:12:05,750 --> 00:12:04,639
that can

312
00:12:08,230 --> 00:12:05,760
exist

313
00:12:11,030 --> 00:12:08,240

as long as they're an integer number of

314

00:12:13,030 --> 00:12:11,040

half wavelengths within this category

315

00:12:15,110 --> 00:12:13,040

within this

316

00:12:16,629 --> 00:12:15,120

this closely spaced

317

00:12:17,750 --> 00:12:16,639

mirror region

318

00:12:20,949 --> 00:12:17,760

and if

319

00:12:22,949 --> 00:12:20,959

in fact they are longer wavelengths then

320

00:12:24,949 --> 00:12:22,959

they're suppressed they can't exist in

321

00:12:26,949 --> 00:12:24,959

this region and

322

00:12:28,069 --> 00:12:26,959

only the shorter wavelengths can and the

323

00:12:30,310 --> 00:12:28,079

ones that meet

324

00:12:33,430 --> 00:12:30,320

boundary conditions and so this is an

325

00:12:36,310 --> 00:12:33,440

image here of a casimir cavity you can

326

00:12:39,110 --> 00:12:36,320

see that outside the casimir cavity all

327

00:12:40,470 --> 00:12:39,120

of the electromagnetic modes are pushing

328

00:12:43,190 --> 00:12:40,480

on the walls

329

00:12:45,910 --> 00:12:43,200

inside the casimir cavity

330

00:12:48,389 --> 00:12:45,920

there's a reduced set of modes that are

331

00:12:51,509 --> 00:12:48,399

pushing against the walls and so the net

332

00:12:52,710 --> 00:12:51,519

effect is that the two walls get pushed

333

00:12:57,030 --> 00:12:52,720

together

334

00:13:00,790 --> 00:12:57,040

casimir force

335

00:13:03,509 --> 00:13:00,800

he proposed this in 1948 and it wasn't

336

00:13:05,590 --> 00:13:03,519

for quite a few decades until this was

337

00:13:07,509 --> 00:13:05,600

experimentally tested and verified and

338

00:13:09,590 --> 00:13:07,519

he was exactly right

339

00:13:11,990 --> 00:13:09,600

it turns out though that this casimir

340

00:13:14,150 --> 00:13:12,000

force is only significant when you get

341

00:13:16,550 --> 00:13:14,160

down to very very small geometries to

342

00:13:19,430 --> 00:13:16,560

spacing of less than a micron which is a

343

00:13:22,230 --> 00:13:19,440

millionth of a meter

344

00:13:24,710 --> 00:13:22,240

um and so

345

00:13:26,949 --> 00:13:24,720

when people think about harvesting zero

346

00:13:29,430 --> 00:13:26,959

point energy often they think about

347

00:13:31,670 --> 00:13:29,440

trying to use the casimir force

348

00:13:33,910 --> 00:13:31,680

and harvesting that force

349

00:13:36,389 --> 00:13:33,920

but it turns out you really can't

350

00:13:38,949 --> 00:13:36,399

because yes you can get energy from

351
00:13:41,430 --> 00:13:38,959
those two plates going together but once

352
00:13:44,310 --> 00:13:41,440
the two plates are together if you pull

353
00:13:45,670 --> 00:13:44,320
them apart to do them to do that again

354
00:13:47,269 --> 00:13:45,680
you've

355
00:13:49,189 --> 00:13:47,279
had to use all the energy that you

356
00:13:51,670 --> 00:13:49,199
gained from having the two plates come

357
00:13:55,269 --> 00:13:51,680
together so you really don't gain much

358
00:14:00,710 --> 00:13:56,710
therefore

359
00:14:02,790 --> 00:14:00,720
we are not looking at the casimir force

360
00:14:04,790 --> 00:14:02,800
in this technology that i'm going to be

361
00:14:06,949 --> 00:14:04,800
talking about today what we're

362
00:14:09,030 --> 00:14:06,959
interested in is the fact that inside

363
00:14:12,470 --> 00:14:09,040

this casimir cavity

364

00:14:14,949 --> 00:14:12,480

uh the energy density is lower and

365

00:14:16,470 --> 00:14:14,959

that's what we're going to be using

366

00:14:19,430 --> 00:14:16,480

so in that way

367

00:14:21,269 --> 00:14:19,440

we can get around the second issue this

368

00:14:23,509 --> 00:14:21,279

this this first issue of the universal

369

00:14:25,430 --> 00:14:23,519

ground state can we modify it so we'll

370

00:14:27,509 --> 00:14:25,440

be using casimir cavities

371

00:14:29,509 --> 00:14:27,519

then comes this pesky second issue of

372

00:14:31,189 --> 00:14:29,519

the violation of the second law of

373

00:14:32,230 --> 00:14:31,199

thermodynamics

374

00:14:38,150 --> 00:14:32,240

and

375

00:14:40,069 --> 00:14:38,160

the way around it will involve

376

00:14:43,110 --> 00:14:40,079

as you'll see these short-lived

377

00:14:44,949 --> 00:14:43,120

fluctuations but before we go there

378

00:14:46,389 --> 00:14:44,959

let's think a little bit about

379

00:14:51,269 --> 00:14:46,399

equilibrium

380

00:14:53,829 --> 00:14:51,279

is a quiescent state where everything is

381

00:14:55,910 --> 00:14:53,839

uniform there's no flow from anywhere

382

00:14:59,430 --> 00:14:55,920

from one place to another

383

00:15:02,870 --> 00:14:59,440

and that's a conservation

384

00:15:05,509 --> 00:15:02,880

uh perspective uh looking at it from the

385

00:15:07,269 --> 00:15:05,519

principle of equilibrium you can also

386

00:15:09,430 --> 00:15:07,279

take a kinetic view

387

00:15:11,189 --> 00:15:09,440

and that kinetic view is going to be

388

00:15:12,389 --> 00:15:11,199

informative to us

389

00:15:15,509 --> 00:15:12,399

equilibrium

390

00:15:18,230 --> 00:15:15,519

means detailed balance and in detail

391

00:15:20,389 --> 00:15:18,240

balance we actually can have

392

00:15:22,790 --> 00:15:20,399

different parts of the system let's say

393

00:15:26,389 --> 00:15:22,800

part a and part b and there can be

394

00:15:29,269 --> 00:15:26,399

energy flow in equilibrium from a to b

395

00:15:32,470 --> 00:15:29,279

but it'll be balanced precisely by an

396

00:15:36,150 --> 00:15:32,480

energy flow from b to a and so we get

397

00:15:38,550 --> 00:15:36,160

this net flow of zero by balancing every

398

00:15:39,590 --> 00:15:38,560

flow between every different part of the

399

00:15:43,590 --> 00:15:39,600

system

400

00:15:45,910 --> 00:15:43,600

and so uh from looking at equilibrium

401
00:15:47,590 --> 00:15:45,920
from this detailed balance perspective

402
00:15:50,790 --> 00:15:47,600
it'll provide some

403
00:15:52,949 --> 00:15:50,800
uh uh insights into us into how we might

404
00:15:54,629 --> 00:15:52,959
harvest this zero point energy now what

405
00:15:57,110 --> 00:15:54,639
would happen if we didn't have this

406
00:16:00,069 --> 00:15:57,120
detailed balance well let's say that we

407
00:16:03,110 --> 00:16:00,079
had zero point energy in nature

408
00:16:05,910 --> 00:16:03,120
and uh we we didn't have to uh we didn't

409
00:16:08,470 --> 00:16:05,920
have detailed balance in that case if

410
00:16:10,870 --> 00:16:08,480
the zero point energy that's all around

411
00:16:12,790 --> 00:16:10,880
interacted say with the leaf that leaf

412
00:16:14,470 --> 00:16:12,800
has non-linearities in it things that

413
00:16:16,949 --> 00:16:14,480

are going to convert that zero point

414

00:16:18,790 --> 00:16:16,959

energy into heat and we'd be seeing

415

00:16:20,389 --> 00:16:18,800

seeing heating everywhere but we don't

416

00:16:23,189 --> 00:16:20,399

see heating everywhere

417

00:16:26,389 --> 00:16:23,199

things are really in balance

418

00:16:28,870 --> 00:16:26,399

and so this detailed balance is what we

419

00:16:31,910 --> 00:16:28,880

need to be able to break if we're going

420

00:16:34,550 --> 00:16:31,920

to harvest zero point energy

421

00:16:35,430 --> 00:16:34,560

okay so how might we do it

422

00:16:37,430 --> 00:16:35,440

well

423

00:16:39,829 --> 00:16:37,440

let's take a look at those extremely

424

00:16:40,870 --> 00:16:39,839

short-lived fluctuations

425

00:16:43,189 --> 00:16:40,880

uh

426

00:16:45,990 --> 00:16:43,199

there is the notion that's been

427

00:16:47,590 --> 00:16:46,000

developed by wood and others over a

428

00:16:48,389 --> 00:16:47,600

number of years

429

00:16:49,110 --> 00:16:48,399

that

430

00:16:52,310 --> 00:16:49,120

uh

431

00:16:54,870 --> 00:16:52,320

if you you can develop a sort of quantum

432

00:16:58,629 --> 00:16:54,880

inequality and in this quantum

433

00:17:01,110 --> 00:16:58,639

inequality an amount of energy ΔE

434

00:17:04,309 --> 00:17:01,120

can be borrowed from the quantum vacuum

435

00:17:06,870 --> 00:17:04,319

for an amount of time Δt and this

436

00:17:09,029 --> 00:17:06,880

follows an uncertainty principle sort of

437

00:17:11,429 --> 00:17:09,039

relationship so the larger the amount of

438

00:17:12,549 --> 00:17:11,439

energy you borrow the less time you have

439

00:17:13,990 --> 00:17:12,559

it for

440

00:17:16,789 --> 00:17:14,000

so for example

441

00:17:19,189 --> 00:17:16,799

let if you want to borrow a red light

442

00:17:21,429 --> 00:17:19,199

photon which is about two electron volts

443

00:17:23,429 --> 00:17:21,439

you can borrow it but you need you can

444

00:17:26,069 --> 00:17:23,439

only borrow it for

445

00:17:30,710 --> 00:17:26,079

about a tenth of a femtosecond so that's

446

00:17:33,990 --> 00:17:30,720

a point zero with fifteen zeros one six

447

00:17:35,669 --> 00:17:34,000

seconds it's an extremely short time

448

00:17:38,549 --> 00:17:35,679

and so

449

00:17:41,029 --> 00:17:38,559

if you can borrow this though perhaps we

450

00:17:43,909 --> 00:17:41,039

can do something with it because if we

451
00:17:45,510 --> 00:17:43,919
can borrow it perhaps we can capture it

452
00:17:47,510 --> 00:17:45,520
but we need to be able to capture it

453
00:17:50,310 --> 00:17:47,520
extremely quickly

454
00:17:52,789 --> 00:17:50,320
and in that way maybe maybe we could

455
00:17:55,909 --> 00:17:52,799
skirt detailed balance so let's talk

456
00:17:58,710 --> 00:17:55,919
about how you might borrow it

457
00:18:00,789 --> 00:17:58,720
uh the way that i'm proposing

458
00:18:02,870 --> 00:18:00,799
is to use a metal insulator metal

459
00:18:04,789 --> 00:18:02,880
barrier so we're tunneling

460
00:18:06,950 --> 00:18:04,799
through a metal insulator metal barrier

461
00:18:09,510 --> 00:18:06,960
what does that be got a metal thin

462
00:18:13,110 --> 00:18:09,520
insulator just a few angstroms thick

463
00:18:16,630 --> 00:18:13,120

and another metal layer if you have

464

00:18:18,070 --> 00:18:16,640

an excited state here let's say a hot

465

00:18:19,510 --> 00:18:18,080

electron that's an electron that's

466

00:18:21,510 --> 00:18:19,520

energetic

467

00:18:24,549 --> 00:18:21,520

it can tunnel through

468

00:18:26,789 --> 00:18:24,559

forming an evanescent state in in this

469

00:18:28,549 --> 00:18:26,799

region in between the two metal layers

470

00:18:30,630 --> 00:18:28,559

and it can be transmitted into this

471

00:18:32,549 --> 00:18:30,640

second metal layer

472

00:18:34,710 --> 00:18:32,559

once it's transmitted into the second

473

00:18:37,750 --> 00:18:34,720

metal layer it can

474

00:18:40,230 --> 00:18:37,760

lose its energy and decay and it really

475

00:18:43,190 --> 00:18:40,240

will not go back we've essentially

476

00:18:44,310 --> 00:18:43,200

captured it most of the time

477

00:18:46,789 --> 00:18:44,320

and so

478

00:18:49,270 --> 00:18:46,799

uh this process using a metal insulator

479

00:18:52,070 --> 00:18:49,280

metal barrier may be a way to capture

480

00:18:55,510 --> 00:18:52,080

the zero point energy

481

00:18:57,909 --> 00:18:55,520

using mim devices is something that my

482

00:18:59,750 --> 00:18:57,919

lab has been working on for a couple of

483

00:19:02,150 --> 00:18:59,760

decades and we've probably made more of

484

00:19:04,549 --> 00:19:02,160

these devices than any other lab in the

485

00:19:07,909 --> 00:19:04,559

world and and looked at them for

486

00:19:09,590 --> 00:19:07,919

conventional uh energy applications but

487

00:19:10,390 --> 00:19:09,600

here we're going to be doing something

488

00:19:12,549 --> 00:19:10,400

different

489

00:19:14,710 --> 00:19:12,559

so let's see how this might interact

490

00:19:17,750 --> 00:19:14,720

with zero point energy

491

00:19:20,470 --> 00:19:17,760

so let's say that we have this metal

492

00:19:22,470 --> 00:19:20,480

insulator metal barrier the base metal

493

00:19:24,789 --> 00:19:22,480

is going to be thick

494

00:19:26,390 --> 00:19:24,799

the upper metal layer in this case is

495

00:19:28,549 --> 00:19:26,400

going to be very thin and then we've got

496

00:19:30,789 --> 00:19:28,559

an ultra thin insulator in between it

497

00:19:33,029 --> 00:19:30,799

just a couple of nanometers thick

498

00:19:35,590 --> 00:19:33,039

so if we've got zero point energy

499

00:19:37,669 --> 00:19:35,600

impinging on the outer surface it can

500

00:19:39,750 --> 00:19:37,679

energize some of those electrons we were

501
00:19:42,310 --> 00:19:39,760
talking about and if this upper

502
00:19:45,029 --> 00:19:42,320
electrode is thin enough those energized

503
00:19:48,630 --> 00:19:45,039
electrons can go across the barrier and

504
00:19:50,870 --> 00:19:48,640
be absorbed in the base electrode now

505
00:19:53,270 --> 00:19:50,880
just sitting out in free space they're

506
00:19:55,510 --> 00:19:53,280
going to be a balance of processes

507
00:19:57,430 --> 00:19:55,520
there'll be energy going from the upper

508
00:19:59,990 --> 00:19:57,440
electrode to the base electrode and then

509
00:20:02,390 --> 00:20:00,000
also internal zero point energy modes in

510
00:20:04,310 --> 00:20:02,400
the base electrode that excite electrons

511
00:20:06,549 --> 00:20:04,320
that go into the upper electrode and so

512
00:20:09,029 --> 00:20:06,559
there's no net flow of current this

513
00:20:12,070 --> 00:20:09,039

thing just sits around

514

00:20:13,350 --> 00:20:12,080

but what happens aha if we add a casimir

515

00:20:17,190 --> 00:20:13,360

cavity

516

00:20:19,110 --> 00:20:17,200

of this

517

00:20:21,190 --> 00:20:19,120

we've now suppressed

518

00:20:23,669 --> 00:20:21,200

some of the electromagnetic modes some

519

00:20:25,029 --> 00:20:23,679

of the light that's impinging on the

520

00:20:26,950 --> 00:20:25,039

upper cavity

521

00:20:27,990 --> 00:20:26,960

and so that means we're now going to

522

00:20:29,110 --> 00:20:28,000

have

523

00:20:31,110 --> 00:20:29,120

fewer

524

00:20:34,630 --> 00:20:31,120

electrons going

525

00:20:37,110 --> 00:20:34,640

that are excited by this outside

526
00:20:38,230 --> 00:20:37,120
quantum vacuum that reached the lower

527
00:20:41,190 --> 00:20:38,240
cavity

528
00:20:44,230 --> 00:20:41,200
and so we reduce the flow this way the

529
00:20:47,350 --> 00:20:44,240
flow this way may stay the same and so

530
00:20:50,390 --> 00:20:47,360
now we've induced a net flow from the

531
00:20:53,990 --> 00:20:50,400
base electrode to the upper electrode

532
00:20:56,470 --> 00:20:54,000
and that is the secret sauce that's how

533
00:20:57,830 --> 00:20:56,480
our device works

534
00:21:00,950 --> 00:20:57,840
let's take a look at the actual

535
00:21:02,870 --> 00:21:00,960
structure we're dealing with so we have

536
00:21:04,870 --> 00:21:02,880
a structure that's very much like what i

537
00:21:07,669 --> 00:21:04,880
said we've got a substrate a base

538
00:21:09,590 --> 00:21:07,679

electrode insulator up electrode for the

539

00:21:11,590 --> 00:21:09,600

casimir cavity instead of having free

540

00:21:13,750 --> 00:21:11,600

space we're actually putting a piece of

541

00:21:16,149 --> 00:21:13,760

transparent dielectric there

542

00:21:19,669 --> 00:21:16,159

so that we can keep the spacing constant

543

00:21:22,630 --> 00:21:19,679

it's either a polymer or a glass and

544

00:21:25,909 --> 00:21:22,640

then we put a mirror on top so this is

545

00:21:28,710 --> 00:21:25,919

our casimir cavity this is our metal

546

00:21:31,510 --> 00:21:28,720

insulator metal diode and we measure the

547

00:21:33,830 --> 00:21:31,520

current that goes between the upper

548

00:21:35,669 --> 00:21:33,840

electrode and the lower electrode what

549

00:21:38,870 --> 00:21:35,679

you see in the bottom right

550

00:21:43,830 --> 00:21:40,470

image of

551
00:21:45,990 --> 00:21:43,840
an electron microscope

552
00:21:47,590 --> 00:21:46,000
image of one of our actual working

553
00:21:50,310 --> 00:21:47,600
devices

554
00:21:53,510 --> 00:21:50,320
and uh so we built these we built them

555
00:21:57,029 --> 00:21:53,520
over a number of years

556
00:21:59,830 --> 00:21:57,039
it was a tricky technology to get going

557
00:22:02,070 --> 00:21:59,840
we i was kind of skeptical as to whether

558
00:22:03,190 --> 00:22:02,080
our results really showed anything or

559
00:22:04,149 --> 00:22:03,200
not

560
00:22:04,950 --> 00:22:04,159
and

561
00:22:07,110 --> 00:22:04,960
uh

562
00:22:09,590 --> 00:22:07,120
finally a technician who's been working

563
00:22:11,510 --> 00:22:09,600

in my lab for three decades now dave

564

00:22:15,669 --> 00:22:11,520

doroski said look garrett you really

565

00:22:17,510 --> 00:22:15,679

have got to do this so we we we just

566

00:22:19,430 --> 00:22:17,520

dug in and

567

00:22:21,350 --> 00:22:19,440

spent a lot of our spare time this was

568

00:22:24,390 --> 00:22:21,360

not our main project

569

00:22:26,149 --> 00:22:24,400

and uh he along with the postdoc ayandra

570

00:22:28,149 --> 00:22:26,159

wearakodi

571

00:22:29,510 --> 00:22:28,159

built some devices and they built it and

572

00:22:31,110 --> 00:22:29,520

they seemed to produce something and

573

00:22:33,510 --> 00:22:31,120

they built it and it seemed to produce

574

00:22:34,470 --> 00:22:33,520

something and this happened over and

575

00:22:37,909 --> 00:22:34,480

over

576

00:22:40,630 --> 00:22:37,919

and so actually it looks like the thing

577

00:22:41,590 --> 00:22:40,640

works believe it or not and i was blown

578

00:22:43,909 --> 00:22:41,600

away

579

00:22:46,310 --> 00:22:43,919

so if we take a look

580

00:22:49,190 --> 00:22:46,320

at a current voltage characteristic this

581

00:22:52,070 --> 00:22:49,200

is a way of looking at the output of a

582

00:22:55,830 --> 00:22:52,080

device so you can see here's current as

583

00:22:57,750 --> 00:22:55,840

a function of voltage and the way that

584

00:22:58,710 --> 00:22:57,760

one should look at these current voltage

585

00:23:00,950 --> 00:22:58,720

curves

586

00:23:01,750 --> 00:23:00,960

is that uh if

587

00:23:04,149 --> 00:23:01,760

the

588

00:23:06,470 --> 00:23:04,159

curve falls in

589

00:23:08,710 --> 00:23:06,480

so this is quadrant number one if the

590

00:23:11,590 --> 00:23:08,720

curve fall when the curve is down here

591

00:23:14,230 --> 00:23:11,600

it's the device is using power when the

592

00:23:16,870 --> 00:23:14,240

curve is over here it's producing power

593

00:23:19,750 --> 00:23:16,880

using and producing and you find that

594

00:23:21,590 --> 00:23:19,760

right here in fact we are producing

595

00:23:23,590 --> 00:23:21,600

power the thing is just sitting there

596

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

it's putting out voltage and it's

597

00:23:28,230 --> 00:23:26,080

putting out current and in fact in some

598

00:23:30,470 --> 00:23:28,240

of our better devices so far they put

599

00:23:33,350 --> 00:23:30,480

about put out about 70 watts per square

600

00:23:35,110 --> 00:23:33,360

meter of power

601
00:23:37,669 --> 00:23:35,120
and

602
00:23:40,710 --> 00:23:37,679
so we looked at this as a function of

603
00:23:43,269 --> 00:23:40,720
the casimir cavity thickness now we know

604
00:23:45,269 --> 00:23:43,279
that the thinner the casimir cavity is

605
00:23:47,350 --> 00:23:45,279
the more it will suppress these

606
00:23:49,830 --> 00:23:47,360
zero-point energy modes and so the

607
00:23:52,310 --> 00:23:49,840
bigger the differences between having

608
00:23:54,390 --> 00:23:52,320
the cavity there not having it there

609
00:23:56,310 --> 00:23:54,400
so that's exactly what we see

610
00:23:59,750 --> 00:23:56,320
we see that this current

611
00:24:03,269 --> 00:23:59,760
increases for thinner cavities and it

612
00:24:04,789 --> 00:24:03,279
decreases for thicker cavities and we've

613
00:24:07,750 --> 00:24:04,799

used again two different types of

614

00:24:10,070 --> 00:24:07,760

cavities one with a polymer and one with

615

00:24:14,070 --> 00:24:10,080

sio2 in it

616

00:24:16,870 --> 00:24:15,510

we

617

00:24:19,510 --> 00:24:16,880

then

618

00:24:22,149 --> 00:24:19,520

said can this really be true and we

619

00:24:24,950 --> 00:24:22,159

ended up spending more time trying to

620

00:24:27,350 --> 00:24:24,960

disprove ourselves than we did in the

621

00:24:30,149 --> 00:24:27,360

initial findings and we went through

622

00:24:31,990 --> 00:24:30,159

eight fairly rigorous tests to test

623

00:24:33,110 --> 00:24:32,000

whether we might be seeing artifacts or

624

00:24:35,909 --> 00:24:33,120

not

625

00:24:37,750 --> 00:24:35,919

so one of the tests was to see whether

626

00:24:39,830 --> 00:24:37,760

maybe there's some chemical reaction

627

00:24:41,830 --> 00:24:39,840

that's occurring and it's really it will

628

00:24:45,110 --> 00:24:41,840

peter out after a time and it's not

629

00:24:48,310 --> 00:24:45,120

really a constant current but in fact it

630

00:24:50,630 --> 00:24:48,320

is it continues for

631

00:24:52,149 --> 00:24:50,640

indefinitely here's a plot showing four

632

00:24:54,230 --> 00:24:52,159

hours in which the current is pretty

633

00:24:56,950 --> 00:24:54,240

much constant so we don't have a

634

00:24:58,870 --> 00:24:56,960

depletion of any built-in charge

635

00:25:01,269 --> 00:24:58,880

so then we thought if this really works

636

00:25:03,110 --> 00:25:01,279

it should scale with area so we built

637

00:25:05,510 --> 00:25:03,120

devices

638

00:25:08,470 --> 00:25:05,520

from sub micron size up to about 100

639

00:25:10,149 --> 00:25:08,480

microns on edge and yes the current does

640

00:25:12,710 --> 00:25:10,159

scale with area

641

00:25:14,630 --> 00:25:12,720

and we said well if this really works

642

00:25:15,830 --> 00:25:14,640

then if you built an array of these

643

00:25:18,390 --> 00:25:15,840

devices

644

00:25:19,750 --> 00:25:18,400

the currents and the voltages should add

645

00:25:22,149 --> 00:25:19,760

up

646

00:25:23,350 --> 00:25:22,159

and so so far we've built some small

647

00:25:25,269 --> 00:25:23,360

arrays

648

00:25:26,710 --> 00:25:25,279

and we built them in two different ways

649

00:25:29,029 --> 00:25:26,720

they're a series in parallel

650

00:25:30,870 --> 00:25:29,039

combinations so we get we should be

651
00:25:33,750 --> 00:25:30,880
getting about four times current and

652
00:25:36,710 --> 00:25:33,760
four times the voltage for this and you

653
00:25:38,310 --> 00:25:36,720
see here that in fact uh this is the

654
00:25:39,750 --> 00:25:38,320
short circuit current and again open

655
00:25:42,870 --> 00:25:39,760
circuit voltage

656
00:25:44,549 --> 00:25:42,880
this is a single device and these are

657
00:25:47,750 --> 00:25:44,559
two different types of four by four

658
00:25:49,510 --> 00:25:47,760
arrays and they do in fact produce about

659
00:25:51,909 --> 00:25:49,520
four times as much voltage and four

660
00:25:53,830 --> 00:25:51,919
times as much current let me say well

661
00:25:55,669 --> 00:25:53,840
maybe this is due to some pickup maybe

662
00:25:58,310 --> 00:25:55,679
there's pickup from electromagnetic

663
00:26:00,630 --> 00:25:58,320

radiation outside so we measured these

664

00:26:02,470 --> 00:26:00,640

devices in a new metal box

665

00:26:04,310 --> 00:26:02,480

which blocks

666

00:26:06,710 --> 00:26:04,320

low frequency

667

00:26:09,190 --> 00:26:06,720

electromagnetic pickup got the same

668

00:26:11,029 --> 00:26:09,200

current voltage curve we measured it in

669

00:26:14,390 --> 00:26:11,039

an aluminum box which blocks the high

670

00:26:16,470 --> 00:26:14,400

frequency uh electromagnetic radiation

671

00:26:18,549 --> 00:26:16,480

again we got the same

672

00:26:19,669 --> 00:26:18,559

curve so it doesn't seem to be due to

673

00:26:21,510 --> 00:26:19,679

that

674

00:26:24,070 --> 00:26:21,520

we carried out

675

00:26:25,990 --> 00:26:24,080

four more tests that i don't have time

676

00:26:28,870 --> 00:26:26,000

to go into them all now

677

00:26:30,310 --> 00:26:28,880

we've built thousands of devices uh

678

00:26:31,909 --> 00:26:30,320

dozens of different types of

679

00:26:35,110 --> 00:26:31,919

configurations

680

00:26:37,430 --> 00:26:35,120

and we see this result over and over

681

00:26:39,669 --> 00:26:37,440

we're convinced that we really are

682

00:26:41,990 --> 00:26:39,679

seeing something but is it zero point

683

00:26:44,950 --> 00:26:42,000

energy might it be something else for

684

00:26:47,830 --> 00:26:44,960

example could it be due to cosmic rays

685

00:26:50,950 --> 00:26:47,840

well a quick calculation tells us that

686

00:26:53,110 --> 00:26:50,960

the highest flux of cosmic rays we know

687

00:26:56,310 --> 00:26:53,120

is about 10 000 particles per square

688

00:26:58,950 --> 00:26:56,320

meter per second impinging on earth

689

00:27:02,310 --> 00:26:58,960

and so for our tiny devices that

690

00:27:04,630 --> 00:27:02,320

translates into about one hit every 160

691

00:27:06,950 --> 00:27:04,640

years so that would mean we wouldn't see

692

00:27:09,190 --> 00:27:06,960

a continuous current but we do it's not

693

00:27:11,909 --> 00:27:09,200

cosmic rays well could it even be

694

00:27:14,789 --> 00:27:11,919

something exotic like neutrinos

695

00:27:17,350 --> 00:27:14,799

so neutrinos have a higher flux

696

00:27:20,710 --> 00:27:17,360

there we would end up with about four

697

00:27:23,590 --> 00:27:20,720

hits per second for our devices

698

00:27:26,070 --> 00:27:23,600

for the of the highest flux neutrinos

699

00:27:28,710 --> 00:27:26,080

but the problem is that neutrinos are

700

00:27:31,350 --> 00:27:28,720

known to have an extremely small capture

701
00:27:33,269 --> 00:27:31,360
cross-section in matter in other words

702
00:27:35,430 --> 00:27:33,279
neutrinos are constantly going through

703
00:27:37,510 --> 00:27:35,440
us and through earth and everything else

704
00:27:39,269 --> 00:27:37,520
and there's no known means that you

705
00:27:42,470 --> 00:27:39,279
could absorb the neutrinos to give us

706
00:27:45,269 --> 00:27:42,480
the effect that we're seeing so no it's

707
00:27:48,389 --> 00:27:45,279
not you due to neutrinos

708
00:27:51,350 --> 00:27:48,399
so this really looks like we are

709
00:27:53,830 --> 00:27:51,360
harvesting energy

710
00:27:55,669 --> 00:27:53,840
and so you think what what can we do

711
00:27:58,070 --> 00:27:55,679
with this energy

712
00:27:59,990 --> 00:27:58,080
so the way we've thought about working

713
00:28:03,510 --> 00:28:00,000

of using it

714

00:28:04,789 --> 00:28:03,520

is uh essentially making batteries that

715

00:28:07,430 --> 00:28:04,799

don't run out

716

00:28:10,710 --> 00:28:07,440

so it's similar in cost to solar cells

717

00:28:12,870 --> 00:28:10,720

per unit area but potentially uh can

718

00:28:14,630 --> 00:28:12,880

have higher power densities and in fact

719

00:28:16,710 --> 00:28:14,640

you can stack these things and do all

720

00:28:18,950 --> 00:28:16,720

sorts of things to to give them higher

721

00:28:20,789 --> 00:28:18,960

power density

722

00:28:23,029 --> 00:28:20,799

uh so initially the goal is to make

723

00:28:26,230 --> 00:28:23,039

small batteries for mobile phones

724

00:28:27,350 --> 00:28:26,240

electronics uh then for lighting

725

00:28:28,950 --> 00:28:27,360

uh then

726

00:28:31,190 --> 00:28:28,960

stacking these things together and

727

00:28:33,590 --> 00:28:31,200

making power for electric vehicles

728

00:28:35,510 --> 00:28:33,600

desalinization

729

00:28:37,110 --> 00:28:35,520

wearable electronics and temperature

730

00:28:38,789 --> 00:28:37,120

control

731

00:28:39,909 --> 00:28:38,799

industrial

732

00:28:41,909 --> 00:28:39,919

and

733

00:28:42,950 --> 00:28:41,919

home power units

734

00:28:45,110 --> 00:28:42,960

maybe

735

00:28:48,549 --> 00:28:45,120

ultimately aircraft

736

00:28:50,710 --> 00:28:48,559

trains ships space vehicles imagine

737

00:28:54,389 --> 00:28:50,720

airplanes that don't have these engines

738

00:28:55,750 --> 00:28:54,399

that are constantly irritating us

739

00:28:58,710 --> 00:28:55,760

so

740

00:28:59,990 --> 00:28:58,720

the uses are are tremendous

741

00:29:00,950 --> 00:29:00,000

so far

742

00:29:03,110 --> 00:29:00,960

we've

743

00:29:05,590 --> 00:29:03,120

not been able to demonstrate these

744

00:29:08,230 --> 00:29:05,600

things because i've got a small lab just

745

00:29:10,230 --> 00:29:08,240

a few people working and so we're slowly

746

00:29:12,870 --> 00:29:10,240

slowly building up

747

00:29:15,669 --> 00:29:12,880

to try to demonstrate this but if this

748

00:29:18,789 --> 00:29:15,679

in fact is as it appears to be it could

749

00:29:21,590 --> 00:29:18,799

be earth-shaking i mean think about the

750

00:29:24,070 --> 00:29:21,600

the the implications for our life on

751
00:29:25,350 --> 00:29:24,080
earth just let your imagination

752
00:29:26,389 --> 00:29:25,360
wander

753
00:29:29,590 --> 00:29:26,399
um

754
00:29:31,830 --> 00:29:29,600
we could have no electric power lines

755
00:29:34,070 --> 00:29:31,840
we could have no cords for devices

756
00:29:35,909 --> 00:29:34,080
everything has its own power we can have

757
00:29:39,029 --> 00:29:35,919
ubiquitous power

758
00:29:41,190 --> 00:29:39,039
everywhere all the time 24 hours a day

759
00:29:42,789 --> 00:29:41,200
remote power globally

760
00:29:44,149 --> 00:29:42,799
it would essentially eliminate all

761
00:29:47,190 --> 00:29:44,159
carbon-based

762
00:29:49,110 --> 00:29:47,200
uh producing greenhouse gases

763
00:29:53,750 --> 00:29:49,120

uh

764

00:29:55,110 --> 00:29:53,760

i mean it can be quite upsetting but it

765

00:29:56,870 --> 00:29:55,120

can also be

766

00:29:58,710 --> 00:29:56,880

the uh

767

00:30:01,990 --> 00:29:58,720

really change the world in a much better

768

00:30:04,549 --> 00:30:02,000

way if in fact it's right

769

00:30:05,990 --> 00:30:04,559

okay so what do we know so far

770

00:30:08,230 --> 00:30:06,000

uh we know

771

00:30:09,190 --> 00:30:08,240

that we have casimir cavities and when

772

00:30:12,070 --> 00:30:09,200

they're

773

00:30:14,389 --> 00:30:12,080

adjoining ultra fast charge transport

774

00:30:16,549 --> 00:30:14,399

devices then we produce powers and we've

775

00:30:18,630 --> 00:30:16,559

tested this many times over and over

776

00:30:21,269 --> 00:30:18,640

there's no question it works

777

00:30:23,510 --> 00:30:21,279

uh we've had current increases for

778

00:30:24,789 --> 00:30:23,520

thinner casimir cavities so that's

779

00:30:27,909 --> 00:30:24,799

consistent

780

00:30:29,190 --> 00:30:27,919

with creating a larger sink for zero

781

00:30:32,549 --> 00:30:29,200

point energy when you make these

782

00:30:34,789 --> 00:30:32,559

cavities smaller and so it looks like it

783

00:30:36,789 --> 00:30:34,799

has the signature of zero point energy

784

00:30:37,909 --> 00:30:36,799

but we certainly don't we haven't proved

785

00:30:42,630 --> 00:30:37,919

that

786

00:30:45,110 --> 00:30:42,640

anyone can suggest to us as to what's

787

00:30:48,389 --> 00:30:45,120

happening and all of the different tests

788

00:30:51,669 --> 00:30:48,399

for artifacts were negative

789

00:30:54,310 --> 00:30:51,679

we've published uh two papers

790

00:30:55,269 --> 00:30:54,320

uh which have been pretty much

791

00:30:57,070 --> 00:30:55,279

uh

792

00:30:59,509 --> 00:30:57,080

gone out there they're they're in

793

00:31:01,350 --> 00:30:59,519

non-mainstream journals

794

00:31:04,389 --> 00:31:01,360

i'm sorry they're in mainstream journals

795

00:31:05,830 --> 00:31:04,399

but not very high profile journals and

796

00:31:07,990 --> 00:31:05,840

they've been met

797

00:31:11,269 --> 00:31:08,000

pretty much with

798

00:31:14,149 --> 00:31:11,279

neglect there's been no reaction from

799

00:31:15,029 --> 00:31:14,159

the scientific community

800

00:31:16,549 --> 00:31:15,039

why

801
00:31:18,230 --> 00:31:16,559
because people can't believe these

802
00:31:20,230 --> 00:31:18,240
results

803
00:31:23,110 --> 00:31:20,240
and there's good reason to not believe

804
00:31:26,310 --> 00:31:23,120
the results so let's take a look at in

805
00:31:29,430 --> 00:31:26,320
the way that perhaps we're challenging

806
00:31:30,310 --> 00:31:29,440
the second law of thermodynamics here

807
00:31:31,990 --> 00:31:30,320
so

808
00:31:33,750 --> 00:31:32,000
second law of thermodynamics says that

809
00:31:36,710 --> 00:31:33,760
it's impossible to convert heat from a

810
00:31:40,950 --> 00:31:36,720
system in uniform temperature into work

811
00:31:44,230 --> 00:31:40,960
and it's a very uh rigorously uh uh

812
00:31:47,110 --> 00:31:44,240
understood law and believed in uh so for

813
00:31:49,350 --> 00:31:47,120

example sir arthur eddington wrote if

814

00:31:50,710 --> 00:31:49,360

somebody points out to you that your pet

815

00:31:53,190 --> 00:31:50,720

theory of the universe is in

816

00:31:54,950 --> 00:31:53,200

disagreement with maxwell's equations

817

00:31:56,070 --> 00:31:54,960

then so much worse for maxwell's

818

00:31:57,750 --> 00:31:56,080

equations

819

00:32:00,470 --> 00:31:57,760

if it's found to be contradicted by

820

00:32:02,310 --> 00:32:00,480

observation well these experimental

821

00:32:03,590 --> 00:32:02,320

experimentalists do bungled things

822

00:32:05,430 --> 00:32:03,600

sometimes

823

00:32:08,310 --> 00:32:05,440

but if your theory is found to be

824

00:32:10,789 --> 00:32:08,320

against the second law of thermodynamics

825

00:32:12,149 --> 00:32:10,799

i can give you no hope there's nothing

826

00:32:16,470 --> 00:32:12,159

for for it

827

00:32:19,669 --> 00:32:16,480

but to collapse into deepest humiliation

828

00:32:21,430 --> 00:32:19,679

uh einstein uh wrote that thermodynamics

829

00:32:24,870 --> 00:32:21,440

is the only physical theory which i'm

830

00:32:26,950 --> 00:32:24,880

convinced will never be overthrown

831

00:32:30,549 --> 00:32:26,960

uh he it even

832

00:32:32,789 --> 00:32:30,559

enters into our patent and legal system

833

00:32:35,350 --> 00:32:32,799

through essential reinforcement of this

834

00:32:37,990 --> 00:32:35,360

law the second law of thermodynamics is

835

00:32:39,909 --> 00:32:38,000

considered so fundamental that the u.s

836

00:32:42,310 --> 00:32:39,919

patent and trademark office will not

837

00:32:44,789 --> 00:32:42,320

consider patent applications that claim

838

00:32:47,350 --> 00:32:44,799

to violate it unless a working model is

839

00:32:50,230 --> 00:32:47,360
provided with the application

840

00:32:53,509 --> 00:32:50,240
so if this law is so

841

00:32:56,630 --> 00:32:53,519
rigorously believed it's proven right

842

00:32:58,630 --> 00:32:56,640
well it's been observed for well over a

843

00:33:00,870 --> 00:32:58,640
century since the invention of this of

844

00:33:02,789 --> 00:33:00,880
the steam engine the implications of the

845

00:33:05,990 --> 00:33:02,799
second law have been observed

846

00:33:08,470 --> 00:33:06,000
it's been derived theoretically in

847

00:33:10,470 --> 00:33:08,480
idealized situations with

848

00:33:12,710 --> 00:33:10,480
various assumptions about the initial

849

00:33:15,269 --> 00:33:12,720
state but it's not

850

00:33:16,549 --> 00:33:15,279
fully derived it's not a proven law in

851
00:33:18,149 --> 00:33:16,559
that sense

852
00:33:19,190 --> 00:33:18,159
and

853
00:33:20,310 --> 00:33:19,200
then

854
00:33:22,630 --> 00:33:20,320
another

855
00:33:24,789 --> 00:33:22,640
argument again in favor of the second

856
00:33:27,669 --> 00:33:24,799
law is that it's often stated that no

857
00:33:29,750 --> 00:33:27,679
demonstrated violations are generally

858
00:33:31,909 --> 00:33:29,760
recognized that's right isn't it there

859
00:33:32,789 --> 00:33:31,919
are no demonstrated violations

860
00:33:35,029 --> 00:33:32,799
well

861
00:33:37,590 --> 00:33:35,039
uh how about the paper published by

862
00:33:39,830 --> 00:33:37,600
daniel sheehan on epic catalysis in

863
00:33:42,389 --> 00:33:39,840

which he had a system

864

00:33:44,630 --> 00:33:42,399

at supposedly equilibrium where he

865

00:33:45,350 --> 00:33:44,640

created a temperature difference because

866

00:33:47,350 --> 00:33:45,360

of

867

00:33:51,830 --> 00:33:47,360

interactions and surfaces between two

868

00:33:53,990 --> 00:33:51,840

gases or a recent paper by tibeto

869

00:33:57,590 --> 00:33:54,000

in which they had a

870

00:34:00,389 --> 00:33:57,600

graphene layer that thermally vibrated

871

00:34:02,789 --> 00:34:00,399

and these vibrations were turned into

872

00:34:05,029 --> 00:34:02,799

electrical power thibodeaux was able to

873

00:34:06,470 --> 00:34:05,039

publish it because he said right next to

874

00:34:08,790 --> 00:34:06,480

it he had a little resistor that

875

00:34:11,030 --> 00:34:08,800

dissipated the power so all the power

876

00:34:13,190 --> 00:34:11,040

that was generated ended up being used

877

00:34:14,790 --> 00:34:13,200

up there so he said this shows that the

878

00:34:16,710 --> 00:34:14,800

second law of thermodynamics is

879

00:34:17,510 --> 00:34:16,720

conserved

880

00:34:20,069 --> 00:34:17,520

but

881

00:34:20,950 --> 00:34:20,079

that's really i i wonder whether he did

882

00:34:22,389 --> 00:34:20,960

this

883

00:34:24,629 --> 00:34:22,399

in order to get it published i don't

884

00:34:27,109 --> 00:34:24,639

have any particular insights but it sure

885

00:34:30,149 --> 00:34:27,119

seems like a violation to me

886

00:34:33,510 --> 00:34:30,159

daniel sheehan has other uh work on a

887

00:34:35,750 --> 00:34:33,520

concentration gradients with membranes

888

00:34:36,550 --> 00:34:35,760

we've published two papers which clearly

889

00:34:39,829 --> 00:34:36,560

show

890

00:34:41,510 --> 00:34:39,839

uh energy being harvested and then we've

891

00:34:43,829 --> 00:34:41,520

got to ask the question how many other

892

00:34:46,310 --> 00:34:43,839

papers or ideas

893

00:34:48,230 --> 00:34:46,320

were rejected by publishers and patent

894

00:34:49,190 --> 00:34:48,240

examiners because they just couldn't be

895

00:34:50,470 --> 00:34:49,200

right

896

00:34:53,270 --> 00:34:50,480

so i don't know if there are

897

00:34:55,270 --> 00:34:53,280

demonstrated violations

898

00:34:57,910 --> 00:34:55,280

so then we can say well

899

00:35:00,630 --> 00:34:57,920

at least we know mainstream science is

900

00:35:03,910 --> 00:35:00,640

much more reliable than

901
00:35:06,790 --> 00:35:03,920
than looking at these exotic phenomena

902
00:35:09,349 --> 00:35:06,800
and so to to discuss this i'd like to

903
00:35:12,470 --> 00:35:09,359
tell you a story about when i was a

904
00:35:14,950 --> 00:35:12,480
beginning graduate student at harvard

905
00:35:17,589 --> 00:35:14,960
so i was working for a postdoc

906
00:35:20,390 --> 00:35:17,599
and we were looking at this material

907
00:35:21,589 --> 00:35:20,400
amorphous silicon made by sputtering

908
00:35:23,829 --> 00:35:21,599
and

909
00:35:24,950 --> 00:35:23,839
the post-doc had the idea

910
00:35:27,349 --> 00:35:24,960
that if

911
00:35:29,589 --> 00:35:27,359
we sputter it i know you don't need to

912
00:35:30,550 --> 00:35:29,599
go into this but if we deposit it in a

913
00:35:33,109 --> 00:35:30,560

condition

914

00:35:35,910 --> 00:35:33,119

where we vary the argon pressure we're

915

00:35:37,829 --> 00:35:35,920

going to be seeing different

916

00:35:39,670 --> 00:35:37,839

qualities of amorphous silicon so we

917

00:35:43,589 --> 00:35:39,680

used photoconductivity to measure the

918

00:35:45,589 --> 00:35:43,599

quality and he expected that really at

919

00:35:48,310 --> 00:35:45,599

low argon pressure this stuff would be

920

00:35:50,390 --> 00:35:48,320

defective at high argon pressure it

921

00:35:52,310 --> 00:35:50,400

would also be defective for various

922

00:35:53,430 --> 00:35:52,320

other reasons and in the middle we'd

923

00:35:55,990 --> 00:35:53,440

we'd have a

924

00:35:58,150 --> 00:35:56,000

a region where we'd sort of peak and

925

00:35:59,829 --> 00:35:58,160

have the best

926
00:36:02,150 --> 00:35:59,839
condition

927
00:36:04,710 --> 00:36:02,160
and so

928
00:36:06,390 --> 00:36:04,720
we did some tests and it came out a

929
00:36:08,630 --> 00:36:06,400
little bit different it looked sort of

930
00:36:11,030 --> 00:36:08,640
like this and he said well wait a minute

931
00:36:13,190 --> 00:36:11,040
we had some beryllium substrates in the

932
00:36:16,069 --> 00:36:13,200
chamber and they must have contaminated

933
00:36:17,829 --> 00:36:16,079
so we better redo the tests and and make

934
00:36:20,470 --> 00:36:17,839
another batch of films and test them

935
00:36:22,790 --> 00:36:20,480
again so we did it again and again it

936
00:36:23,910 --> 00:36:22,800
came out with a a different sort of

937
00:36:25,750 --> 00:36:23,920
trend

938
00:36:27,670 --> 00:36:25,760

and he said well wait a minute i think

939

00:36:30,470 --> 00:36:27,680

there was a leak in the sputtering

940

00:36:32,390 --> 00:36:30,480

system let's repair that leak and redo

941

00:36:34,630 --> 00:36:32,400

it so we did it again

942

00:36:36,150 --> 00:36:34,640

and we got the trend that he observed

943

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

and we published it

944

00:36:40,950 --> 00:36:38,240

so is that good science

945

00:36:43,589 --> 00:36:40,960

just to choose the results you want

946

00:36:45,270 --> 00:36:43,599

this this is a mainstream publication

947

00:36:47,589 --> 00:36:45,280

except this was something that was

948

00:36:49,670 --> 00:36:47,599

believable so we didn't really need to

949

00:36:51,589 --> 00:36:49,680

prove it and so you wonder how many

950

00:36:53,670 --> 00:36:51,599

other things that are believable are

951
00:36:55,270 --> 00:36:53,680
actually rubbish that are published out

952
00:36:59,430 --> 00:36:55,280
there

953
00:37:01,030 --> 00:36:59,440
so we got a a number of very critical

954
00:37:03,990 --> 00:37:01,040
comments from reviewers on our

955
00:37:06,790 --> 00:37:04,000
manuscript for the zero point energy uh

956
00:37:09,270 --> 00:37:06,800
to review two reviews that weren't that

957
00:37:10,550 --> 00:37:09,280
uh negative came out with the following

958
00:37:12,870 --> 00:37:10,560
suggestion

959
00:37:14,870 --> 00:37:12,880
one viewer said perhaps the authors need

960
00:37:17,270 --> 00:37:14,880
to add a theoretical co-author to the

961
00:37:19,430 --> 00:37:17,280
paper to help come up with a plausible

962
00:37:21,030 --> 00:37:19,440
explanation for the effect

963
00:37:22,870 --> 00:37:21,040

another reviewer who

964

00:37:24,950 --> 00:37:22,880

who said we should publish it said i

965

00:37:27,670 --> 00:37:24,960

still hope the authors could give at

966

00:37:29,270 --> 00:37:27,680

least some basic theoretical analysis

967

00:37:31,670 --> 00:37:29,280

and compare it to the experimental

968

00:37:34,630 --> 00:37:31,680

results before publication

969

00:37:38,310 --> 00:37:34,640

so they're saying that you need to have

970

00:37:39,589 --> 00:37:38,320

a theory before you believe a result

971

00:37:41,270 --> 00:37:39,599

wait a minute

972

00:37:43,589 --> 00:37:41,280

is that how we live

973

00:37:45,510 --> 00:37:43,599

do do i need to understand

974

00:37:48,390 --> 00:37:45,520

how

975

00:37:50,550 --> 00:37:48,400

plants grow and digestion works before i

976

00:37:53,109 --> 00:37:50,560

can eat an apple and be satisfied from

977

00:37:55,670 --> 00:37:53,119

it or can i look at the experiment

978

00:37:59,030 --> 00:37:55,680

and then just believe that

979

00:38:02,230 --> 00:37:59,040

so in 1990 phillip anderson who won the

980

00:38:04,710 --> 00:38:02,240

nobel prize of in theoretical physics

981

00:38:06,790 --> 00:38:04,720

wrote in physics today

982

00:38:08,630 --> 00:38:06,800

in the reviewing process excessive

983

00:38:09,990 --> 00:38:08,640

weight is given to theoretical

984

00:38:12,390 --> 00:38:10,000

interpretation

985

00:38:14,390 --> 00:38:12,400

we don't want to lose sight of the fact

986

00:38:16,790 --> 00:38:14,400

that the most important experimental

987

00:38:19,190 --> 00:38:16,800

results are precisely those that do not

988

00:38:21,910 --> 00:38:19,200

have a theoretical interpretation

989

00:38:25,190 --> 00:38:21,920

a major weakness of our approach as

990

00:38:28,550 --> 00:38:25,200

scientists is a collective unwillingness

991

00:38:31,349 --> 00:38:28,560

to welcome new or anomalous results

992

00:38:33,589 --> 00:38:31,359

so even if we don't have a quantitative

993

00:38:36,470 --> 00:38:33,599

theory

994

00:38:39,349 --> 00:38:36,480

shouldn't we be looking at the data

995

00:38:41,030 --> 00:38:39,359

so this raises the question then

996

00:38:43,030 --> 00:38:41,040

how do you find the right balance

997

00:38:46,390 --> 00:38:43,040

because i spend a lot of my

998

00:38:47,349 --> 00:38:46,400

career actually dealing with

999

00:38:49,910 --> 00:38:47,359

uh

1000

00:38:53,349 --> 00:38:49,920

people who come to me with various sorts

1001
00:38:56,310 --> 00:38:53,359
of scientific inventions or conclusions

1002
00:38:57,750 --> 00:38:56,320
or ideas that really don't make sense

1003
00:39:00,230 --> 00:38:57,760
they actually

1004
00:39:02,390 --> 00:39:00,240
don't have any sort of theory but they

1005
00:39:05,430 --> 00:39:02,400
also don't have solid

1006
00:39:08,310 --> 00:39:05,440
experimental verification so is science

1007
00:39:10,870 --> 00:39:08,320
self-correcting is it and if so

1008
00:39:13,750 --> 00:39:10,880
how quickly are scientists too gullible

1009
00:39:16,150 --> 00:39:13,760
or are they not gullible enough

1010
00:39:18,950 --> 00:39:16,160
then we asked the basic question is the

1011
00:39:21,430 --> 00:39:18,960
second law of thermodynamics inviable or

1012
00:39:23,430 --> 00:39:21,440
has it already been violated but just

1013
00:39:25,349 --> 00:39:23,440

nobody believes it

1014

00:39:26,550 --> 00:39:25,359

um

1015

00:39:30,390 --> 00:39:26,560

how much

1016

00:39:33,270 --> 00:39:30,400

our renegade results worth investigating

1017

00:39:36,390 --> 00:39:33,280

uh for all of the people who come to us

1018

00:39:39,190 --> 00:39:36,400

and say einstein was wrong how much time

1019

00:39:41,589 --> 00:39:39,200

should we spend in trying to understand

1020

00:39:43,750 --> 00:39:41,599

uh whether their perspective is is

1021

00:39:46,230 --> 00:39:43,760

correct

1022

00:39:48,069 --> 00:39:46,240

should we accept results that we have no

1023

00:39:49,430 --> 00:39:48,079

explanation for

1024

00:39:50,310 --> 00:39:49,440

so which is it

1025

00:39:52,470 --> 00:39:50,320

uh

1026
00:39:54,870 --> 00:39:52,480
is our

1027
00:39:57,670 --> 00:39:54,880
technology um

1028
00:39:59,349 --> 00:39:57,680
a a consequence

1029
00:40:01,670 --> 00:39:59,359
is the the suppression of it or the

1030
00:40:04,309 --> 00:40:01,680
disbelief in it a consequence of the

1031
00:40:07,190 --> 00:40:04,319
dogmatic mainstream breaking through

1032
00:40:08,950 --> 00:40:07,200
or am i a mad scientist and am i

1033
00:40:11,109 --> 00:40:08,960
deluding myself

1034
00:40:12,230 --> 00:40:11,119
i don't know by the way does that look

1035
00:40:13,829 --> 00:40:12,240
like me

1036
00:40:15,670 --> 00:40:13,839
it is

1037
00:40:16,950 --> 00:40:15,680
so the question is

1038
00:40:20,390 --> 00:40:16,960

really

1039

00:40:22,710 --> 00:40:20,400

what do we do with this technology

1040

00:40:26,069 --> 00:40:22,720

thank you very much and

1041

00:40:28,470 --> 00:40:26,079

i appreciate your your attention to this