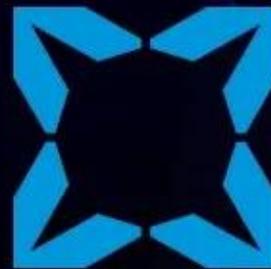
A portrait of Garret Model, an older man with white hair and a beard, looking slightly to the right. He is wearing a dark jacket over a green turtleneck. The background is dark with a network of glowing blue and purple lines and dots, and a field of red and orange dots on the right side.

EXTRACTING ZERO-POINT ENERGY: DOES IT VIOLATE THE SECOND LAW?

GARRET MODEL



SOCIETY
FOR
SCIENTIFIC
EXPLORATION

1
00:00:17,910 --> 00:00:15,110
okay welcome everybody to the last of

2
00:00:20,310 --> 00:00:17,920
the talks before the panel discussion in

3
00:00:23,349 --> 00:00:20,320
the symposium and it's a it's a real

4
00:00:24,710 --> 00:00:23,359
pleasure again to

5
00:00:26,870 --> 00:00:24,720
introduce

6
00:00:28,390 --> 00:00:26,880
uh garrett medell who's a professor of

7
00:00:30,150 --> 00:00:28,400
electrical computer

8
00:00:31,589 --> 00:00:30,160
and energy engineering at the university

9
00:00:34,069 --> 00:00:31,599
of colorado

10
00:00:36,069 --> 00:00:34,079
his research group pursues new energy

11
00:00:38,790 --> 00:00:36,079
conversion technologies

12
00:00:41,350 --> 00:00:38,800
and other sciences um other science at

13
00:00:42,950 --> 00:00:41,360

the edge of our understanding prior to

14

00:00:45,590 --> 00:00:42,960

his academic position he worked in

15

00:00:48,869 --> 00:00:45,600

silicon valley solar cell startups where

16

00:00:50,790 --> 00:00:48,879

he sought entrepreneur entrepreneurial

17

00:00:51,830 --> 00:00:50,800

money and has caught the entrepreneurial

18

00:00:54,310 --> 00:00:51,840

bug

19

00:00:57,029 --> 00:00:54,320

that's he says continues to plague him

20

00:00:59,990 --> 00:00:57,039

uh garrett earned his bachelor's ee from

21

00:01:02,310 --> 00:01:00,000

stanford ms and phd and applied physics

22

00:01:03,990 --> 00:01:02,320

from from harvard

23

00:01:06,070 --> 00:01:04,000

among all the people i've known over the

24

00:01:08,550 --> 00:01:06,080

years garrett has one of the most active

25

00:01:09,670 --> 00:01:08,560

minds and most ambitious and fascinating

26

00:01:11,109 --> 00:01:09,680

research

27

00:01:13,750 --> 00:01:11,119

programs and this

28

00:01:15,749 --> 00:01:13,760

of his talk i'm sure will evidence this

29

00:01:17,590 --> 00:01:15,759

um but i'd like to

30

00:01:19,030 --> 00:01:17,600

finish the introduction with just

31

00:01:21,749 --> 00:01:19,040

continuing his

32

00:01:24,230 --> 00:01:21,759

uh motif of moby dick

33

00:01:26,630 --> 00:01:24,240

ishmael as you know is

34

00:01:28,950 --> 00:01:26,640

the first person narrator in in moby

35

00:01:30,630 --> 00:01:28,960

dick and and uh

36

00:01:32,310 --> 00:01:30,640

garrett is the first person narrator i

37

00:01:33,670 --> 00:01:32,320

think of this of this particular

38

00:01:36,390 --> 00:01:33,680

symposium

39

00:01:38,710 --> 00:01:36,400

and also the protagonist um

40

00:01:40,630 --> 00:01:38,720

unlike captain ahab

41

00:01:42,870 --> 00:01:40,640

ishmael kept an open mind with respect

42

00:01:44,550 --> 00:01:42,880

to moby dick and yes you'll find in this

43

00:01:46,870 --> 00:01:44,560

talk garrett will keep an open mind with

44

00:01:49,270 --> 00:01:46,880

respect to the second law

45

00:01:50,950 --> 00:01:49,280

his mind is always in motion

46

00:01:52,469 --> 00:01:50,960

and

47

00:01:55,429 --> 00:01:52,479

um as melvin

48

00:01:57,270 --> 00:01:55,439

melville said about ishmael

49

00:01:58,709 --> 00:01:57,280

the flux in turn is the chief

50

00:02:00,950 --> 00:01:58,719

characteristic

51
00:02:03,510 --> 00:02:00,960
of ishmael himself

52
00:02:04,469 --> 00:02:03,520
so we shall call you ishmael

53
00:02:05,830 --> 00:02:04,479
garrett

54
00:02:07,990 --> 00:02:05,840
best for last

55
00:02:09,109 --> 00:02:08,000
contingent

56
00:02:10,790 --> 00:02:09,119
you captain

57
00:02:12,150 --> 00:02:10,800
um

58
00:02:13,830 --> 00:02:12,160
are we i just want to check are we

59
00:02:16,550 --> 00:02:13,840
recording

60
00:02:18,949 --> 00:02:16,560
i can't tell uh yes we are

61
00:02:22,070 --> 00:02:18,959
okay good all right thanks very much

62
00:02:24,630 --> 00:02:22,080
folks uh so last year i talked about

63
00:02:27,589 --> 00:02:24,640

extracting zero point energy at the ape

64

00:02:30,550 --> 00:02:27,599

conference and also at a the last sse

65

00:02:32,630 --> 00:02:30,560

conference what i want to do today is

66

00:02:35,190 --> 00:02:32,640

quickly go over those results and then

67

00:02:37,589 --> 00:02:35,200

extend the discussion to talk about

68

00:02:39,430 --> 00:02:37,599

really the question of what's what are

69

00:02:43,030 --> 00:02:39,440

the underlying principles here what's

70

00:02:46,550 --> 00:02:43,040

happening do we violate the second law

71

00:02:48,309 --> 00:02:46,560

and spoiler alert it's ambiguous

72

00:02:50,710 --> 00:02:48,319

okay so

73

00:02:51,990 --> 00:02:50,720

let's take a look at what uh the

74

00:02:54,470 --> 00:02:52,000

contents are going to be so i'll be

75

00:02:56,630 --> 00:02:54,480

talking about zero point energy

76

00:02:59,750 --> 00:02:56,640

in general and the problems in

77

00:03:03,750 --> 00:02:59,760

harvesting it then we'll talk about our

78

00:03:05,509 --> 00:03:03,760

device and uh how we might be able to

79

00:03:07,509 --> 00:03:05,519

actually harvest it and what results

80

00:03:10,229 --> 00:03:07,519

we're getting then i'll talk about the

81

00:03:13,030 --> 00:03:10,239

whole issue of virtual particles because

82

00:03:15,670 --> 00:03:13,040

virtual particles for the quantum vacuum

83

00:03:17,430 --> 00:03:15,680

are are a fundamental and somewhat

84

00:03:19,030 --> 00:03:17,440

puzzling issue

85

00:03:21,110 --> 00:03:19,040

we'll get into the second law of

86

00:03:23,190 --> 00:03:21,120

thermodynamics and also the first one

87

00:03:25,270 --> 00:03:23,200

too and whether we're violating it and

88

00:03:26,710 --> 00:03:25,280

then finally i'll have some questions to

89

00:03:29,270 --> 00:03:26,720

ask you

90

00:03:30,869 --> 00:03:29,280

about this whole phenomena

91

00:03:32,869 --> 00:03:30,879

these phenomena

92

00:03:35,509 --> 00:03:32,879

so let's start off and just talk in

93

00:03:39,830 --> 00:03:35,519

general about zero point energy

94

00:03:41,589 --> 00:03:39,840

so we know that the background that the

95

00:03:43,670 --> 00:03:41,599

general background contains

96

00:03:46,630 --> 00:03:43,680

electromagnetic fields

97

00:03:47,910 --> 00:03:46,640

in 1900 planck came up with the

98

00:03:49,030 --> 00:03:47,920

description

99

00:03:51,350 --> 00:03:49,040

of

100

00:03:53,910 --> 00:03:51,360

the spectrum and this is the well-known

101
00:03:57,350 --> 00:03:53,920
planck formula the first theory which

102
00:03:59,910 --> 00:03:57,360
shows that the electric field that the

103
00:04:01,830 --> 00:03:59,920
electromagnetic field distribution at a

104
00:04:03,350 --> 00:04:01,840
given temperature is a function of that

105
00:04:06,949 --> 00:04:03,360
temperature

106
00:04:08,869 --> 00:04:06,959
then in 1911 he extended his theory to

107
00:04:11,110 --> 00:04:08,879
the second theory

108
00:04:13,429 --> 00:04:11,120
in which he talked about the need for an

109
00:04:15,270 --> 00:04:13,439
additional term which was a temperature

110
00:04:17,670 --> 00:04:15,280
independent term

111
00:04:19,990 --> 00:04:17,680
this became known as the zero point

112
00:04:23,909 --> 00:04:20,000
energy term because it exists

113
00:04:27,030 --> 00:04:23,919

even in the absence of any temperature

114

00:04:29,350 --> 00:04:27,040

later we'll see that it comes again

115

00:04:32,469 --> 00:04:29,360

this term so if we take a look at the

116

00:04:34,870 --> 00:04:32,479

spectrum this is a plot of the energy

117

00:04:37,430 --> 00:04:34,880

density of the electromagnetic spectrum

118

00:04:39,909 --> 00:04:37,440

as a function of photon energy down here

119

00:04:43,189 --> 00:04:39,919

we've got infrared photons visible light

120

00:04:45,749 --> 00:04:43,199

photons and then ultraviolet light

121

00:04:48,469 --> 00:04:45,759

and we can see the black body spectrum

122

00:04:50,469 --> 00:04:48,479

the well-known planck distribution and

123

00:04:52,790 --> 00:04:50,479

it peters out by the time we get to the

124

00:04:54,629 --> 00:04:52,800

visible light and that's why at room

125

00:04:57,590 --> 00:04:54,639

temperature we don't see all the

126

00:05:00,550 --> 00:04:57,600

radiation around us it's in the infrared

127

00:05:03,029 --> 00:05:00,560

but there is this radiation that extends

128

00:05:03,909 --> 00:05:03,039

up as frequency cubed

129

00:05:07,110 --> 00:05:03,919

that

130

00:05:08,710 --> 00:05:07,120

exists from this last term from the zero

131

00:05:12,070 --> 00:05:08,720

point energy and that's the quantum

132

00:05:15,590 --> 00:05:12,080

vacuum energy that we're talking about

133

00:05:19,029 --> 00:05:15,600

and so a question is can we use it well

134

00:05:19,909 --> 00:05:19,039

the first question is how much energy is

135

00:05:22,629 --> 00:05:19,919

there

136

00:05:25,029 --> 00:05:22,639

this shows the energy i've done a little

137

00:05:27,670 --> 00:05:25,039

calculation to see what is the

138

00:05:29,430 --> 00:05:27,680

power that you can get from it

139

00:05:32,390 --> 00:05:29,440

and what in particular what is the

140

00:05:33,189 --> 00:05:32,400

current so if we take a look at all of

141

00:05:39,110 --> 00:05:33,199

the

142

00:05:42,230 --> 00:05:39,120

from long wavelengths going out to

143

00:05:45,029 --> 00:05:42,240

about down to about sorry up to about 4

144

00:05:47,590 --> 00:05:45,039

electron volts which corresponds to

145

00:05:48,550 --> 00:05:47,600

about 0.3 microns

146

00:05:51,830 --> 00:05:48,560

the

147

00:05:54,950 --> 00:05:51,840

current that we can get from that photon

148

00:05:58,629 --> 00:05:54,960

flux if we could capture it as photons

149

00:05:59,830 --> 00:05:58,639

is huge it's 1.7 giga amps per square

150

00:06:02,629 --> 00:05:59,840

meter

151

00:06:06,309 --> 00:06:02,639

so there's there's a lot there it's it's

152

00:06:08,790 --> 00:06:06,319

worth looking at if we can get it

153

00:06:10,309 --> 00:06:08,800

this zero point energy

154

00:06:13,189 --> 00:06:10,319

uh was

155

00:06:15,670 --> 00:06:13,199

originally proposed by planck but it's

156

00:06:16,950 --> 00:06:15,680

really been come to people have come to

157

00:06:19,110 --> 00:06:16,960

understand it in terms of the

158

00:06:20,950 --> 00:06:19,120

uncertainty principle there are several

159

00:06:23,430 --> 00:06:20,960

ways as you know for expressing the

160

00:06:25,909 --> 00:06:23,440

uncertainty principle one is that the

161

00:06:28,469 --> 00:06:25,919

uncertainty in energy times the

162

00:06:29,350 --> 00:06:28,479

uncertainty in time

163

00:06:30,070 --> 00:06:29,360

uh

164

00:06:32,710 --> 00:06:30,080

is

165

00:06:34,710 --> 00:06:32,720

has certain limits you can't know both

166

00:06:37,110 --> 00:06:34,720

absolutely precisely

167

00:06:39,510 --> 00:06:37,120

and so the consequence of this

168

00:06:43,189 --> 00:06:39,520

is that there must be fluctuations and

169

00:06:46,150 --> 00:06:43,199

the shorter the time that we look at for

170

00:06:47,029 --> 00:06:46,160

those fluctuations the larger the energy

171

00:06:48,870 --> 00:06:47,039

can be

172

00:06:51,029 --> 00:06:48,880

so if we want substantial energies

173

00:06:53,830 --> 00:06:51,039

they're at very short times

174

00:06:56,550 --> 00:06:53,840

okay so what are the problems in trying

175

00:06:59,270 --> 00:06:56,560

to harvest this energy and there are a

176

00:07:02,710 --> 00:06:59,280

number of different discussions about it

177

00:07:04,870 --> 00:07:02,720

i'll talk about really two basic uh

178

00:07:07,189 --> 00:07:04,880

problems in trying to get the energy one

179

00:07:09,110 --> 00:07:07,199

is that it's the universal ground state

180

00:07:12,150 --> 00:07:09,120

and since it's the universal ground

181

00:07:13,110 --> 00:07:12,160

state that means that we can't induce a

182

00:07:15,189 --> 00:07:13,120

flow

183

00:07:17,270 --> 00:07:15,199

by having a change in its density

184

00:07:19,510 --> 00:07:17,280

because it's the same everywhere

185

00:07:21,430 --> 00:07:19,520

the second is that these fluctuations

186

00:07:23,589 --> 00:07:21,440

are extremely short-lived

187

00:07:26,710 --> 00:07:23,599

so let's take a look at these in turn

188

00:07:29,990 --> 00:07:26,720

can we modify the ground state and most

189

00:07:33,110 --> 00:07:30,000

of you know that yes in fact we can it

190

00:07:34,550 --> 00:07:33,120

would be a little bit like uh having an

191

00:07:37,670 --> 00:07:34,560

ocean

192

00:07:40,629 --> 00:07:37,680

a sea level and we could then all of a

193

00:07:43,189 --> 00:07:40,639

sudden dig out like mooses a little

194

00:07:44,550 --> 00:07:43,199

region of the sea that was at a lower

195

00:07:47,589 --> 00:07:44,560

level

196

00:07:50,309 --> 00:07:47,599

so if we could do that with the vacuum

197

00:07:52,390 --> 00:07:50,319

energy and dig out a region which is at

198

00:07:54,950 --> 00:07:52,400

a lower level then we could induce a

199

00:07:56,070 --> 00:07:54,960

flow and we can do that with the casimir

200

00:07:59,029 --> 00:07:56,080

cavity

201
00:08:04,150 --> 00:07:59,039
most of you know this was developed by

202
00:08:06,070 --> 00:08:04,160
casimir in 1948 and then finally um

203
00:08:08,390 --> 00:08:06,080
proven to work

204
00:08:10,710 --> 00:08:08,400
at the end of the 20th century the basic

205
00:08:14,070 --> 00:08:10,720
idea is that we've got two closely

206
00:08:15,350 --> 00:08:14,080
spaced mirrors in between these mirrors

207
00:08:17,589 --> 00:08:15,360
we have

208
00:08:19,189 --> 00:08:17,599
the boundary conditions at the mirror

209
00:08:22,390 --> 00:08:19,199
saying that the electric field goes to

210
00:08:24,469 --> 00:08:22,400
zero and so we have a restricted number

211
00:08:26,550 --> 00:08:24,479
of modes it's an integer number of half

212
00:08:30,309 --> 00:08:26,560
wavelengths that can exist within this

213
00:08:31,430 --> 00:08:30,319

region whereas outside we have the full

214

00:08:33,990 --> 00:08:31,440

spectrum

215

00:08:36,870 --> 00:08:34,000

therefore there's more radiant energy

216

00:08:39,589 --> 00:08:36,880

outside the inside there's a net force

217

00:08:40,469 --> 00:08:39,599

and these two plates should collapse and

218

00:08:41,990 --> 00:08:40,479

in fact

219

00:08:45,110 --> 00:08:42,000

they do

220

00:08:48,630 --> 00:08:45,120

uh what i'd like to take from this for

221

00:08:50,470 --> 00:08:48,640

today's discussion is that this is sort

222

00:08:54,790 --> 00:08:50,480

of a

223

00:08:56,710 --> 00:08:54,800

it blocks all the low frequency along

224

00:08:59,670 --> 00:08:56,720

wavelength modes

225

00:09:02,070 --> 00:08:59,680

in the zero-point energy spectrum

226

00:09:03,590 --> 00:09:02,080

all right so we talked about modifying

227

00:09:06,389 --> 00:09:03,600

the ground state what about these

228

00:09:09,269 --> 00:09:06,399

short-lived fluctuations

229

00:09:11,190 --> 00:09:09,279

uh there is a quantum inequality

230

00:09:12,470 --> 00:09:11,200

developed by larry ford a number of

231

00:09:15,590 --> 00:09:12,480

years ago

232

00:09:18,230 --> 00:09:15,600

and he says that an energy ΔE

233

00:09:20,790 --> 00:09:18,240

may be borrowed from the quantum vacuum

234

00:09:23,910 --> 00:09:20,800

for a time Δt

235

00:09:27,110 --> 00:09:23,920

and so it's an uncertainty like relation

236

00:09:29,750 --> 00:09:27,120

uh i'm here putting it into

237

00:09:32,230 --> 00:09:29,760

the uncertainty uh uh

238

00:09:34,310 --> 00:09:32,240

formalism although this

239

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

it made the number here may not actually

240

00:09:37,910 --> 00:09:35,120

be

241

00:09:40,389 --> 00:09:37,920

\hbar over 2 planck's constant

242

00:09:42,470 --> 00:09:40,399

over 4 pi

243

00:09:44,550 --> 00:09:42,480

but instead maybe a different number but

244

00:09:47,350 --> 00:09:44,560

it's something like that and so the

245

00:09:48,630 --> 00:09:47,360

basic idea is that

246

00:09:50,470 --> 00:09:48,640

you can have

247

00:09:53,350 --> 00:09:50,480

radiation

248

00:09:56,389 --> 00:09:53,360

uh that can have a substantial amount of

249

00:09:59,190 --> 00:09:56,399

energy ΔE if you look at it for

250

00:10:00,870 --> 00:09:59,200

just a short enough time so these things

251

00:10:04,470 --> 00:10:00,880

bop in and out of

252

00:10:05,430 --> 00:10:04,480

existence these these photons and uh

253

00:10:07,750 --> 00:10:05,440

pairs

254

00:10:09,990 --> 00:10:07,760

of virtual particles pop in and out of

255

00:10:11,509 --> 00:10:10,000

existence so how much energy and how

256

00:10:14,389 --> 00:10:11,519

much time

257

00:10:17,030 --> 00:10:14,399

if you say we want to ev light two

258

00:10:19,269 --> 00:10:17,040

electron volt light which is red

259

00:10:20,150 --> 00:10:19,279

uh then

260

00:10:28,069 --> 00:10:20,160

that

261

00:10:29,030 --> 00:10:28,079

borrowed for

262

00:10:31,430 --> 00:10:29,040

is

263

00:10:34,470 --> 00:10:31,440

less than a femtosecond about a tenth of

264

00:10:35,670 --> 00:10:34,480

a femtosecond so extremely short it's

265

00:10:38,550 --> 00:10:35,680

it's they're just

266

00:10:39,509 --> 00:10:38,560

very very ephemeral

267

00:10:42,069 --> 00:10:39,519

all right

268

00:10:43,190 --> 00:10:42,079

so this is borrowing energy from the

269

00:10:45,509 --> 00:10:43,200

vacuum

270

00:10:48,389 --> 00:10:45,519

what would happen if we were sneaky and

271

00:10:49,750 --> 00:10:48,399

we borrowed the energy and captured it

272

00:10:51,750 --> 00:10:49,760

quickly

273

00:10:53,750 --> 00:10:51,760

uh what would happen then

274

00:10:54,790 --> 00:10:53,760

can you do that

275

00:10:55,590 --> 00:10:54,800

uh

276

00:10:57,750 --> 00:10:55,600

the

277

00:10:59,430 --> 00:10:57,760

traditional physics has not addressed

278

00:11:02,069 --> 00:10:59,440

that

279

00:11:04,389 --> 00:11:02,079

all right so now we've talked about zero

280

00:11:08,470 --> 00:11:04,399

point energy let's now talk about our

281

00:11:12,389 --> 00:11:08,480

devices and then get into the results

282

00:11:15,590 --> 00:11:12,399

the basic device consists of a metal

283

00:11:18,870 --> 00:11:15,600

insulator metal structure so this is a

284

00:11:21,509 --> 00:11:18,880

thin metal it's semi-transparent it's a

285

00:11:24,870 --> 00:11:21,519

very thin insulator which allows

286

00:11:26,470 --> 00:11:24,880

electrons to tunnel or

287

00:11:28,790 --> 00:11:26,480

hop over

288

00:11:30,630 --> 00:11:28,800

this barrier and then the base metal is

289

00:11:33,430 --> 00:11:30,640

a little bit thicker

290

00:11:34,470 --> 00:11:33,440

so if we imagine this thing just sitting

291

00:11:38,150 --> 00:11:34,480

in

292

00:11:40,550 --> 00:11:38,160

we've got

293

00:11:43,269 --> 00:11:40,560

zero point energy modes

294

00:11:43,990 --> 00:11:43,279

in the base metal these are dominantly

295

00:11:47,350 --> 00:11:44,000

for

296

00:11:50,710 --> 00:11:47,360

visible light and uh energies these are

297

00:11:53,030 --> 00:11:50,720

dominantly uh in the form of plasmons

298

00:11:55,829 --> 00:11:53,040

and so these plasmons will have a

299

00:11:57,750 --> 00:11:55,839

distribution uh there'll be fluctuations

300

00:12:00,389 --> 00:11:57,760

that can create a sufficiently hot

301
00:12:02,230 --> 00:12:00,399
electron to go across the barrier to the

302
00:12:07,670 --> 00:12:02,240
top metal

303
00:12:09,910 --> 00:12:07,680
to be these plasmons powered by zero

304
00:12:13,829 --> 00:12:09,920
point energy that will create electrons

305
00:12:18,550 --> 00:12:15,990
but this top metal is a little bit

306
00:12:22,069 --> 00:12:18,560
thinner so there were fewer of those

307
00:12:25,350 --> 00:12:22,079
electrons on the other hand there also

308
00:12:28,069 --> 00:12:25,360
are the external vacuum energy modes and

309
00:12:28,949 --> 00:12:28,079
so these external vacuum energy modes

310
00:12:30,629 --> 00:12:28,959
can

311
00:12:33,750 --> 00:12:30,639
energize an electron by the

312
00:12:37,030 --> 00:12:33,760
photoelectric effect that electron that

313
00:12:38,790 --> 00:12:37,040

hot electron might be able to traverse

314

00:12:41,110 --> 00:12:38,800

this thin metal

315

00:12:43,430 --> 00:12:41,120

go through across the insulator and get

316

00:12:45,509 --> 00:12:43,440

to the bottom metal and so on this way

317

00:12:47,910 --> 00:12:45,519

if we're sitting in equilibrium these

318

00:12:49,350 --> 00:12:47,920

two arrows are balanced there's no net

319

00:12:51,269 --> 00:12:49,360

flow

320

00:12:53,509 --> 00:12:51,279

i haven't gone into the details of

321

00:12:56,150 --> 00:12:53,519

virtual particles or anything yet

322

00:12:58,790 --> 00:12:56,160

there's there's more subtlety here

323

00:13:01,670 --> 00:12:58,800

okay now let's put a casimir cavity on

324

00:13:04,949 --> 00:13:01,680

top uh we just found out that the

325

00:13:06,550 --> 00:13:04,959

casimir cavity blocks the low frequency

326
00:13:08,949 --> 00:13:06,560
modes

327
00:13:10,230 --> 00:13:08,959
and so that means that we're now going

328
00:13:11,269 --> 00:13:10,240
to have

329
00:13:13,230 --> 00:13:11,279
fewer

330
00:13:16,230 --> 00:13:13,240
uh

331
00:13:19,110 --> 00:13:16,240
electromagnetic modes from

332
00:13:22,069 --> 00:13:19,120
the zero point field impinging on the

333
00:13:23,430 --> 00:13:22,079
top surface and that diminishes the size

334
00:13:24,790 --> 00:13:23,440
of this arrow

335
00:13:27,030 --> 00:13:24,800
so we've now

336
00:13:30,389 --> 00:13:27,040
notionally at least

337
00:13:33,990 --> 00:13:30,399
broken this balance and so the detailed

338
00:13:36,870 --> 00:13:34,000

balance between down and up has changed

339

00:13:39,110 --> 00:13:36,880

we now have a net electron flow from the

340

00:13:41,829 --> 00:13:39,120

bottom to the top

341

00:13:44,310 --> 00:13:41,839

i don't claim this is a a rigorous model

342

00:13:46,310 --> 00:13:44,320

in any sense it's simply a notional idea

343

00:13:48,230 --> 00:13:46,320

of what's happening

344

00:13:50,870 --> 00:13:48,240

so this is the basic structure of our

345

00:13:52,069 --> 00:13:50,880

device uh the actual implementation is

346

00:13:54,230 --> 00:13:52,079

shown here

347

00:13:56,790 --> 00:13:54,240

we start with the silicon uh with a

348

00:13:59,430 --> 00:13:56,800

glass silicon dioxide coated glass

349

00:14:00,710 --> 00:13:59,440

silicon substrate put a base metal of

350

00:14:03,750 --> 00:14:00,720

nickel on it

351

00:14:06,470 --> 00:14:03,760

then a very thin double insulator of

352

00:14:09,829 --> 00:14:06,480

nickel oxide and aluminum oxide and then

353

00:14:14,470 --> 00:14:09,839

a thin layer of palladium on top

354

00:14:16,870 --> 00:14:14,480

uh to form the cavity on top the the

355

00:14:18,790 --> 00:14:16,880

casimir cavity it would be nice if we

356

00:14:20,550 --> 00:14:18,800

could do use vacuum deposition but

357

00:14:23,110 --> 00:14:20,560

vacuum deposition doesn't mean

358

00:14:24,550 --> 00:14:23,120

depositing a vacuum unfortunately so it

359

00:14:25,670 --> 00:14:24,560

means

360

00:14:28,230 --> 00:14:25,680

we uh

361

00:14:30,710 --> 00:14:28,240

have to put some sort of a thin

362

00:14:35,269 --> 00:14:30,720

transparent medium here we're using

363

00:14:36,790 --> 00:14:35,279

either an organic or a glass or as as

364

00:14:38,310 --> 00:14:36,800

our

365

00:14:40,790 --> 00:14:38,320

transparent medium and then we put the

366

00:14:43,350 --> 00:14:40,800

mirror on top the measurement circuit

367

00:14:45,910 --> 00:14:43,360

goes between these two uh metal

368

00:14:48,550 --> 00:14:45,920

electrodes in the mim device this is a

369

00:14:50,310 --> 00:14:48,560

scanning electron micrograph of one of

370

00:14:53,910 --> 00:14:50,320

our devices as you can see they're quite

371

00:14:57,509 --> 00:14:53,920

small the dimensions are about a tenth

372

00:14:58,470 --> 00:14:57,519

of a micron by two tenths of a micron

373

00:15:00,629 --> 00:14:58,480

and

374

00:15:02,069 --> 00:15:00,639

so we built these devices i won't go

375

00:15:04,470 --> 00:15:02,079

through the history of it i've talked

376

00:15:05,269 --> 00:15:04,480

about that in in our in our previous

377

00:15:08,150 --> 00:15:05,279

talk

378

00:15:12,230 --> 00:15:08,160

instead i'll just jump to a result

379

00:15:14,550 --> 00:15:12,240

so we did find a significant change in

380

00:15:16,790 --> 00:15:14,560

the current voltage curve so this is

381

00:15:19,990 --> 00:15:16,800

current as a function of voltage

382

00:15:22,550 --> 00:15:20,000

for a device with a fat casimir cavity

383

00:15:25,590 --> 00:15:22,560

we have the red line and that's an 1100

384

00:15:28,150 --> 00:15:25,600

nanometer cavity when we make a narrow

385

00:15:29,269 --> 00:15:28,160

casimir cavity that's the blue line

386

00:15:32,150 --> 00:15:29,279

the uh

387

00:15:35,350 --> 00:15:32,160

resistance decreases substantially that

388

00:15:38,389 --> 00:15:35,360

is we get more current per unit voltage

389

00:15:41,430 --> 00:15:38,399

and so we see what i'm calling a casimir

390

00:15:45,829 --> 00:15:41,440

doping effect that

391

00:15:48,629 --> 00:15:45,839

the more modes that we can exclude that

392

00:15:51,430 --> 00:15:48,639

is in the thin cavity the more

393

00:15:53,910 --> 00:15:51,440

we reduce the resistance of the device

394

00:15:56,389 --> 00:15:53,920

and we publish this result in a physical

395

00:15:57,910 --> 00:15:56,399

review research article the beginning of

396

00:16:01,350 --> 00:15:57,920

last year

397

00:16:05,110 --> 00:16:01,360

and more recently

398

00:16:07,910 --> 00:16:05,120

larry ford has applied

399

00:16:10,870 --> 00:16:07,920

some of his theory to looking at this

400

00:16:14,629 --> 00:16:10,880

and says yes it does look plausible that

401
00:16:16,150 --> 00:16:14,639
the casimir cavity does in fact induce

402
00:16:17,829 --> 00:16:16,160
uh um

403
00:16:19,990 --> 00:16:17,839
some injection

404
00:16:22,790 --> 00:16:20,000
into the into the metal insulator metal

405
00:16:26,790 --> 00:16:22,800
device which would then

406
00:16:28,710 --> 00:16:26,800
give us the reduction in resistance

407
00:16:30,949 --> 00:16:28,720
but this is a fairly

408
00:16:34,389 --> 00:16:30,959
large voltage scale for these tiny

409
00:16:37,590 --> 00:16:34,399
devices we're plus or minus 0.3 volts

410
00:16:40,230 --> 00:16:37,600
what happens if we look right in here in

411
00:16:42,150 --> 00:16:40,240
this region for the very low voltage and

412
00:16:43,030 --> 00:16:42,160
very low current

413
00:16:45,749 --> 00:16:43,040

well

414

00:16:48,150 --> 00:16:45,759

if we do that we find the strange and

415

00:16:50,389 --> 00:16:48,160

intriguing result that the curve does

416

00:16:52,629 --> 00:16:50,399

not pass through the origin

417

00:16:54,790 --> 00:16:52,639

if it doesn't pass through the origin

418

00:16:56,389 --> 00:16:54,800

that means it's either using power or

419

00:17:01,110 --> 00:16:56,399

producing power

420

00:17:03,749 --> 00:17:01,120

solar cells normally operate in the

421

00:17:05,669 --> 00:17:03,759

first quadrant our devices operate in

422

00:17:07,270 --> 00:17:05,679

the third quadrant which is also a power

423

00:17:10,549 --> 00:17:07,280

production quadrant

424

00:17:12,470 --> 00:17:10,559

so we actually are producing power in

425

00:17:15,189 --> 00:17:12,480

these devices

426

00:17:17,510 --> 00:17:15,199

and the power is substantial

427

00:17:21,029 --> 00:17:17,520

for some of our better devices we get

428

00:17:23,669 --> 00:17:21,039

about 70 watts per square meter

429

00:17:25,829 --> 00:17:23,679

now i have to add the caveat that this

430

00:17:29,029 --> 00:17:25,839

is these are very small devices so we've

431

00:17:32,390 --> 00:17:29,039

not yet made large area devices

432

00:17:35,110 --> 00:17:32,400

well if this is really due to zero point

433

00:17:38,390 --> 00:17:35,120

energy that would mean that as we

434

00:17:40,549 --> 00:17:38,400

widen the casimir cavity and exclude

435

00:17:42,549 --> 00:17:40,559

fewer modes we ought to be getting a

436

00:17:45,110 --> 00:17:42,559

lower current

437

00:17:46,630 --> 00:17:45,120

and that's exactly what we see so this

438

00:17:49,510 --> 00:17:46,640

is the short circuit current as a

439

00:17:51,830 --> 00:17:49,520

function of the cavity thickness and the

440

00:17:56,070 --> 00:17:51,840

thicker the cavity is either for the

441

00:17:59,510 --> 00:17:56,080

organic pmma or for the glass sio2

442

00:18:01,590 --> 00:17:59,520

we do get a fall off in the current

443

00:18:02,950 --> 00:18:01,600

there are a number of other uh

444

00:18:04,710 --> 00:18:02,960

measurements that we made on these

445

00:18:06,070 --> 00:18:04,720

devices which i'm not going to show

446

00:18:08,549 --> 00:18:06,080

right now

447

00:18:11,909 --> 00:18:08,559

for lack of time and we have discussed

448

00:18:14,230 --> 00:18:11,919

them previously but i will very briefly

449

00:18:16,150 --> 00:18:14,240

address the issue of the reliability of

450

00:18:19,510 --> 00:18:16,160

the results

451

00:18:22,870 --> 00:18:19,520

because this this this is if it is

452

00:18:25,430 --> 00:18:22,880

correct uh quite important

453

00:18:27,430 --> 00:18:25,440

we verified these results in over 30

454

00:18:29,990 --> 00:18:27,440

batches of devices and measured

455

00:18:32,070 --> 00:18:30,000

thousands and thousands of devices there

456

00:18:35,110 --> 00:18:32,080

is scatter in the results but we

457

00:18:37,830 --> 00:18:35,120

consistently see these trends

458

00:18:39,750 --> 00:18:37,840

so could this be due to some sort of a

459

00:18:41,669 --> 00:18:39,760

measurement artifact

460

00:18:43,430 --> 00:18:41,679

we spent a long time looking for

461

00:18:46,070 --> 00:18:43,440

measurement artifacts and i'm going to

462

00:18:49,510 --> 00:18:46,080

very quickly go through nine tests we

463

00:18:52,150 --> 00:18:49,520

made for measurement artifacts

464

00:18:54,789 --> 00:18:52,160

one question is whether

465

00:18:57,750 --> 00:18:54,799

this degrades over time is it some sort

466

00:19:00,470 --> 00:18:57,760

of chemical effect and the answer is no

467

00:19:02,630 --> 00:19:00,480

the current is continuous over time this

468

00:19:04,870 --> 00:19:02,640

shows four hours we've actually upped

469

00:19:07,350 --> 00:19:04,880

this to 24 hours

470

00:19:09,830 --> 00:19:07,360

uh if this really is due to

471

00:19:12,070 --> 00:19:09,840

this sort of photoelectric effect that

472

00:19:14,310 --> 00:19:12,080

i'm talking about it ought to scale with

473

00:19:17,350 --> 00:19:14,320

area and in fact it does we've made

474

00:19:19,669 --> 00:19:17,360

devices between these submicron devices

475

00:19:22,789 --> 00:19:19,679

up to devices that are 100 microns on

476

00:19:24,390 --> 00:19:22,799

the side and it scales with area

477

00:19:26,950 --> 00:19:24,400

well does it scale with number of

478

00:19:29,990 --> 00:19:26,960

devices so we've made

479

00:19:32,630 --> 00:19:30,000

two types of small arrays these are four

480

00:19:35,669 --> 00:19:32,640

by four arrays and we find in these

481

00:19:38,310 --> 00:19:35,679

arrays that when we have a four by four

482

00:19:41,190 --> 00:19:38,320

we do get four times the current and

483

00:19:43,270 --> 00:19:41,200

four times the voltage

484

00:19:45,029 --> 00:19:43,280

might it just be due to something in our

485

00:19:47,909 --> 00:19:45,039

processing because we're cooking the

486

00:19:50,230 --> 00:19:47,919

devices as we build them

487

00:19:52,789 --> 00:19:50,240

so we made measurements first with the

488

00:19:55,270 --> 00:19:52,799

basic metal insulator metal device there

489

00:19:56,789 --> 00:19:55,280

was no current we heated it to the

490

00:19:59,590 --> 00:19:56,799

temperatures that we would use for

491

00:20:02,470 --> 00:19:59,600

processing no current we added the

492

00:20:03,750 --> 00:20:02,480

dielectric the the transparent layer

493

00:20:06,710 --> 00:20:03,760

that we'd have

494

00:20:09,430 --> 00:20:06,720

and uh for the for making the casimir

495

00:20:11,590 --> 00:20:09,440

current cavity again no current only

496

00:20:13,669 --> 00:20:11,600

when we put the mirror on do we all of a

497

00:20:15,510 --> 00:20:13,679

sudden see a current

498

00:20:17,510 --> 00:20:15,520

okay well might it be due to some sort

499

00:20:20,789 --> 00:20:17,520

of a leakage effect you've got this

500

00:20:23,270 --> 00:20:20,799

thick uh casimir cavity on top of a

501
00:20:25,110 --> 00:20:23,280
thinner metal insulator metal might

502
00:20:27,350 --> 00:20:25,120
there be some charge building up there

503
00:20:28,710 --> 00:20:27,360
that gets through so we measured the

504
00:20:32,549 --> 00:20:28,720
relative

505
00:20:33,350 --> 00:20:32,559
resistance of the casimir cavity and

506
00:20:38,549 --> 00:20:33,360
the

507
00:20:41,110 --> 00:20:38,559
cavity is at least a million times more

508
00:20:42,789 --> 00:20:41,120
resistive it's very unlikely that any

509
00:20:45,029 --> 00:20:42,799
charge that's

510
00:20:46,870 --> 00:20:45,039
built up there would get through and

511
00:20:48,950 --> 00:20:46,880
give a significant current

512
00:20:51,750 --> 00:20:48,960
might it be due to electromagnetic

513
00:20:54,230 --> 00:20:51,760

pickup from the ambient surroundings we

514

00:20:56,390 --> 00:20:54,240

did our measurements in a new metal box

515

00:20:57,990 --> 00:20:56,400

and an aluminum metal box and then that

516

00:20:59,750 --> 00:20:58,000

i checked for loaf

517

00:21:03,270 --> 00:20:59,760

low frequency and high frequency

518

00:21:04,870 --> 00:21:03,280

electromagnetic pickup and found neither

519

00:21:07,750 --> 00:21:04,880

might it be due to some sort of a

520

00:21:09,750 --> 00:21:07,760

thermoelectric effect there could be two

521

00:21:12,470 --> 00:21:09,760

one is thermoelectric effects within the

522

00:21:14,149 --> 00:21:12,480

device itself due to very very slight

523

00:21:16,310 --> 00:21:14,159

temperature differences

524

00:21:18,630 --> 00:21:16,320

or thermoelectric effects between the

525

00:21:20,710 --> 00:21:18,640

device and the measurement apparatus so

526

00:21:22,710 --> 00:21:20,720

we did some thorough testing for both of

527

00:21:26,390 --> 00:21:22,720

those found nothing

528

00:21:28,710 --> 00:21:26,400

uh no no effect and then just recently

529

00:21:30,870 --> 00:21:28,720

we carried out another type of test and

530

00:21:33,029 --> 00:21:30,880

this was actually recommended to us by

531

00:21:34,549 --> 00:21:33,039

jeremy mundy monday

532

00:21:36,789 --> 00:21:34,559

and that is

533

00:21:39,190 --> 00:21:36,799

uh maybe there's some sort of a field

534

00:21:41,510 --> 00:21:39,200

effect maybe there's a voltage that

535

00:21:45,590 --> 00:21:41,520

builds up on the mirror and that voltage

536

00:21:47,909 --> 00:21:45,600

somehow induces current in the in the

537

00:21:50,390 --> 00:21:47,919

metal insulator metal device and so we

538

00:21:52,789 --> 00:21:50,400

did a measurement where we varied the

539

00:21:54,630 --> 00:21:52,799

voltage on the mirror up to 10 volts to

540

00:21:57,990 --> 00:21:54,640

see if it changed the current through

541

00:22:00,549 --> 00:21:58,000

the mim the answer is no

542

00:22:04,390 --> 00:22:00,559

all right so that's for the for the

543

00:22:07,350 --> 00:22:04,400

those kind of sanity checks what about

544

00:22:09,830 --> 00:22:07,360

some sort of external source for example

545

00:22:13,350 --> 00:22:09,840

might it be due to cosmic rays

546

00:22:14,870 --> 00:22:13,360

well the highest flux of cosmic rays

547

00:22:17,750 --> 00:22:14,880

come from the sun

548

00:22:20,149 --> 00:22:17,760

and there are about 10 000 particles per

549

00:22:22,390 --> 00:22:20,159

square meter per second and given the

550

00:22:24,310 --> 00:22:22,400

size of our device that would mean that

551

00:22:26,470 --> 00:22:24,320

one cosmic ray would hit our device

552

00:22:28,630 --> 00:22:26,480

every 160 years

553

00:22:30,470 --> 00:22:28,640

we seem to see a current that occurs

554

00:22:32,470 --> 00:22:30,480

more often than that so i don't think

555

00:22:35,270 --> 00:22:32,480

it's cosmic rays

556

00:22:36,870 --> 00:22:35,280

well what about neutrinos the neutrino

557

00:22:40,070 --> 00:22:36,880

flux is greater

558

00:22:43,029 --> 00:22:40,080

however the absorption cross section for

559

00:22:45,110 --> 00:22:43,039

neutrinos is extremely small it's very

560

00:22:47,029 --> 00:22:45,120

unlikely that we can capture them

561

00:22:48,549 --> 00:22:47,039

because we can't even get them to be

562

00:22:50,549 --> 00:22:48,559

captured going all the way through the

563

00:22:52,950 --> 00:22:50,559

earth never mind in our very thin

564

00:22:56,230 --> 00:22:52,960

submicron device so it's not due to

565

00:22:57,110 --> 00:22:56,240

neutrinos or cosmic rays

566

00:22:59,669 --> 00:22:57,120

okay

567

00:23:03,350 --> 00:22:59,679

so that's the results now i want to get

568

00:23:07,510 --> 00:23:03,360

on to some of the uh new discussion and

569

00:23:09,990 --> 00:23:07,520

uh mulling over uh that we're discussed

570

00:23:11,750 --> 00:23:10,000

that's related to the the topics of this

571

00:23:14,950 --> 00:23:11,760

conference

572

00:23:17,350 --> 00:23:14,960

um and so first i will

573

00:23:19,350 --> 00:23:17,360

discuss the issue of vertical particles

574

00:23:23,110 --> 00:23:19,360

and fast capture

575

00:23:25,669 --> 00:23:23,120

so one way to think about this is we we

576

00:23:27,510 --> 00:23:25,679

know about the photoelectric effect the

577

00:23:28,710 --> 00:23:27,520

photoelectric effect

578

00:23:33,190 --> 00:23:28,720

says that

579

00:23:35,029 --> 00:23:33,200

light incoming to a metal surface

580

00:23:37,430 --> 00:23:35,039

energizes the electrons and those

581

00:23:40,149 --> 00:23:37,440

electrons can be emitted and this was

582

00:23:43,110 --> 00:23:40,159

discovered by hertz in 1887

583

00:23:45,830 --> 00:23:43,120

in 1905 einstein

584

00:23:50,630 --> 00:23:45,840

codified it as the photoelectric effect

585

00:23:53,990 --> 00:23:50,640

mixing it with planck's idea of a

586

00:23:57,110 --> 00:23:54,000

packet if you like of of electromagnetic

587

00:24:00,310 --> 00:23:57,120

radiation which we now call a photon

588

00:24:02,870 --> 00:24:00,320

and so if we have this photoelectric

589

00:24:05,269 --> 00:24:02,880

effect it's been measured by you know

590

00:24:07,990 --> 00:24:05,279

shining light on a piece of metal but if

591

00:24:10,630 --> 00:24:08,000

we really have these zero-point energy

592

00:24:13,110 --> 00:24:10,640

fluctuations all over the place in the

593

00:24:15,669 --> 00:24:13,120

vacuum doesn't that mean that we ought

594

00:24:18,470 --> 00:24:15,679

to just be having this huge stream of

595

00:24:19,830 --> 00:24:18,480

electrons coming off metal surfaces

596

00:24:20,950 --> 00:24:19,840

but we don't

597

00:24:21,830 --> 00:24:20,960

why

598

00:24:22,789 --> 00:24:21,840

well

599

00:24:25,029 --> 00:24:22,799

one

600

00:24:26,710 --> 00:24:25,039

way to answer the question

601
00:24:30,950 --> 00:24:26,720
is that

602
00:24:31,750 --> 00:24:30,960
the incoming radiation from the

603
00:24:33,990 --> 00:24:31,760
our vacuum

604
00:24:37,029 --> 00:24:34,000
virtue is virtual these are virtual

605
00:24:40,310 --> 00:24:37,039
photons and the virtual photons aren't

606
00:24:42,310 --> 00:24:40,320
going to give us real electron ejection

607
00:24:45,669 --> 00:24:42,320
so let's get into this virtual photon

608
00:24:48,470 --> 00:24:45,679
bit and talk about it a little bit

609
00:24:51,669 --> 00:24:48,480
so virtual particles are transient

610
00:24:54,789 --> 00:24:51,679
quantum fluctuations their existence is

611
00:24:57,669 --> 00:24:54,799
limited by the uncertainty principle

612
00:24:59,510 --> 00:24:57,679
they're usually interaction particles

613
00:25:01,830 --> 00:24:59,520

they mediate

614

00:25:05,190 --> 00:25:01,840

interactions between other particles and

615

00:25:08,070 --> 00:25:05,200

you don't see a naked virtual particle

616

00:25:10,230 --> 00:25:08,080

you just see the results of it

617

00:25:14,310 --> 00:25:10,240

and it's well accepted that vacuum

618

00:25:16,230 --> 00:25:14,320

fluctuations produce virtual photons and

619

00:25:19,269 --> 00:25:16,240

pairs

620

00:25:21,510 --> 00:25:19,279

can you take these virtual photons and

621

00:25:24,070 --> 00:25:21,520

make them into real photons the answer

622

00:25:27,110 --> 00:25:24,080

is yes and it's been demonstrated using

623

00:25:29,269 --> 00:25:27,120

the dynamical casimir effect so the

624

00:25:32,549 --> 00:25:29,279

dynamical casimir effect

625

00:25:36,230 --> 00:25:32,559

involves taking this casimir cavity and

626
00:25:39,510 --> 00:25:36,240
very rapidly moving those plates you've

627
00:25:41,110 --> 00:25:39,520
got to do it at relativistic velocities

628
00:25:43,510 --> 00:25:41,120
and the way that it's actually done in

629
00:25:46,149 --> 00:25:43,520
practice is by changing the dielectric

630
00:25:47,990 --> 00:25:46,159
of the material so you're effectively

631
00:25:49,350 --> 00:25:48,000
moving them back and forth and this was

632
00:25:51,990 --> 00:25:49,360
demonstrated

633
00:25:53,909 --> 00:25:52,000
and you actually can see the the

634
00:25:56,070 --> 00:25:53,919
existence of real

635
00:25:58,070 --> 00:25:56,080
photons produced from these virtual

636
00:25:59,190 --> 00:25:58,080
photons

637
00:26:01,590 --> 00:25:59,200
okay

638
00:26:05,350 --> 00:26:01,600

well if you can do that

639

00:26:08,950 --> 00:26:05,360

might it be possible to use fast capture

640

00:26:11,990 --> 00:26:08,960

to do the same thing so use fast capture

641

00:26:14,230 --> 00:26:12,000

to capture these photons these virtual

642

00:26:17,110 --> 00:26:14,240

particles or photons or whatever we

643

00:26:19,510 --> 00:26:17,120

produce from them and make it real then

644

00:26:23,110 --> 00:26:19,520

and that's really the question that i'm

645

00:26:26,789 --> 00:26:23,120

asking can fast capture convert virtual

646

00:26:29,029 --> 00:26:26,799

quantum vacuum photons into real photons

647

00:26:32,630 --> 00:26:29,039

and we can get a key to understanding

648

00:26:35,029 --> 00:26:32,640

this by looking at evanescent modes

649

00:26:36,630 --> 00:26:35,039

because evanescent waves which are well

650

00:26:38,950 --> 00:26:36,640

known in optics

651
00:26:40,230 --> 00:26:38,960
are in fact virtual photons it's the

652
00:26:43,350 --> 00:26:40,240
same thing

653
00:26:45,190 --> 00:26:43,360
so let's take a look at evanescent waves

654
00:26:47,909 --> 00:26:45,200
and see if we can get some understanding

655
00:26:54,789 --> 00:26:52,149
we know about total internal reflection

656
00:26:57,590 --> 00:26:54,799
if we have a prism and we've got light

657
00:27:00,390 --> 00:26:57,600
coming into it and it encounters an

658
00:27:03,190 --> 00:27:00,400
interface at a sharp enough angle

659
00:27:06,070 --> 00:27:03,200
then we can get all of the light to be

660
00:27:08,310 --> 00:27:06,080
reflected none of it is transmitted if

661
00:27:10,950 --> 00:27:08,320
we're put past this article this this

662
00:27:14,870 --> 00:27:10,960
this critical angle

663
00:27:17,190 --> 00:27:14,880

um and that's true for all of the power

664

00:27:19,909 --> 00:27:17,200

but there is a strange phenomenon in

665

00:27:21,269 --> 00:27:19,919

that we have an evanescent wave we get

666

00:27:23,750 --> 00:27:21,279

some leakage

667

00:27:27,110 --> 00:27:23,760

of the electromagnetic energy

668

00:27:28,149 --> 00:27:27,120

into to the outside just outside the

669

00:27:30,630 --> 00:27:28,159

prism

670

00:27:31,990 --> 00:27:30,640

there's no power that flows but it is

671

00:27:35,350 --> 00:27:32,000

there

672

00:27:37,990 --> 00:27:35,360

if we take another prism and we put it a

673

00:27:40,870 --> 00:27:38,000

few microns away or a few wavelengths

674

00:27:44,470 --> 00:27:40,880

let me say away from the from the first

675

00:27:46,549 --> 00:27:44,480

prism no change we still get a total

676

00:27:47,590 --> 00:27:46,559

internal reflection

677

00:27:49,830 --> 00:27:47,600

however

678

00:27:52,389 --> 00:27:49,840

we can frustrate that total internal

679

00:27:54,070 --> 00:27:52,399

reflection and the way we can frustrate

680

00:27:56,710 --> 00:27:54,080

the total eternal

681

00:27:59,510 --> 00:27:56,720

reflection is by putting these two

682

00:28:02,950 --> 00:27:59,520

prisms close enough together if we get

683

00:28:03,750 --> 00:28:02,960

within a fraction of a wavelength then

684

00:28:05,510 --> 00:28:03,760

this

685

00:28:08,230 --> 00:28:05,520

uh

686

00:28:10,630 --> 00:28:08,240

evanescent wave becomes a propagating

687

00:28:11,990 --> 00:28:10,640

wave and we can get the light to go all

688

00:28:14,630 --> 00:28:12,000

the way through

689

00:28:17,990 --> 00:28:14,640

and we can get energy transmitting

690

00:28:19,830 --> 00:28:18,000

so by allowing this

691

00:28:21,750 --> 00:28:19,840

close spacing

692

00:28:24,310 --> 00:28:21,760

of these evanescent way

693

00:28:26,549 --> 00:28:24,320

with the evanescent wave we've turned

694

00:28:29,830 --> 00:28:26,559

virtual into real

695

00:28:31,269 --> 00:28:29,840

we can do the same thing with uh

696

00:28:33,510 --> 00:28:31,279

electrons

697

00:28:35,909 --> 00:28:33,520

so if we have an incident wave of

698

00:28:38,310 --> 00:28:35,919

electrons hitting a barrier

699

00:28:40,389 --> 00:28:38,320

in the barrier it'll tunnel through and

700

00:28:42,870 --> 00:28:40,399

that's an evanescent state the

701
00:28:45,510 --> 00:28:42,880
transmitted wave will then be some

702
00:28:48,470 --> 00:28:45,520
fraction of the incident wave and in

703
00:28:51,269 --> 00:28:48,480
this way we can capture some of the

704
00:28:54,310 --> 00:28:51,279
incident wave uh in transmission in the

705
00:28:55,590 --> 00:28:54,320
other side and then so in this way we're

706
00:28:58,950 --> 00:28:55,600
actually

707
00:29:03,110 --> 00:28:58,960
creating a propagating charge

708
00:29:04,549 --> 00:29:03,120
by capturing capturing these virtual

709
00:29:06,549 --> 00:29:04,559
particles if you like or these

710
00:29:09,190 --> 00:29:06,559
effenescent particles

711
00:29:12,470 --> 00:29:09,200
and my conjecture is that we're doing

712
00:29:13,510 --> 00:29:12,480
something similar in our devices

713
00:29:15,750 --> 00:29:13,520

okay

714

00:29:18,549 --> 00:29:15,760

so we've talked about virtual particles

715

00:29:20,870 --> 00:29:18,559

and capture now let's expand a little

716

00:29:22,710 --> 00:29:20,880

bit to the topic of this

717

00:29:24,870 --> 00:29:22,720

conference and talk about the second law

718

00:29:26,470 --> 00:29:24,880

of thermodynamics and once we're at it

719

00:29:27,590 --> 00:29:26,480

talk about the first law

720

00:29:29,990 --> 00:29:27,600

and whether

721

00:29:30,789 --> 00:29:30,000

capturing zero point energy would in

722

00:29:34,549 --> 00:29:30,799

fact

723

00:29:40,389 --> 00:29:37,590

the sensible point of view is that

724

00:29:43,190 --> 00:29:40,399

forays into free energy inventions and

725

00:29:45,350 --> 00:29:43,200

perpetual motion machines using zero

726

00:29:47,750 --> 00:29:45,360

point energy are considered by the

727

00:29:51,110 --> 00:29:47,760

broader scientific community to be

728

00:29:54,549 --> 00:29:51,120

pseudoscience this was stated in a u.s

729

00:29:56,310 --> 00:29:54,559

army intelligence report in 2007 so it

730

00:29:59,590 --> 00:29:56,320

must be true

731

00:30:00,710 --> 00:29:59,600

and so that's the general view

732

00:30:02,710 --> 00:30:00,720

let's see

733

00:30:04,710 --> 00:30:02,720

what we think about it

734

00:30:06,630 --> 00:30:04,720

if we want to talk about the second law

735

00:30:08,789 --> 00:30:06,640

of thermodynamics the first question

736

00:30:10,950 --> 00:30:08,799

we've got to ask of course is which

737

00:30:12,070 --> 00:30:10,960

second law of thermodynamics

738

00:30:14,070 --> 00:30:12,080

and

739

00:30:16,710 --> 00:30:14,080

we can go through carnot's principle

740

00:30:20,870 --> 00:30:16,720

clausius kelvin and so on they all

741

00:30:22,870 --> 00:30:20,880

involve temperature and colder warmer

742

00:30:24,789 --> 00:30:22,880

things like that but if we're talking

743

00:30:27,750 --> 00:30:24,799

about zero point energy

744

00:30:30,549 --> 00:30:27,760

we believe that zero point energy can

745

00:30:32,230 --> 00:30:30,559

exist in the absence of temperature it

746

00:30:34,470 --> 00:30:32,240

can exist when you go all the way down

747

00:30:38,230 --> 00:30:34,480

to very low temperatures

748

00:30:40,149 --> 00:30:38,240

and uh therefore let's use a statement

749

00:30:42,549 --> 00:30:40,159

of the second law that does not involve

750

00:30:44,310 --> 00:30:42,559

temperature and that's planck statement

751

00:30:46,870 --> 00:30:44,320

so planck's statement is that every

752

00:30:49,110 --> 00:30:46,880

process occurring in nature

753

00:30:51,990 --> 00:30:49,120

proceeds in a way in which the sum of

754

00:30:54,310 --> 00:30:52,000

the entropies of all bodies taking part

755

00:30:57,190 --> 00:30:54,320

in the process is increased in other

756

00:30:59,669 --> 00:30:57,200

words we don't have any sort of decrease

757

00:31:02,149 --> 00:30:59,679

in entropy in any closed system and so

758

00:31:04,149 --> 00:31:02,159

let's take that as our as our

759

00:31:05,509 --> 00:31:04,159

description of the second law that's

760

00:31:09,509 --> 00:31:05,519

applicable

761

00:31:12,310 --> 00:31:09,519

so is there entropy associated with

762

00:31:13,509 --> 00:31:12,320

zero-point energy modes in a casimir

763

00:31:16,149 --> 00:31:13,519

cavity

764

00:31:19,750 --> 00:31:16,159

i took this from a publication that

765

00:31:22,070 --> 00:31:19,760

looked at a casimir cavity formed by two

766

00:31:24,070 --> 00:31:22,080

metal spheres now it can be planes or

767

00:31:26,310 --> 00:31:24,080

spheres i'm using this one simply

768

00:31:27,990 --> 00:31:26,320

because it was a nice plot

769

00:31:30,870 --> 00:31:28,000

and this shows

770

00:31:33,990 --> 00:31:30,880

how the entropy varies as a function of

771

00:31:36,630 --> 00:31:34,000

spacing between these two metal spheres

772

00:31:39,830 --> 00:31:36,640

and you can see that yes in fact there

773

00:31:45,990 --> 00:31:39,840

is a variation of the entropy in a

774

00:31:49,029 --> 00:31:47,830

so what does that mean

775

00:31:51,750 --> 00:31:49,039

well

776

00:31:55,029 --> 00:31:51,760

if we wanted to change the spacing in a

777

00:31:56,549 --> 00:31:55,039

casimir cavity and get energy out yeah

778

00:31:57,909 --> 00:31:56,559

we may be having some trouble with the

779

00:31:59,269 --> 00:31:57,919

second law

780

00:32:00,710 --> 00:31:59,279

so uh

781

00:32:03,590 --> 00:32:00,720

a lot of the

782

00:32:05,110 --> 00:32:03,600

earlier concepts for harvesting zero

783

00:32:07,269 --> 00:32:05,120

point energy involve

784

00:32:11,350 --> 00:32:07,279

allowing the two cavity plates to move

785

00:32:13,669 --> 00:32:11,360

together extracting energy from that

786

00:32:14,950 --> 00:32:13,679

there's a famous fort paper by forward

787

00:32:17,830 --> 00:32:14,960

on this

788

00:32:19,990 --> 00:32:17,840

and that would produce in fact a

789

00:32:21,750 --> 00:32:20,000

reduction in entropy there's also an

790

00:32:23,669 --> 00:32:21,760

another prop problem which i won't get

791

00:32:25,350 --> 00:32:23,679

into here and that is that the casimir

792

00:32:29,509 --> 00:32:25,360

force is a conservative force so you

793

00:32:30,630 --> 00:32:29,519

can't get out more than you put in

794

00:32:33,509 --> 00:32:30,640

so

795

00:32:34,789 --> 00:32:33,519

mechanical extraction is an issue

796

00:32:37,990 --> 00:32:34,799

however

797

00:32:39,669 --> 00:32:38,000

our device does not modify the casimir

798

00:32:42,789 --> 00:32:39,679

cavity spacing

799

00:32:45,590 --> 00:32:42,799

we have the same device before we

800

00:32:48,149 --> 00:32:45,600

extracting current as we do after we're

801
00:32:50,389 --> 00:32:48,159
extracting current the casimir cavity is

802
00:32:52,870 --> 00:32:50,399
a stationary vehicle for making the

803
00:32:55,029 --> 00:32:52,880
device work

804
00:32:56,389 --> 00:32:55,039
so therefore what we really want to look

805
00:32:59,110 --> 00:32:56,399
at is

806
00:33:00,950 --> 00:32:59,120
the entropy of the quantum vacuum itself

807
00:33:04,789 --> 00:33:00,960
rather than the the entropy inside a

808
00:33:06,870 --> 00:33:04,799
casimir cavity so what is the entropy

809
00:33:09,110 --> 00:33:06,880
of the quantum vacuum

810
00:33:10,630 --> 00:33:09,120
well the the standard answer from

811
00:33:13,509 --> 00:33:10,640
quantum mechanics

812
00:33:17,509 --> 00:33:13,519
is it's the the the uh it's a

813
00:33:19,350 --> 00:33:17,519

well-defined state it's it's the um

814

00:33:22,789 --> 00:33:19,360

the uh

815

00:33:25,590 --> 00:33:22,799

base state for everything and therefore

816

00:33:32,230 --> 00:33:25,600

its entropy is zero

817

00:33:33,830 --> 00:33:32,240

that if we want to convert that energy

818

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

into work

819

00:33:38,630 --> 00:33:35,919

we're free to do so because we don't

820

00:33:41,350 --> 00:33:38,640

have to exclude we don't have to throw

821

00:33:42,789 --> 00:33:41,360

out any entropy along the way in order

822

00:33:45,430 --> 00:33:42,799

to make it work

823

00:33:47,029 --> 00:33:45,440

so at least on a fundamental level

824

00:33:47,830 --> 00:33:47,039

there's no problem

825

00:33:54,230 --> 00:33:47,840

in

826

00:33:56,950 --> 00:33:54,240

but there's

827

00:33:59,110 --> 00:33:56,960

a corollary to the

828

00:34:01,669 --> 00:33:59,120

second law of thermodynamics which

829

00:34:04,070 --> 00:34:01,679

really has to do with perpetual motion

830

00:34:07,509 --> 00:34:04,080

so a perpetual motion machine

831

00:34:11,030 --> 00:34:07,519

would do work without an external energy

832

00:34:13,109 --> 00:34:11,040

source and in doing that it either has

833

00:34:15,829 --> 00:34:13,119

to violate the first or the second law

834

00:34:18,869 --> 00:34:15,839

of thermodynamics or both of them

835

00:34:22,470 --> 00:34:18,879

and so let's take a look at what we're

836

00:34:24,629 --> 00:34:22,480

doing a little bit more closely and ask

837

00:34:27,270 --> 00:34:24,639

whether we're building some sort of a

838

00:34:28,950 --> 00:34:27,280

perpetual motion machine that violates a

839

00:34:31,270 --> 00:34:28,960

fundamental law

840

00:34:34,310 --> 00:34:31,280

so in order to do that

841

00:34:36,389 --> 00:34:34,320

we need to say what we're talking about

842

00:34:38,710 --> 00:34:36,399

when we talk about the quantum vacuum in

843

00:34:41,909 --> 00:34:38,720

zero point energy there are multiple

844

00:34:45,030 --> 00:34:41,919

models of it and i'm going to

845

00:34:48,310 --> 00:34:45,040

describe three here very briefly one is

846

00:34:49,909 --> 00:34:48,320

the standard in quantum interpretation

847

00:34:54,950 --> 00:34:49,919

uh

848

00:34:56,510 --> 00:34:54,960

and

849

00:34:59,430 --> 00:34:56,520

then there's also stochastic

850

00:35:02,550 --> 00:34:59,440

electrodynamics which which i i is i

851

00:35:04,390 --> 00:35:02,560

love it's it's a it's a fascinating uh

852

00:35:06,390 --> 00:35:04,400

classical approach and then something

853

00:35:08,150 --> 00:35:06,400

that i'm calling a thermal model so

854

00:35:10,710 --> 00:35:08,160

let's start with the stochastic with the

855

00:35:12,150 --> 00:35:10,720

standard quantum interpretation

856

00:35:15,589 --> 00:35:12,160

so the standard

857

00:35:17,270 --> 00:35:15,599

uh model the copenhagen interpretation

858

00:35:19,910 --> 00:35:17,280

is that

859

00:35:22,630 --> 00:35:19,920

the zero point energy is a fixture it's

860

00:35:24,710 --> 00:35:22,640

just a fixture of nature it's there

861

00:35:26,390 --> 00:35:24,720

you can't deplete it you can't add to it

862

00:35:28,470 --> 00:35:26,400

it's just there so if you have a little

863

00:35:30,069 --> 00:35:28,480

box and you could take all the energy

864

00:35:31,990 --> 00:35:30,079

out of the zero point energy out of that

865

00:35:35,030 --> 00:35:32,000

little box you'd still have the same

866

00:35:37,510 --> 00:35:35,040

amount of energy in that little box so

867

00:35:39,750 --> 00:35:37,520

if we accept that that would mean that

868

00:35:41,750 --> 00:35:39,760

removing energy would violate

869

00:35:45,030 --> 00:35:41,760

conservation of energy would violate the

870

00:35:47,030 --> 00:35:45,040

first law of thermodynamics

871

00:35:48,710 --> 00:35:47,040

okay let's take a look at stochastic

872

00:35:51,829 --> 00:35:48,720

electrodynamics so stochastic

873

00:35:54,550 --> 00:35:51,839

electrodynamics says that the world is

874

00:35:56,790 --> 00:35:54,560

really classical with the addition of

875

00:35:57,670 --> 00:35:56,800

background electromagnetic fields that

876

00:36:00,150 --> 00:35:57,680

make up

877

00:36:03,510 --> 00:36:00,160

zero point energy radiation so for

878

00:36:06,310 --> 00:36:03,520

example if we take a look at an atom

879

00:36:10,790 --> 00:36:06,320

according to stochastic electrodynamic

880

00:36:13,829 --> 00:36:10,800

model the atom has a orbiting electron

881

00:36:16,310 --> 00:36:13,839

that electron is in fact accelerating

882

00:36:18,550 --> 00:36:16,320

and it's radiating larmor radiation all

883

00:36:21,270 --> 00:36:18,560

around and so it would wind down and

884

00:36:23,270 --> 00:36:21,280

fall into the into the nucleus except

885

00:36:25,910 --> 00:36:23,280

that there's also incoming radiation

886

00:36:27,670 --> 00:36:25,920

from the vacuum and that dynamic

887

00:36:30,310 --> 00:36:27,680

equilibrium between the incoming

888

00:36:32,710 --> 00:36:30,320

radiation and the outgoing radiation

889

00:36:35,670 --> 00:36:32,720

support electronic orbitals so there's a

890

00:36:37,270 --> 00:36:35,680

balance of emission and absorption

891

00:36:39,030 --> 00:36:37,280

so if we take

892

00:36:40,630 --> 00:36:39,040

there's much much more about stochastic

893

00:36:41,910 --> 00:36:40,640

electrodynamics which we're not going to

894

00:36:45,990 --> 00:36:41,920

talk about now

895

00:36:48,950 --> 00:36:46,000

so if we take this interpretation of uh

896

00:36:51,990 --> 00:36:48,960

of our quantum appearing world

897

00:36:54,390 --> 00:36:52,000

then what does that say about

898

00:36:55,510 --> 00:36:54,400

the first and second laws

899

00:36:56,630 --> 00:36:55,520

so

900

00:36:59,990 --> 00:36:56,640

it says

901
00:37:02,870 --> 00:37:00,000
that any way of extracting energy

902
00:37:05,270 --> 00:37:02,880
locally from the zero point fields would

903
00:37:07,349 --> 00:37:05,280
have to be fed by the surrounding

904
00:37:08,470 --> 00:37:07,359
electromagnetic fields

905
00:37:10,710 --> 00:37:08,480
and so

906
00:37:13,510 --> 00:37:10,720
in that way we actually would be

907
00:37:15,030 --> 00:37:13,520
conserving energy because we're pulling

908
00:37:16,390 --> 00:37:15,040
it from somewhere but we're putting it

909
00:37:18,630 --> 00:37:16,400
in as well

910
00:37:20,390 --> 00:37:18,640
and so the first law is observed and as

911
00:37:22,390 --> 00:37:20,400
we said earlier

912
00:37:24,710 --> 00:37:22,400
the the zero entropy interpretation of

913
00:37:27,190 --> 00:37:24,720

the quantum vacuum says the second law

914

00:37:28,950 --> 00:37:27,200

is also being observed

915

00:37:30,230 --> 00:37:28,960

finally let's take a look at the thermal

916

00:37:31,109 --> 00:37:30,240

model

917

00:37:32,630 --> 00:37:31,119

so

918

00:37:34,150 --> 00:37:32,640

again this is what i'm calling the

919

00:37:36,790 --> 00:37:34,160

thermal model

920

00:37:39,190 --> 00:37:36,800

uh so if we take a look at the formula

921

00:37:41,750 --> 00:37:39,200

once again for the uh

922

00:37:44,630 --> 00:37:41,760

energy density of zero point energy

923

00:37:46,630 --> 00:37:44,640

radiation the energy density

924

00:37:48,230 --> 00:37:46,640

includes a

925

00:37:50,790 --> 00:37:48,240

temperature dependent term and a

926
00:37:52,870 --> 00:37:50,800
temperature independent term this being

927
00:37:55,750 --> 00:37:52,880
the zero point energy

928
00:37:58,630 --> 00:37:55,760
interestingly we can express that same

929
00:38:00,630 --> 00:37:58,640
thing mathematically as a

930
00:38:01,750 --> 00:38:00,640
hyperbolic cotangent

931
00:38:04,150 --> 00:38:01,760
and so

932
00:38:06,230 --> 00:38:04,160
if we're actually mixing if you like the

933
00:38:09,190 --> 00:38:06,240
zero point energy in the thermal terms

934
00:38:11,109 --> 00:38:09,200
here this is just a an

935
00:38:13,829 --> 00:38:11,119
arithmetic there's nothing

936
00:38:14,710 --> 00:38:13,839
fundamental here but it sure makes me

937
00:38:17,670 --> 00:38:14,720
think

938
00:38:19,510 --> 00:38:17,680

that these two things the thermal energy

939

00:38:21,910 --> 00:38:19,520

and the zero point energy are

940

00:38:24,069 --> 00:38:21,920

fundamentally tied at the hip

941

00:38:25,430 --> 00:38:24,079

are they somehow combined

942

00:38:27,589 --> 00:38:25,440

for example

943

00:38:29,829 --> 00:38:27,599

even though our quantum mechanical

944

00:38:30,870 --> 00:38:29,839

viewpoint right now certainly doesn't

945

00:38:33,349 --> 00:38:30,880

say this

946

00:38:36,230 --> 00:38:33,359

is it possible that if we were able to

947

00:38:38,710 --> 00:38:36,240

extract zero point energy we'd have to

948

00:38:41,190 --> 00:38:38,720

feed it uh with thermal energy and so

949

00:38:43,349 --> 00:38:41,200

the the the location where we extracted

950

00:38:45,990 --> 00:38:43,359

it from would cool

951

00:38:49,109 --> 00:38:46,000

so in that way if zero point energy and

952

00:38:50,870 --> 00:38:49,119

thermal energy come from the same source

953

00:38:52,310 --> 00:38:50,880

extracting zero point energy would

954

00:38:54,390 --> 00:38:52,320

produce cooling

955

00:38:55,109 --> 00:38:54,400

we would obey the first law because

956

00:38:59,750 --> 00:38:55,119

we're

957

00:39:01,190 --> 00:38:59,760

but we would be violating the second law

958

00:39:04,950 --> 00:39:01,200

because cooling

959

00:39:07,109 --> 00:39:04,960

an ambient situation in equilibrium is a

960

00:39:09,750 --> 00:39:07,119

clear violation

961

00:39:13,750 --> 00:39:09,760

so which of these three models do we

962

00:39:16,069 --> 00:39:13,760

take or is there another model entirely

963

00:39:17,910 --> 00:39:16,079

let's that's up to you

964

00:39:19,589 --> 00:39:17,920

okay so let's take a look at the summary

965

00:39:21,829 --> 00:39:19,599

of our results so far

966

00:39:24,230 --> 00:39:21,839

we've made casimir cavities adjoining

967

00:39:28,150 --> 00:39:24,240

ultra fast charge transport transport

968

00:39:29,190 --> 00:39:28,160

devices uh they produce power

969

00:39:31,430 --> 00:39:29,200

we've

970

00:39:32,150 --> 00:39:31,440

shown that they uh

971

00:39:33,990 --> 00:39:32,160

the

972

00:39:36,950 --> 00:39:34,000

form for this power

973

00:39:38,950 --> 00:39:36,960

varies as we would expect it to if the

974

00:39:41,270 --> 00:39:38,960

source of the power were zero point

975

00:39:43,589 --> 00:39:41,280

energy and i wasn't able to show you all

976
00:39:45,109 --> 00:39:43,599
of that our papers describe it in more

977
00:39:47,430 --> 00:39:45,119
detail

978
00:39:49,349 --> 00:39:47,440
we've looked carefully for artifacts and

979
00:39:51,589 --> 00:39:49,359
at least so far we've not been able to

980
00:39:53,670 --> 00:39:51,599
find any sort of artifacts and our

981
00:39:56,310 --> 00:39:53,680
measurement apparatus is the most

982
00:39:59,109 --> 00:39:56,320
sensitive available we're also starting

983
00:40:01,030 --> 00:39:59,119
to get some measurements from outside

984
00:40:02,069 --> 00:40:01,040
labs that are corroborating what we're

985
00:40:03,750 --> 00:40:02,079
seeing

986
00:40:04,870 --> 00:40:03,760
but we haven't yet

987
00:40:07,030 --> 00:40:04,880
done that

988
00:40:09,109 --> 00:40:07,040

to a sufficient

989

00:40:11,990 --> 00:40:09,119

accuracy for publication

990

00:40:12,790 --> 00:40:12,000

we've written two papers on this so far

991

00:40:16,230 --> 00:40:12,800

so

992

00:40:19,349 --> 00:40:16,240

what are the consequences of all of this

993

00:40:20,870 --> 00:40:19,359

if the measured 70 watts per square

994

00:40:22,470 --> 00:40:20,880

meter power

995

00:40:25,589 --> 00:40:22,480

that we

996

00:40:28,550 --> 00:40:25,599

found in our small devices if that could

997

00:40:30,309 --> 00:40:28,560

be reproduced over large areas

998

00:40:31,910 --> 00:40:30,319

and if we could take these and stack

999

00:40:35,430 --> 00:40:31,920

these devices i mean there's no reason

1000

00:40:36,550 --> 00:40:35,440

we can't go into the third dimension

1001

00:40:38,950 --> 00:40:36,560

we could

1002

00:40:40,790 --> 00:40:38,960

quite easily get lithium-ion battery

1003

00:40:43,589 --> 00:40:40,800

power densities

1004

00:40:45,109 --> 00:40:43,599

we could make a very practical uh power

1005

00:40:46,470 --> 00:40:45,119

source

1006

00:40:49,190 --> 00:40:46,480

what's the consequence it would be

1007

00:40:52,470 --> 00:40:49,200

revolutionary

1008

00:40:56,470 --> 00:40:52,480

okay so let's go quickly to the last

1009

00:40:58,069 --> 00:40:56,480

part which is the unanswered questions

1010

00:40:58,870 --> 00:40:58,079

a one question

1011

00:41:00,950 --> 00:40:58,880

is

1012

00:41:03,589 --> 00:41:00,960

why do we not see

1013

00:41:05,750 --> 00:41:03,599

a large photoelectric effect from zero

1014

00:41:06,870 --> 00:41:05,760

point energy at all metal surfaces and i

1015

00:41:09,190 --> 00:41:06,880

raised this

1016

00:41:09,910 --> 00:41:09,200

and the the the standard answer is that

1017

00:41:10,630 --> 00:41:09,920

the

1018

00:41:11,990 --> 00:41:10,640

uh

1019

00:41:13,430 --> 00:41:12,000

photons or

1020

00:41:15,430 --> 00:41:13,440

we shouldn't even call them that the

1021

00:41:16,710 --> 00:41:15,440

electromagnetic modes

1022

00:41:19,510 --> 00:41:16,720

from the

1023

00:41:20,870 --> 00:41:19,520

vacuum are virtual

1024

00:41:24,630 --> 00:41:20,880

can we

1025

00:41:26,550 --> 00:41:24,640

use fast capture to convert those uh

1026

00:41:29,589 --> 00:41:26,560

particles those virtual particles to

1027

00:41:31,829 --> 00:41:29,599

real particles i don't know

1028

00:41:34,950 --> 00:41:31,839

if the zero-point energy hot electron

1029

00:41:36,550 --> 00:41:34,960

excitation between both electric

1030

00:41:37,670 --> 00:41:36,560

electrodes

1031

00:41:40,230 --> 00:41:37,680

exists

1032

00:41:43,510 --> 00:41:40,240

why isn't there a huge conductivity even

1033

00:41:46,790 --> 00:41:43,520

in the absence of the casimir cavity

1034

00:41:51,190 --> 00:41:46,800

well the model of larry ford

1035

00:41:54,390 --> 00:41:51,200

says that in fact we do require a cavity

1036

00:41:56,150 --> 00:41:54,400

uh for the electron injection and he he

1037

00:41:59,190 --> 00:41:56,160

discussed that briefly

1038

00:42:01,109 --> 00:41:59,200

earlier in this conference

1039

00:42:03,829 --> 00:42:01,119

however

1040

00:42:06,069 --> 00:42:03,839

larry is very clear to say that he does

1041

00:42:09,270 --> 00:42:06,079

not have an asymmetry in other words

1042

00:42:11,990 --> 00:42:09,280

current goes in both directions so he

1043

00:42:14,470 --> 00:42:12,000

it's not an explanation for the currents

1044

00:42:16,390 --> 00:42:14,480

that we're seeing

1045

00:42:19,190 --> 00:42:16,400

um so if there is

1046

00:42:21,910 --> 00:42:19,200

a symmetric excitation

1047

00:42:25,030 --> 00:42:21,920

why don't we see currents in both

1048

00:42:28,309 --> 00:42:25,040

directions why do we see an asymmetry

1049

00:42:30,470 --> 00:42:28,319

and i raise the conjecture is that due

1050

00:42:31,349 --> 00:42:30,480

to fast capture

1051

00:42:33,670 --> 00:42:31,359

or

1052

00:42:36,230 --> 00:42:33,680

are we uh really looking at this whole

1053

00:42:39,030 --> 00:42:36,240

thing the wrong way altogether and is

1054

00:42:41,190 --> 00:42:39,040

there another model for operation that

1055

00:42:42,950 --> 00:42:41,200

fits our results a lot better

1056

00:42:45,510 --> 00:42:42,960

it's really early in the game and it's

1057

00:42:53,990 --> 00:42:45,520

too soon to tell

1058

00:42:56,309 --> 00:42:55,349

thank you garrett that was a wonderful

1059

00:42:57,990 --> 00:42:56,319

talk

1060

00:43:01,589 --> 00:42:58,000

so i'm sure we'll have some questions

1061

00:43:05,190 --> 00:43:01,599

here let me get to the participants

1062

00:43:05,200 --> 00:43:09,030

okay we'll start with kent peacock

1063

00:43:13,990 --> 00:43:11,750

thanks very much and uh fascinating talk

1064

00:43:14,950 --> 00:43:14,000

i don't quite understand every detail of

1065

00:43:18,230 --> 00:43:14,960

it but

1066

00:43:19,750 --> 00:43:18,240

uh it did strike me that that

1067

00:43:21,190 --> 00:43:19,760

there's there may be an interesting

1068

00:43:23,670 --> 00:43:21,200

parallel between

1069

00:43:25,109 --> 00:43:23,680

your work and uh schrodinger's

1070

00:43:27,190 --> 00:43:25,119

observations

1071

00:43:29,109 --> 00:43:27,200

in 1943 so schrodinger published a

1072

00:43:31,589 --> 00:43:29,119

famous book called what is life

1073

00:43:32,710 --> 00:43:31,599

uh in which he asked himself

1074

00:43:34,790 --> 00:43:32,720

how can we account for the

1075

00:43:36,390 --> 00:43:34,800

thermodynamics of a living organism

1076

00:43:38,870 --> 00:43:36,400

because a living organism as long as

1077

00:43:41,349 --> 00:43:38,880

you're still alive it maintains a cons

1078

00:43:43,109 --> 00:43:41,359

roughly constant level of entropy

1079

00:43:44,230 --> 00:43:43,119

and um

1080

00:43:46,550 --> 00:43:44,240

how's it

1081

00:43:49,030 --> 00:43:46,560

how is this possible without violating

1082

00:43:50,870 --> 00:43:49,040

thermodynamics somehow and he realized

1083

00:43:53,510 --> 00:43:50,880

of course that

1084

00:43:56,230 --> 00:43:53,520

it's because we metabolize and in the

1085

00:43:57,829 --> 00:43:56,240

process we're pumping entropy out

1086

00:43:59,349 --> 00:43:57,839

through infrared radiation from our

1087

00:44:01,190 --> 00:43:59,359

bodies from

1088

00:44:03,190 --> 00:44:01,200

when we exhale carbon dioxide and so

1089

00:44:05,750 --> 00:44:03,200

forth we're um so

1090

00:44:07,510 --> 00:44:05,760

so we're actually creating more entropy

1091

00:44:09,270 --> 00:44:07,520

than we're

1092

00:44:11,670 --> 00:44:09,280

i guess you could say preventing within

1093

00:44:13,910 --> 00:44:11,680

our bodies and and so nothing gets

1094

00:44:16,630 --> 00:44:13,920

violated but you can create

1095

00:44:19,030 --> 00:44:16,640

local areas where the entropy is either

1096

00:44:21,030 --> 00:44:19,040

constant or or lowered

1097

00:44:23,349 --> 00:44:21,040

but there's always an energy cost so you

1098

00:44:25,109 --> 00:44:23,359

have to so i sort of compare this to

1099

00:44:27,270 --> 00:44:25,119

like imagine there's a giant pile of

1100

00:44:28,870 --> 00:44:27,280

basketballs on the gym floor and it's

1101

00:44:30,870 --> 00:44:28,880

going to fall down very easily and

1102

00:44:32,870 --> 00:44:30,880

you've got to always keep on putting

1103

00:44:34,630 --> 00:44:32,880

basketballs back onto it to hold it up

1104

00:44:36,550 --> 00:44:34,640

again so anyway i just throw that out is

1105

00:44:38,390 --> 00:44:36,560

there a parallel between what schroder

1106

00:44:42,390 --> 00:44:38,400

was talking about there and what you're

1107

00:44:44,470 --> 00:44:43,190

so

1108

00:44:47,030 --> 00:44:44,480

from a

1109

00:44:48,870 --> 00:44:47,040

conventional thermodynamics point of

1110

00:44:51,030 --> 00:44:48,880

view

1111

00:44:52,150 --> 00:44:51,040

i'd say no

1112

00:44:55,030 --> 00:44:52,160

because

1113

00:44:58,790 --> 00:44:55,040

uh we know that we can re reduce entropy

1114

00:45:01,510 --> 00:44:58,800

by adding energy to the system and

1115

00:45:03,800 --> 00:45:01,520

as as in what is life

1116

00:45:05,829 --> 00:45:03,810

from schrodinger

1117

00:45:07,589 --> 00:45:05,839

[Music]

1118

00:45:11,190 --> 00:45:07,599

in this case

1119

00:45:13,990 --> 00:45:11,200

we're actually extracting energy

1120

00:45:16,790 --> 00:45:14,000

and we don't seem to be paying any sort

1121

00:45:19,670 --> 00:45:16,800

of entropic cost for that

1122

00:45:22,790 --> 00:45:19,680

so you know i i really don't know i mean

1123

00:45:25,190 --> 00:45:22,800

i i i honestly and totally don't know

1124

00:45:27,589 --> 00:45:25,200

but i i'm not sure that we need to uh

1125

00:45:29,750 --> 00:45:27,599

take that approach

1126

00:45:32,390 --> 00:45:29,760

okay i'm willing to bet the energy's

1127

00:45:35,030 --> 00:45:32,400

coming from somewhere but well i believe

1128

00:45:37,589 --> 00:45:35,040

it is certainly not to email question

1129

00:45:38,870 --> 00:45:37,599

your results but but

1130

00:45:40,230 --> 00:45:38,880

we might be

1131

00:45:42,390 --> 00:45:40,240

surprised where the energy's coming from

1132

00:45:44,150 --> 00:45:42,400

but i'll just leave it at that uh you

1133

00:45:45,270 --> 00:45:44,160

you're probably right

1134

00:45:47,109 --> 00:45:45,280

well

1135

00:45:49,670 --> 00:45:47,119

okay um

1136

00:45:52,390 --> 00:45:49,680

paul menker

1137

00:45:53,990 --> 00:45:52,400

yeah i just had a couple um

1138

00:45:57,270 --> 00:45:54,000

more maybe more comments than questions

1139

00:45:58,390 --> 00:45:57,280

but it is interesting that

1140

00:45:59,829 --> 00:45:58,400

you know in some sense all these

1141

00:46:02,390 --> 00:45:59,839

quantities are formally infinite the

1142

00:46:04,309 --> 00:46:02,400

energy of the vacuum so

1143

00:46:06,309 --> 00:46:04,319

if you're using kind of underhanded math

1144

00:46:07,589 --> 00:46:06,319

you could have

1145

00:46:09,190 --> 00:46:07,599

you know subtract a finite amount of

1146

00:46:10,470 --> 00:46:09,200

energy from an infinite vacuum and not

1147

00:46:12,150 --> 00:46:10,480

kind of change that

1148

00:46:13,109 --> 00:46:12,160

but i think what this might be touching

1149

00:46:18,390 --> 00:46:13,119

on

1150

00:46:22,309 --> 00:46:20,710

the the vacuum energy breaks down at the

1151

00:46:23,510 --> 00:46:22,319

planck scale um

1152

00:46:24,950 --> 00:46:23,520

otherwise everything would turn to a

1153

00:46:26,870 --> 00:46:24,960

black hole and like

1154

00:46:28,390 --> 00:46:26,880

all of these ideas like quantum field

1155

00:46:30,390 --> 00:46:28,400

theory formally breaks down

1156

00:46:32,470 --> 00:46:30,400

so it's it's really interesting that

1157

00:46:34,870 --> 00:46:32,480

this could be an avenue into these you

1158

00:46:36,390 --> 00:46:34,880

know very pressing questions one day um

1159

00:46:37,589 --> 00:46:36,400

but maybe for more of a question do you

1160

00:46:40,150 --> 00:46:37,599

see any

1161

00:46:41,990 --> 00:46:40,160

like true challenges just to scaling up

1162

00:46:44,230 --> 00:46:42,000

the size aside from like the normal

1163

00:46:46,390 --> 00:46:44,240

logistic challenges or is there

1164

00:46:48,230 --> 00:46:46,400
any like theoretical or engineering

1165

00:46:50,309 --> 00:46:48,240
reason to think that this is like only

1166

00:46:53,589 --> 00:46:50,319
valid at small scales

1167

00:46:56,069 --> 00:46:53,599
uh no i think it can be scaled the big

1168

00:46:58,230 --> 00:46:56,079
problem that we're having and the reason

1169

00:46:59,910 --> 00:46:58,240
that we're slow at doing that is that

1170

00:47:01,589 --> 00:46:59,920
we're using metal insulator metal

1171

00:47:03,510 --> 00:47:01,599
devices

1172

00:47:05,829 --> 00:47:03,520
which are

1173

00:47:08,550 --> 00:47:05,839
essentially all interface

1174

00:47:10,950 --> 00:47:08,560
and i think

1175

00:47:13,270 --> 00:47:10,960
george in the previous talked and

1176

00:47:15,109 --> 00:47:13,280

previous talk talked about how really

1177

00:47:18,230 --> 00:47:15,119

the the the devil lives in the

1178

00:47:20,470 --> 00:47:18,240

interfaces and it's it's a it's a

1179

00:47:22,950 --> 00:47:20,480

challenging technology so at this point

1180

00:47:24,390 --> 00:47:22,960

it's a technological issue sure because

1181

00:47:25,670 --> 00:47:24,400

you know there's nothing in principle

1182

00:47:27,829 --> 00:47:25,680

wrong with a small effect i mean you

1183

00:47:29,990 --> 00:47:27,839

know g minus two is in the tenth decimal

1184

00:47:31,270 --> 00:47:30,000

place of defined structure constant but

1185

00:47:33,030 --> 00:47:31,280

there is

1186

00:47:34,630 --> 00:47:33,040

on the rhetorical side something a

1187

00:47:36,069 --> 00:47:34,640

little more convincing i think to a

1188

00:47:38,710 --> 00:47:36,079

general audience about just a larger

1189

00:47:40,870 --> 00:47:38,720

effect you know there's just there's the

1190

00:47:42,150 --> 00:47:40,880

unknown unknowns you know and the larger

1191

00:47:43,349 --> 00:47:42,160

the effect the harder it is to explain

1192

00:47:45,589 --> 00:47:43,359

it's just something we're not thinking

1193

00:47:47,589 --> 00:47:45,599

of you know yes i

1194

00:47:49,349 --> 00:47:47,599

absolutely agree yeah wonderful talk

1195

00:47:50,390 --> 00:47:49,359

thank you thank you

1196

00:47:55,109 --> 00:47:50,400

okay

1197

00:48:00,150 --> 00:47:58,309

i i'm gonna elaborate a little bit um on

1198

00:48:02,309 --> 00:48:00,160

what i mentioned earlier

1199

00:48:04,710 --> 00:48:02,319

um that uh you know i'm coming from the

1200

00:48:06,549 --> 00:48:04,720

computational sciences uh artificial

1201
00:48:08,150 --> 00:48:06,559
intelligence software engineering

1202
00:48:10,309 --> 00:48:08,160
and for somebody who has to take these

1203
00:48:11,910 --> 00:48:10,319
different scientific models theoretic

1204
00:48:13,910 --> 00:48:11,920
models actually has to put them into you

1205
00:48:15,270 --> 00:48:13,920
know running systems

1206
00:48:17,750 --> 00:48:15,280
and you know we look at these different

1207
00:48:19,990 --> 00:48:17,760
systems and and often you get the same

1208
00:48:22,470 --> 00:48:20,000
thing done with many different models so

1209
00:48:23,910 --> 00:48:22,480
we have different evaluation criteria of

1210
00:48:25,270 --> 00:48:23,920
what are the different properties of

1211
00:48:27,190 --> 00:48:25,280
those models

1212
00:48:29,829 --> 00:48:27,200
and when when you take that view and you

1213
00:48:31,349 --> 00:48:29,839

start looking at let's say laws of

1214

00:48:32,950 --> 00:48:31,359

physics

1215

00:48:34,630 --> 00:48:32,960

you go to the the point that was talked

1216

00:48:36,950 --> 00:48:34,640

about by daniel before that these are

1217

00:48:37,990 --> 00:48:36,960

axioms but you also start looking at

1218

00:48:40,390 --> 00:48:38,000

well

1219

00:48:41,510 --> 00:48:40,400

how is that axiom actually used and if

1220

00:48:43,270 --> 00:48:41,520

you're looking at let's say the

1221

00:48:44,470 --> 00:48:43,280

conservation of energy which underlies

1222

00:48:46,549 --> 00:48:44,480

the second law

1223

00:48:47,990 --> 00:48:46,559

a second property of thermodynamics i

1224

00:48:48,870 --> 00:48:48,000

don't want to call it a law because when

1225

00:48:50,790 --> 00:48:48,880

you're talking about you're talking

1226
00:48:53,349 --> 00:48:50,800
government you're not talking science

1227
00:48:55,829 --> 00:48:53,359
sciences you have models and prayer and

1228
00:48:58,309 --> 00:48:55,839
you have properties of models

1229
00:49:01,349 --> 00:48:58,319
and you know so the conservation of

1230
00:49:02,470 --> 00:49:01,359
energy is it an important

1231
00:49:04,870 --> 00:49:02,480
property

1232
00:49:06,150 --> 00:49:04,880
of any computational model and you're

1233
00:49:07,750 --> 00:49:06,160
going to want to maintain that you're

1234
00:49:10,470 --> 00:49:07,760
going to want to

1235
00:49:12,710 --> 00:49:10,480
have conservation

1236
00:49:15,990 --> 00:49:12,720
either and that conservation can go

1237
00:49:18,549 --> 00:49:16,000
across systems so i'll go back to my you

1238
00:49:20,630 --> 00:49:18,559

know mechanics physics book uh from the

1239

00:49:22,109 --> 00:49:20,640

junior level and how they talked about

1240

00:49:25,030 --> 00:49:22,119

different levels they talked about the

1241

00:49:26,470 --> 00:49:25,040

cosmological level the macro micro level

1242

00:49:28,069 --> 00:49:26,480

then the atomic level and then the

1243

00:49:30,390 --> 00:49:28,079

subparticle level

1244

00:49:32,950 --> 00:49:30,400

and yeah they said well we've got the

1245

00:49:35,109 --> 00:49:32,960

same conservation law same momentum laws

1246

00:49:37,829 --> 00:49:35,119

at the cosmological and macro micro but

1247

00:49:39,589 --> 00:49:37,839

when you start going to the atomic level

1248

00:49:41,990 --> 00:49:39,599

will we change them all up because

1249

00:49:43,990 --> 00:49:42,000

things are not operating the same way

1250

00:49:46,309 --> 00:49:44,000

and then when you go to the subparticle

1251

00:49:48,309 --> 00:49:46,319

everything you know forget about

1252

00:49:50,630 --> 00:49:48,319

now so you want to have a computational

1253

00:49:52,950 --> 00:49:50,640

system that crosses those boundaries and

1254

00:49:55,030 --> 00:49:52,960

you have the same conservation models

1255

00:49:57,430 --> 00:49:55,040

across all of them

1256

00:49:59,190 --> 00:49:57,440

um and you you want to be able to say

1257

00:50:00,150 --> 00:49:59,200

okay what's happening at the subpar

1258

00:50:01,750 --> 00:50:00,160

subparticle level what are the

1259

00:50:03,430 --> 00:50:01,760

mechanisms that are going there and you

1260

00:50:06,150 --> 00:50:03,440

want that justin can you please get to

1261

00:50:08,230 --> 00:50:06,160

the point sure um so so the point is

1262

00:50:10,069 --> 00:50:08,240

when everybody's talking about the

1263

00:50:11,190 --> 00:50:10,079

second law of thermodynamics we're

1264

00:50:12,309 --> 00:50:11,200

talking about a property you're talking

1265

00:50:13,589 --> 00:50:12,319

about a comp

1266

00:50:15,030 --> 00:50:13,599

computational property that's very

1267

00:50:16,870 --> 00:50:15,040

valuable and no matter what

1268

00:50:18,150 --> 00:50:16,880

computational model you want to have

1269

00:50:19,750 --> 00:50:18,160

you're going to want to have that

1270

00:50:21,589 --> 00:50:19,760

property whether you're saying energy is

1271

00:50:23,990 --> 00:50:21,599

coming from the zero point so there's

1272

00:50:26,069 --> 00:50:24,000

some energetic interactions happening at

1273

00:50:28,150 --> 00:50:26,079

the zero point there's some mechanisms

1274

00:50:29,349 --> 00:50:28,160

happening at the zero point and that's

1275

00:50:31,109 --> 00:50:29,359

one of the research groups i'm in

1276
00:50:32,870 --> 00:50:31,119
subquantum kinetics and we're studying

1277
00:50:35,349 --> 00:50:32,880
what are the mechanisms at the zero

1278
00:50:37,910 --> 00:50:35,359
point with paul abbey guides group um

1279
00:50:38,870 --> 00:50:37,920
and so when when you're actually going

1280
00:50:40,870 --> 00:50:38,880
from there

1281
00:50:42,230 --> 00:50:40,880
um you you can have energy and the

1282
00:50:44,069 --> 00:50:42,240
mechanisms that are happening at that

1283
00:50:46,549 --> 00:50:44,079
level you know transferring to the

1284
00:50:48,470 --> 00:50:46,559
atomic level which then transfer to the

1285
00:50:49,750 --> 00:50:48,480
macro micro world that we're looking at

1286
00:50:52,630 --> 00:50:49,760
these things happening and also the

1287
00:50:54,390 --> 00:50:52,640
cosmological level um okay garrett we

1288
00:50:56,390 --> 00:50:54,400

want to have that energy you want to

1289

00:50:57,829 --> 00:50:56,400

have that conservation across those

1290

00:51:00,309 --> 00:50:57,839

different levels and you want to have a

1291

00:51:01,990 --> 00:51:00,319

computational model that has that

1292

00:51:02,870 --> 00:51:02,000

okay

1293

00:51:06,549 --> 00:51:02,880

gareth

1294

00:51:08,549 --> 00:51:06,559

uh time will tell we were we're early

1295

00:51:10,870 --> 00:51:08,559

in in understanding this

1296

00:51:12,230 --> 00:51:10,880

and i i don't have a an intelligent

1297

00:51:15,670 --> 00:51:12,240

answer to that

1298

00:51:18,710 --> 00:51:15,680

okay i'd like to call on larry ford

1299

00:51:21,030 --> 00:51:18,720

okay well for first a couple of comments

1300

00:51:23,430 --> 00:51:21,040

this is a very first a very fascinating

1301
00:51:26,390 --> 00:51:23,440
and thought-provoking talk thank you for

1302
00:51:28,710 --> 00:51:26,400
that but i have to say that i i although

1303
00:51:31,190 --> 00:51:28,720
as i explained a couple of days ago i

1304
00:51:33,670 --> 00:51:31,200
can understand the symmetric results

1305
00:51:36,390 --> 00:51:33,680
that is why why the current why there

1306
00:51:37,829 --> 00:51:36,400
can be a current that varies inversely

1307
00:51:42,150 --> 00:51:37,839
as the

1308
00:51:44,069 --> 00:51:42,160
an applied voltage i'm completely

1309
00:51:46,470 --> 00:51:44,079
puzzled about the uh

1310
00:51:49,349 --> 00:51:46,480
the existence of a current at zero

1311
00:51:51,829 --> 00:51:49,359
applied voltage and have no no idea

1312
00:51:54,150 --> 00:51:51,839
where that could be coming from so in

1313
00:51:56,710 --> 00:51:54,160

terms of that latter result my question

1314

00:51:58,069 --> 00:51:56,720

is are there any other labs that are

1315

00:52:01,349 --> 00:51:58,079

that you know of are attempting to

1316

00:52:03,190 --> 00:52:01,359

independently uh confirm your results

1317

00:52:05,510 --> 00:52:03,200

yes so we've had

1318

00:52:08,069 --> 00:52:05,520

two confirmations so far

1319

00:52:10,790 --> 00:52:08,079

neither of them are uh have been

1320

00:52:13,990 --> 00:52:10,800

replicated enough to be publishable

1321

00:52:15,510 --> 00:52:14,000

and uh so i'm i'm waiting uh i'm hoping

1322

00:52:16,790 --> 00:52:15,520

that that will happen

1323

00:52:18,549 --> 00:52:16,800

within

1324

00:52:19,910 --> 00:52:18,559

a fairly short time

1325

00:52:22,150 --> 00:52:19,920

and uh

1326

00:52:24,549 --> 00:52:22,160

i agree completely that

1327

00:52:26,230 --> 00:52:24,559

you know this this is a radical enough

1328

00:52:28,230 --> 00:52:26,240

result that

1329

00:52:30,150 --> 00:52:28,240

one really wants confirmation we want

1330

00:52:32,470 --> 00:52:30,160

confirmation ourselves

1331

00:52:34,069 --> 00:52:32,480

and so yeah we're doing it as well at

1332

00:52:35,430 --> 00:52:34,079

halfway research

1333

00:52:37,109 --> 00:52:35,440

thank you i didn't want to mention you

1334

00:52:39,510 --> 00:52:37,119

george in case you didn't want to say

1335

00:52:40,390 --> 00:52:39,520

that but yes

1336

00:52:43,589 --> 00:52:40,400

okay

1337

00:52:45,190 --> 00:52:43,599

james lee then uh jacob um did larry

1338

00:52:46,790 --> 00:52:45,200

have a second part to us oh i'm sorry

1339

00:52:48,870 --> 00:52:46,800

did you have a second part i apologize

1340

00:52:49,510 --> 00:52:48,880

no i finished thank you all right thank

1341

00:52:51,750 --> 00:52:49,520

you

1342

00:52:54,470 --> 00:52:51,760

james lee

1343

00:52:56,870 --> 00:52:54,480

uh garrett very fascinating talk um our

1344

00:52:59,829 --> 00:52:56,880

question is in your system um is there

1345

00:53:02,790 --> 00:52:59,839

any asymmetric

1346

00:53:04,390 --> 00:53:02,800

uh structure or function there was not

1347

00:53:06,710 --> 00:53:04,400

clear to me

1348

00:53:09,670 --> 00:53:06,720

and also another question was you said

1349

00:53:11,589 --> 00:53:09,680

the border energy now if if the enemy

1350

00:53:13,190 --> 00:53:11,599

does not exist it bothers that thing is

1351
00:53:15,510 --> 00:53:13,200
a violation of the first law you know we

1352
00:53:17,510 --> 00:53:15,520
never see anything in my season first

1353
00:53:19,510 --> 00:53:17,520
thought is well well conserved you know

1354
00:53:21,109 --> 00:53:19,520
there's nothing we can't see why they

1355
00:53:21,910 --> 00:53:21,119
first law okay

1356
00:53:23,030 --> 00:53:21,920
uh

1357
00:53:25,510 --> 00:53:23,040
why why

1358
00:53:27,910 --> 00:53:25,520
i wasn't regarded as impossible unless

1359
00:53:30,549 --> 00:53:27,920
we don't understand okay so my question

1360
00:53:33,589 --> 00:53:30,559
to focus on is do your structure in your

1361
00:53:36,069 --> 00:53:33,599
system is any symmetric function because

1362
00:53:38,309 --> 00:53:36,079
if you have a summation function then

1363
00:53:40,870 --> 00:53:38,319

then the second law may or may not apply

1364

00:53:44,150 --> 00:53:40,880

okay right so that's my question

1365

00:53:45,190 --> 00:53:44,160

okay so let me quickly show you

1366

00:53:48,950 --> 00:53:45,200

um

1367

00:53:50,630 --> 00:53:48,960

yes we do have an asymmetry and that is

1368

00:53:53,190 --> 00:53:50,640

i believe the

1369

00:53:55,349 --> 00:53:53,200

the con what's producing this here so

1370

00:53:57,670 --> 00:53:55,359

the asymmetry is that we have this metal

1371

00:54:00,390 --> 00:53:57,680

insulator metal device here

1372

00:54:02,950 --> 00:54:00,400

and the ac on one side of it there's a

1373

00:54:04,069 --> 00:54:02,960

casimir cavity on the other side there

1374

00:54:05,430 --> 00:54:04,079

is not

1375

00:54:08,069 --> 00:54:05,440

and

1376

00:54:10,390 --> 00:54:08,079

that i believe is what is inducing the

1377

00:54:12,630 --> 00:54:10,400

the flow of energy i don't think we're

1378

00:54:14,630 --> 00:54:12,640

violating the first law but as i

1379

00:54:16,950 --> 00:54:14,640

described in in

1380

00:54:18,950 --> 00:54:16,960

the various models really it depends on

1381

00:54:21,030 --> 00:54:18,960

what model you choose i should mention

1382

00:54:22,549 --> 00:54:21,040

one thing in passing

1383

00:54:23,510 --> 00:54:22,559

i developed this

1384

00:54:26,870 --> 00:54:23,520

about

1385

00:54:28,069 --> 00:54:26,880

five or six years ago uh this concept it

1386

00:54:30,549 --> 00:54:28,079

it wasn't something where we

1387

00:54:32,230 --> 00:54:30,559

accidentally discovered an uh uh

1388

00:54:34,549 --> 00:54:32,240

something in the lab and tried to figure

1389

00:54:36,230 --> 00:54:34,559

out it was actually the other way around

1390

00:54:38,309 --> 00:54:36,240

we first had the concept and then we

1391

00:54:40,390 --> 00:54:38,319

went around we went about building the

1392

00:54:42,710 --> 00:54:40,400

device to match the concept

1393

00:54:44,309 --> 00:54:42,720

and lo and behold it exactly matched

1394

00:54:47,510 --> 00:54:44,319

what i was hoping

1395

00:54:52,789 --> 00:54:49,430

thank you okay so now i see yeah that

1396

00:54:55,589 --> 00:54:52,799

looks like there's some symmetrical uh

1397

00:54:59,109 --> 00:54:55,599

could be possible thank you

1398

00:55:01,030 --> 00:55:00,150

okay

1399

00:55:03,190 --> 00:55:01,040

um

1400

00:55:07,190 --> 00:55:03,200

okay

1401
00:55:09,270 --> 00:55:07,200
it was fascinating uh your your uh your

1402
00:55:12,390 --> 00:55:09,280
speech about this

1403
00:55:14,789 --> 00:55:12,400
i had the feeling that is that

1404
00:55:17,910 --> 00:55:14,799
that's um

1405
00:55:21,589 --> 00:55:17,920
that was so fascinating because it was

1406
00:55:22,549 --> 00:55:21,599
it was crowned with uh with uh success

1407
00:55:25,270 --> 00:55:22,559
yes

1408
00:55:27,910 --> 00:55:25,280
so uh it was exactly like the same idea

1409
00:55:30,710 --> 00:55:27,920
why don't you put the second

1410
00:55:33,510 --> 00:55:30,720
customer cavity underneath and

1411
00:55:34,789 --> 00:55:33,520
look what happened

1412
00:55:36,710 --> 00:55:34,799
that's right

1413
00:55:40,150 --> 00:55:36,720

thank you would you like to come to my

1414

00:55:46,710 --> 00:55:44,309

these devices are very challenging

1415

00:55:47,910 --> 00:55:46,720

unfortunately when you've got these thin

1416

00:55:50,230 --> 00:55:47,920

layers

1417

00:55:52,870 --> 00:55:50,240

everything depends on everything else

1418

00:55:54,789 --> 00:55:52,880

and if we put down for instance the

1419

00:55:56,630 --> 00:55:54,799

polymer below and then put metal

1420

00:55:59,030 --> 00:55:56,640

insulator metal on top

1421

00:56:01,750 --> 00:55:59,040

it changes everything all the interfaces

1422

00:56:04,150 --> 00:56:01,760

are changed and we would need you know

1423

00:56:06,870 --> 00:56:04,160

months to to refine our process to get

1424

00:56:09,190 --> 00:56:06,880

it to work again so i agree it would be

1425

00:56:11,030 --> 00:56:09,200

very interesting we just haven't done it

1426
00:56:12,710 --> 00:56:11,040
yet

1427
00:56:13,829 --> 00:56:12,720
okay

1428
00:56:17,270 --> 00:56:13,839
all right

1429
00:56:19,829 --> 00:56:17,280
any final questions

1430
00:56:21,589 --> 00:56:19,839
okay gareth thank you so much for this

1431
00:56:23,670 --> 00:56:21,599
wonderful talk and i think people will

1432
00:56:25,750 --> 00:56:23,680
be talking about this for a long time

1433
00:56:27,349 --> 00:56:25,760
at this point i think we'll take a maybe

1434
00:56:29,030 --> 00:56:27,359
a three or four minute break to set up

1435
00:56:31,349 --> 00:56:29,040
for the um