



**THEORETICAL ANALYSIS OF THERMIONIC  
EMISSION AS A WAY TO HARVEST  
HEAT ENERGY AT A  
UNIFORM TEMPERATURE**

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**GERMANO D'ABRAMO**

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**SOCIETY  
FOR  
SCIENTIFIC  
EXPLORATION**

1  
00:00:15,669 --> 00:00:12,629  
all right it's uh it's a it's a real

2  
00:00:16,550 --> 00:00:15,679  
pleasure to introduce uh germano de

3  
00:00:18,390 --> 00:00:16,560  
brama

4  
00:00:19,910 --> 00:00:18,400  
um someone's whose research i've been

5  
00:00:22,310 --> 00:00:19,920  
following for about 10 years but i've

6  
00:00:24,710 --> 00:00:22,320  
never actually met so

7  
00:00:26,870 --> 00:00:24,720  
um germano is a physicist and worked as

8  
00:00:29,269 --> 00:00:26,880  
a researcher

9  
00:00:31,269 --> 00:00:29,279  
in various institutes and companies in

10  
00:00:33,510 --> 00:00:31,279  
rome between 1998

11  
00:00:35,750 --> 00:00:33,520  
and 2014 on near-earth asteroid

12  
00:00:37,990 --> 00:00:35,760  
population modeling and deflection

13  
00:00:40,069 --> 00:00:38,000

his research activities and interests

14

00:00:41,750 --> 00:00:40,079

also include special relativity

15

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

classical electrodynamics and the

16

00:00:45,990 --> 00:00:44,559

history of the philosophy of physics

17

00:00:47,510 --> 00:00:46,000

he currently works for the italian

18

00:00:49,990 --> 00:00:47,520

ministry of education as a physics

19

00:00:53,350 --> 00:00:50,000

teacher he is the author of the books

20

00:00:56,950 --> 00:00:53,360

the impact clan in 2015 and probing the

21

00:00:59,029 --> 00:00:56,960

limits in 2017.

22

00:01:00,630 --> 00:00:59,039

uh germano

23

00:01:01,670 --> 00:01:00,640

please um

24

00:01:04,400 --> 00:01:01,680

thank you

25

00:01:08,070 --> 00:01:06,070

it's a real pleasure for me to be here

26

00:01:11,429 --> 00:01:08,080

with you

27

00:01:14,469 --> 00:01:11,439

let me share my my presentation hope you

28

00:01:23,830 --> 00:01:14,479

care you can

29

00:01:23,840 --> 00:01:28,789

oh sorry

30

00:01:28,799 --> 00:01:36,630

sorry

31

00:01:41,350 --> 00:01:39,510

can you see my presentation yes

32

00:01:43,429 --> 00:01:41,360

okay the presentation looks good we can

33

00:01:45,590 --> 00:01:43,439

hear you just fine

34

00:01:48,230 --> 00:01:45,600

well what i'm going to to present today

35

00:01:49,670 --> 00:01:48,240

is the results of my contribution to the

36

00:01:51,590 --> 00:01:49,680

to the challenge

37

00:01:54,789 --> 00:01:51,600

to the second law of thermodynamics that

38

00:01:55,510 --> 00:01:54,799

i they may i did more than 10 years ago

39

00:01:57,190 --> 00:01:55,520

and

40

00:02:00,870 --> 00:01:57,200

for which i i want to acknowledge the

41

00:02:03,830 --> 00:02:00,880

kind moral support from daniel sheehan

42

00:02:05,749 --> 00:02:03,840

since then i never come back to this

43

00:02:08,389 --> 00:02:05,759

research so what you are we will say

44

00:02:09,830 --> 00:02:08,399

today is more or less a still picture of

45

00:02:11,190 --> 00:02:09,840

10 years ago

46

00:02:13,589 --> 00:02:11,200

but i believe

47

00:02:15,350 --> 00:02:13,599

the results are still interesting and

48

00:02:18,630 --> 00:02:15,360

worth telling

49

00:02:21,270 --> 00:02:18,640

well what's this all about

50

00:02:22,949 --> 00:02:21,280

well i have studied analytically and

51  
00:02:25,750 --> 00:02:22,959  
numerically

52  
00:02:28,790 --> 00:02:25,760  
this simple and well-known idea

53  
00:02:30,869 --> 00:02:28,800  
exploiting the photoelectric effect

54  
00:02:34,309 --> 00:02:30,879  
of the black body radiation on materials

55  
00:02:36,309 --> 00:02:34,319  
with different work functions

56  
00:02:37,270 --> 00:02:36,319  
let me remind briefly what our function

57  
00:02:42,229 --> 00:02:37,280  
is

58  
00:02:44,949 --> 00:02:42,239  
energy required to extract an electron

59  
00:02:46,630 --> 00:02:44,959  
from the bulk of a material to a to its

60  
00:02:50,309 --> 00:02:46,640  
surface

61  
00:02:52,869 --> 00:02:50,319  
what you see on the left is a sketch

62  
00:02:56,070 --> 00:02:52,879  
of a capacitor which have dubbed the

63  
00:02:57,589 --> 00:02:56,080

thermal charger capacitor tcc

64

00:02:58,949 --> 00:02:57,599

where two plates

65

00:03:01,910 --> 00:02:58,959

a and b

66

00:03:03,350 --> 00:03:01,920

are housed inside a vacuum vessel

67

00:03:11,110 --> 00:03:03,360

and

68

00:03:13,110 --> 00:03:11,120

are made of the same metal with the

69

00:03:15,350 --> 00:03:13,120

work function feature

70

00:03:18,070 --> 00:03:15,360

uh plate b is coated with a

71

00:03:20,390 --> 00:03:18,080

semiconductor with a mature with a much

72

00:03:22,710 --> 00:03:20,400

lower work function v1

73

00:03:25,350 --> 00:03:22,720

and the whole device is

74

00:03:27,750 --> 00:03:25,360

is at uniform temperature

75

00:03:29,830 --> 00:03:27,760

but plates amb

76

00:03:32,710 --> 00:03:29,840

receive photons from the black body

77

00:03:34,070 --> 00:03:32,720

radiation but being feature the work

78

00:03:37,509 --> 00:03:34,080

function of the

79

00:03:43,830 --> 00:03:39,990

of a or the electrode a

80

00:03:46,390 --> 00:03:43,840

greater than  $v_1$  the electrons extracted

81

00:03:49,350 --> 00:03:46,400

by the photoelectric effect of from from

82

00:03:52,309 --> 00:03:49,360

the coating of b to plate a

83

00:03:54,470 --> 00:03:52,319

are more numerous and with a higher

84

00:03:57,429 --> 00:03:54,480

kinetic energy than those extracted from

85

00:03:58,710 --> 00:03:57,439

plate a to plate b

86

00:04:00,470 --> 00:03:58,720

at least at the

87

00:04:01,750 --> 00:04:00,480

in the yearly phases of the of the

88

00:04:02,869 --> 00:04:01,760

process

89

00:04:04,390 --> 00:04:02,879

on the right

90

00:04:07,670 --> 00:04:04,400

there is a sketch

91

00:04:09,030 --> 00:04:07,680

of the black body radiation distribution

92

00:04:11,509 --> 00:04:09,040

this gives

93

00:04:13,589 --> 00:04:11,519

the split the spectral radiance versus

94

00:04:16,949 --> 00:04:13,599

the frequency

95

00:04:20,550 --> 00:04:16,959

well it roughly tells us the number of

96

00:04:23,110 --> 00:04:20,560

photons with a given energy each node

97

00:04:25,110 --> 00:04:23,120

in term in the thermal radiation at a

98

00:04:27,990 --> 00:04:25,120

specific temperature and

99

00:04:29,590 --> 00:04:28,000

it is easy to to see why more electrons

100

00:04:32,310 --> 00:04:29,600

are extracted from

101  
00:04:34,150 --> 00:04:32,320  
me to a within and with an higher

102  
00:04:36,870 --> 00:04:34,160  
kinetic energy

103  
00:04:38,230 --> 00:04:36,880  
um all that means that a net flux of

104  
00:04:40,550 --> 00:04:38,240  
electrons

105  
00:04:42,550 --> 00:04:40,560  
should flow from

106  
00:04:44,390 --> 00:04:42,560  
plate b to plate a

107  
00:04:51,510 --> 00:04:44,400  
and therefore there should be an

108  
00:04:57,189 --> 00:04:52,790  
okay so

109  
00:05:02,150 --> 00:04:59,430  
well in the case of an open circuit tcc

110  
00:05:04,469 --> 00:05:02,160  
at equilibrium like in in the image on

111  
00:05:06,550 --> 00:05:04,479  
the left we expect that

112  
00:05:09,510 --> 00:05:06,560  
after a suitable interval time an

113  
00:05:11,830 --> 00:05:09,520

equilibrium potential difference  $\Delta v$

114

00:05:13,029 --> 00:05:11,840

is established across the

115

00:05:15,670 --> 00:05:13,039

the plates

116

00:05:18,310 --> 00:05:15,680

and at equilibrium  $\Delta v$

117

00:05:22,070 --> 00:05:18,320

is necessarily equal to  $v_2$

118

00:05:24,950 --> 00:05:22,080

minus  $v_1$  divided by the electron charge

119

00:05:27,909 --> 00:05:24,960

because only only with that value

120

00:05:29,029 --> 00:05:27,919

the energy needed by an electron to get

121

00:05:32,230 --> 00:05:29,039

extracted

122

00:05:33,670 --> 00:05:32,240

from the coating of b of plate b

123

00:05:36,790 --> 00:05:33,680

and the rich plate

124

00:05:39,189 --> 00:05:36,800

becomes equal to to the energy needed by

125

00:05:41,909 --> 00:05:39,199

an electron to get extracted from plate

126

00:05:43,590 --> 00:05:41,919

a and reach plate b

127

00:05:45,670 --> 00:05:43,600

all in this case

128

00:05:47,189 --> 00:05:45,680

there will be no more imbalance in the

129

00:05:51,110 --> 00:05:47,199

two fluxes of

130

00:05:56,629 --> 00:05:54,310

well in the case of a short circuit dcc

131

00:05:58,710 --> 00:05:56,639

uh on the right

132

00:06:02,629 --> 00:05:58,720

uh a current  $i$  should flow across the

133

00:06:05,029 --> 00:06:02,639

circuit  $u_m$  and and if the resistance of

134

00:06:08,070 --> 00:06:05,039

the circuit external to the

135

00:06:08,950 --> 00:06:08,080

the tcc is negligible and that current

136

00:06:10,950 --> 00:06:08,960

should be

137

00:06:16,629 --> 00:06:10,960

equal to the thermionic

138

00:06:21,909 --> 00:06:19,510

now before getting to

139

00:06:25,670 --> 00:06:21,919

mata the mathematical numerical

140

00:06:28,150 --> 00:06:25,680

simulation of a tcc uh let me dwell on

141

00:06:29,830 --> 00:06:28,160

two objections that could be

142

00:06:32,469 --> 00:06:29,840

advanced

143

00:06:33,430 --> 00:06:32,479

i must warn you that this part

144

00:06:35,430 --> 00:06:33,440

the next

145

00:06:38,790 --> 00:06:35,440

two slides um

146

00:06:41,590 --> 00:06:38,800

are a bit involved but i try to keep

147

00:06:43,270 --> 00:06:41,600

it as simple and short as possible

148

00:06:44,390 --> 00:06:43,280

it is important to reply to these

149

00:06:46,390 --> 00:06:44,400

objections

150

00:06:49,909 --> 00:06:46,400

because if they were correct

151

00:06:52,469 --> 00:06:49,919

the tcc will not work uh as expected

152

00:06:55,510 --> 00:06:52,479

and uh to better introduce them these

153

00:06:57,909 --> 00:06:55,520

two objections uh let me switch to

154

00:07:00,950 --> 00:06:57,919

a topological ana analog

155

00:07:03,749 --> 00:07:00,960

of the short circuit dcc on the left

156

00:07:06,390 --> 00:07:03,759

and it is this uh horseshoe shaped thing

157

00:07:07,909 --> 00:07:06,400

on right on the right

158

00:07:09,110 --> 00:07:07,919

the right half of

159

00:07:11,990 --> 00:07:09,120

the horseshoe

160

00:07:15,110 --> 00:07:12,000

represents a plate a

161

00:07:17,029 --> 00:07:15,120

part of plate b and the connecting wire

162

00:07:19,430 --> 00:07:17,039

with things

163

00:07:21,110 --> 00:07:19,440

and all this stuff as work function

164

00:07:22,629 --> 00:07:21,120

equal to feature

165

00:07:25,029 --> 00:07:22,639

the left

166

00:07:25,990 --> 00:07:25,039

alpha is the coating of plate b

167

00:07:29,670 --> 00:07:26,000

and

168

00:07:32,309 --> 00:07:29,680

it has a work function equal to  $v_1$

169

00:07:34,070 --> 00:07:32,319

in both images

170

00:07:36,230 --> 00:07:34,080

$j_2$

171

00:07:38,950 --> 00:07:36,240

indicates the button gap between the

172

00:07:43,749 --> 00:07:41,510

well it is known that when two materials

173

00:07:46,150 --> 00:07:43,759

with different work functions in

174

00:07:48,710 --> 00:07:46,160

particular a metal and an n-type

175

00:07:50,469 --> 00:07:48,720

semiconductor like in our case

176

00:07:54,070 --> 00:07:50,479

are physically joined

177

00:07:57,189 --> 00:07:54,080

a potential difference  $\Delta v$

178

00:07:59,510 --> 00:07:57,199

builds up across the contact junction  $j_1$

179

00:08:01,270 --> 00:07:59,520

this potential is called the

180

00:08:04,469 --> 00:08:01,280

contact potential

181

00:08:07,029 --> 00:08:04,479

and it is generated by

182

00:08:09,350 --> 00:08:07,039

the electrons that are pushed

183

00:08:10,869 --> 00:08:09,360

from  $v_2$  materials

184

00:08:12,550 --> 00:08:10,879

the yellowish one

185

00:08:15,510 --> 00:08:12,560

to the

186

00:08:19,510 --> 00:08:15,520

2 feet 2 materials across the  $g_1$

187

00:08:22,150 --> 00:08:19,520

by thermally driven diffusion forces

188

00:08:24,230 --> 00:08:22,160

a higher amount of electrons move from

189

00:08:25,350 --> 00:08:24,240

left to right rather than the other way

190

00:08:26,469 --> 00:08:25,360

around

191

00:08:28,629 --> 00:08:26,479

simply because

192

00:08:31,909 --> 00:08:28,639

it's easier to pull electrons out of a

193

00:08:35,029 --> 00:08:31,919

lower work function material

194

00:08:37,509 --> 00:08:35,039

the diffusion process lasts until

195

00:08:38,630 --> 00:08:37,519

a dynamical equilibrium is reached

196

00:08:41,110 --> 00:08:38,640

between

197

00:08:42,070 --> 00:08:41,120

the diffusion forces that push electrons

198

00:08:45,509 --> 00:08:42,080

to

199

00:08:47,269 --> 00:08:45,519

and the electric force do they built in

200

00:08:50,630 --> 00:08:47,279

electric fields

201  
00:08:56,070 --> 00:08:52,949  
also in this case the the the potent the

202  
00:08:58,710 --> 00:08:56,080  
contact potential  $\Delta v$  is equal to  $v_2$

203  
00:08:59,910 --> 00:08:58,720  
minus minus  $v_1$  divided by the electron

204  
00:09:02,550 --> 00:08:59,920  
charge

205  
00:09:04,790 --> 00:09:02,560  
and the reason is the reason is the same

206  
00:09:06,550 --> 00:09:04,800  
as in the previous slide for the final

207  
00:09:09,590 --> 00:09:06,560  
equilibrium

208  
00:09:10,310 --> 00:09:09,600  
of the thermionic charging process

209  
00:09:12,230 --> 00:09:10,320  
and

210  
00:09:14,630 --> 00:09:12,240  
the built-in electric field

211  
00:09:16,949 --> 00:09:14,640  
across  $j_1$  is roughly equal to the

212  
00:09:19,670 --> 00:09:16,959  
contact potential divided by the width

213  
00:09:20,949 --> 00:09:19,680

of the depletion depletion region

214

00:09:23,269 --> 00:09:20,959

xd

215

00:09:25,030 --> 00:09:23,279

and naming namely the

216

00:09:28,389 --> 00:09:25,040

the thin layer across

217

00:09:30,949 --> 00:09:28,399

j1 where the diffusion of electrons

218

00:09:31,829 --> 00:09:30,959

has taken place

219

00:09:33,750 --> 00:09:31,839

well

220

00:09:36,630 --> 00:09:33,760

it is also

221

00:09:39,829 --> 00:09:36,640

a while a widely held belief that as

222

00:09:43,110 --> 00:09:39,839

soon as one joins

223

00:09:45,269 --> 00:09:43,120

the two halves at g1

224

00:09:49,430 --> 00:09:45,279

a potential difference equal and

225

00:09:52,790 --> 00:09:49,440

opposite to the contact potential

226  
00:09:56,150 --> 00:09:52,800  
here g1 should instantaneously beats up

227  
00:09:58,389 --> 00:09:56,160  
also across the gap j2

228  
00:10:00,550 --> 00:09:58,399  
notice that this potential the delta v

229  
00:10:02,870 --> 00:10:00,560  
across g2 across the gap

230  
00:10:05,910 --> 00:10:02,880  
is not that deriving from the thermionic

231  
00:10:10,150 --> 00:10:07,829  
it is intended to

232  
00:10:11,350 --> 00:10:10,160  
to be instantaneously generated by the

233  
00:10:12,790 --> 00:10:11,360  
movement

234  
00:10:14,310 --> 00:10:12,800  
of electrons in the bulk of the

235  
00:10:17,590 --> 00:10:14,320  
horseshoe

236  
00:10:18,949 --> 00:10:17,600  
and just after the physical contact

237  
00:10:20,069 --> 00:10:18,959  
of the materials

238  
00:10:21,829 --> 00:10:20,079

materials

239

00:10:24,069 --> 00:10:21,839

at j1

240

00:10:27,269 --> 00:10:24,079

well people expect the potential

241

00:10:30,150 --> 00:10:27,279

difference across j2 across the gap

242

00:10:32,150 --> 00:10:30,160

because of an allegedly straightforward

243

00:10:35,670 --> 00:10:32,160

application of the kishuf

244

00:10:40,949 --> 00:10:38,310

well what is the problem with that

245

00:10:43,750 --> 00:10:40,959

well if the potential difference

246

00:10:45,829 --> 00:10:43,760

were really there across the gap

247

00:10:47,990 --> 00:10:45,839

then the thermionic charging process

248

00:10:50,630 --> 00:10:48,000

across g2

249

00:10:52,470 --> 00:10:50,640

could not even start

250

00:10:54,230 --> 00:10:52,480

since the delta v

251  
00:10:57,350 --> 00:10:54,240  
across  $j_2$

252  
00:10:59,670 --> 00:10:57,360  
is equal to  $v_2$  minus  $v_1$  okay

253  
00:11:01,910 --> 00:10:59,680  
divided by the electron charge

254  
00:11:04,230 --> 00:11:01,920  
and no net electron flux

255  
00:11:05,910 --> 00:11:04,240  
from plate b to plate a could be

256  
00:11:09,509 --> 00:11:05,920  
possible

257  
00:11:14,710 --> 00:11:12,949  
as i ever as i have described before

258  
00:11:16,310 --> 00:11:14,720  
the energy required

259  
00:11:18,230 --> 00:11:16,320  
uh for an electro to get a structure

260  
00:11:20,550 --> 00:11:18,240  
from the plate uh

261  
00:11:21,910 --> 00:11:20,560  
from one plate to reach the other

262  
00:11:25,110 --> 00:11:21,920  
will be the same

263  
00:11:27,350 --> 00:11:25,120

in this case and incidentally equal to

264

00:11:29,750 --> 00:11:27,360

v2

265

00:11:31,110 --> 00:11:29,760

and therefore there will be no

266

00:11:34,550 --> 00:11:31,120

displacement

267

00:11:36,389 --> 00:11:34,560

of electrons across j across the gap j2

268

00:11:38,230 --> 00:11:36,399

and therefore there will be no current

269

00:11:42,550 --> 00:11:38,240

in the short circuit pcc

270

00:11:49,269 --> 00:11:45,430

moreover and this is the objection to

271

00:11:52,310 --> 00:11:49,279

uh even if a net flux of electrons

272

00:11:54,629 --> 00:11:52,320

were possible across the gap

273

00:11:56,710 --> 00:11:54,639

still the current will not flow across

274

00:12:01,030 --> 00:11:56,720

the the wall circuit

275

00:12:03,590 --> 00:12:01,040

in fact j1 is a metal and type

276

00:12:05,030 --> 00:12:03,600

semiconductor junction also known as

277

00:12:07,269 --> 00:12:05,040

shock junction

278

00:12:10,230 --> 00:12:07,279

and it is known to have a rectifying

279

00:12:13,590 --> 00:12:10,240

property rectifying properties okay

280

00:12:16,629 --> 00:12:13,600

under biasing electrons easy flow from

281

00:12:19,030 --> 00:12:16,639

the semiconductor to the metal

282

00:12:21,110 --> 00:12:19,040

from left to right across g1 but not

283

00:12:23,110 --> 00:12:21,120

that easily from the other way around

284

00:12:25,990 --> 00:12:23,120

from right to left across

285

00:12:31,509 --> 00:12:29,110

okay let me give a

286

00:12:34,069 --> 00:12:31,519

short reply to objection one

287

00:12:36,550 --> 00:12:34,079

well i my stand is that there is no

288

00:12:40,150 --> 00:12:36,560

instantaneous potential difference

289

00:12:42,629 --> 00:12:40,160

across the two across the gap  $j_2$  caused

290

00:12:44,230 --> 00:12:42,639

by the physical joining of the materials

291

00:12:46,470 --> 00:12:44,240

of the two materials

292

00:12:48,389 --> 00:12:46,480

at  $j_1$

293

00:12:50,389 --> 00:12:48,399

to prove that  $i$  applied the basic

294

00:12:52,870 --> 00:12:50,399

definition of

295

00:12:56,069 --> 00:12:52,880

potential difference the potential

296

00:12:58,389 --> 00:12:56,079

difference between two points  $a$  and  $b$

297

00:12:59,670 --> 00:12:58,399

is defined as minus

298

00:13:02,069 --> 00:12:59,680

okay minus

299

00:13:02,790 --> 00:13:02,079

the work done by the forces acting upon

300

00:13:05,430 --> 00:13:02,800

the

301  
00:13:08,150 --> 00:13:05,440  
upon an electron that moves

302  
00:13:10,629 --> 00:13:08,160  
all along the path gamma

303  
00:13:12,310 --> 00:13:10,639  
joining a and b divided by the electron

304  
00:13:14,790 --> 00:13:12,320  
charge

305  
00:13:16,470 --> 00:13:14,800  
um i do this calculation

306  
00:13:18,150 --> 00:13:16,480  
along the blue line

307  
00:13:22,389 --> 00:13:18,160  
on the right

308  
00:13:23,910 --> 00:13:22,399  
in the back of the shoe across g1

309  
00:13:25,509 --> 00:13:23,920  
here

310  
00:13:27,829 --> 00:13:25,519  
effient

311  
00:13:29,829 --> 00:13:27,839  
stands for all forcing all the forces

312  
00:13:32,230 --> 00:13:29,839  
acting upon

313  
00:13:34,389 --> 00:13:32,240

the elect the test electron

314

00:13:36,310 --> 00:13:34,399

when it moves across

315

00:13:39,269 --> 00:13:36,320

the path gamma

316

00:13:42,230 --> 00:13:39,279

uh from equilibrium consideration uh it

317

00:13:44,470 --> 00:13:42,240

is clear that  $f$  inter the the sum of the

318

00:13:47,269 --> 00:13:44,480

two forces or the all the forces acting

319

00:13:49,110 --> 00:13:47,279

upon the detected electron

320

00:13:51,750 --> 00:13:49,120

can be different from zero only across

321

00:13:52,550 --> 00:13:51,760

the the junction  $j_1$

322

00:13:56,069 --> 00:13:52,560

when

323

00:13:59,189 --> 00:13:56,079

the text electron crosses  $j_1$

324

00:14:01,269 --> 00:13:59,199

it does feel only two kinds of forces

325

00:14:02,550 --> 00:14:01,279

the diffusion forces pushing to the

326

00:14:04,389 --> 00:14:02,560

right

327

00:14:06,470 --> 00:14:04,399

and the electric force

328

00:14:08,629 --> 00:14:06,480

due to the built-in electric field

329

00:14:09,750 --> 00:14:08,639

pushing to the left

330

00:14:12,230 --> 00:14:09,760

um

331

00:14:15,350 --> 00:14:12,240

by the way the test electron does feel

332

00:14:16,790 --> 00:14:15,360

the diffusion forces exactly like all

333

00:14:21,910 --> 00:14:16,800

the electrons

334

00:14:25,829 --> 00:14:23,269

okay since

335

00:14:27,670 --> 00:14:25,839

the the diffusion forces dynamically

336

00:14:29,750 --> 00:14:27,680

sustain the electric field

337

00:14:31,110 --> 00:14:29,760

at j1

338

00:14:33,590 --> 00:14:31,120

by the way

339

00:14:34,790 --> 00:14:33,600

if i switch it off the diffusion forces

340

00:14:36,629 --> 00:14:34,800

at  $j_1$

341

00:14:38,150 --> 00:14:36,639

the beating electric field will go to

342

00:14:39,670 --> 00:14:38,160

zero

343

00:14:41,350 --> 00:14:39,680

so since the diffusion force is

344

00:14:43,350 --> 00:14:41,360

dynamically sustained in the electric

345

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

field the  $g_1$  these two forces the

346

00:14:49,750 --> 00:14:45,920

electric forces and the diffusion forces

347

00:14:52,389 --> 00:14:49,760

must be always be present across  $j_1$

348

00:14:54,870 --> 00:14:52,399

and but and also must be equal in

349

00:14:56,150 --> 00:14:54,880

opposite equilibrium

350

00:14:58,230 --> 00:14:56,160

therefore

351  
00:14:59,430 --> 00:14:58,240  
the total force is equal to zero on

352  
00:15:01,829 --> 00:14:59,440  
average

353  
00:15:04,389 --> 00:15:01,839  
and together with the delta v

354  
00:15:07,910 --> 00:15:04,399  
uh between any two points a and b in the

355  
00:15:09,750 --> 00:15:07,920  
back of the in this ocean shaped

356  
00:15:13,430 --> 00:15:09,760  
thing

357  
00:15:15,670 --> 00:15:13,440  
all that means that physically joining

358  
00:15:18,069 --> 00:15:15,680  
different materials at j1

359  
00:15:19,910 --> 00:15:18,079  
cannot instantaneously cause any

360  
00:15:22,310 --> 00:15:19,920  
potential drop

361  
00:15:24,150 --> 00:15:22,320  
across the gap

362  
00:15:27,590 --> 00:15:24,160  
that will kill the terminic process from

363  
00:15:29,749 --> 00:15:28,389

okay

364

00:15:31,670 --> 00:15:29,759

let's face

365

00:15:34,310 --> 00:15:31,680

objection two

366

00:15:36,150 --> 00:15:34,320

we know that every shock junction is

367

00:15:39,189 --> 00:15:36,160

characterized by a reverse leakage

368

00:15:40,949 --> 00:15:39,199

current that overcome

369

00:15:41,910 --> 00:15:40,959

the rectifying barrier

370

00:15:43,269 --> 00:15:41,920

and

371

00:15:45,269 --> 00:15:43,279

that current

372

00:15:47,350 --> 00:15:45,279

may be high or low depending up upon

373

00:15:49,509 --> 00:15:47,360

several factors

374

00:15:50,710 --> 00:15:49,519

for instance according to the the

375

00:15:51,990 --> 00:15:50,720

literature

376

00:15:55,030 --> 00:15:52,000

it may range

377

00:15:58,389 --> 00:15:55,040

from 10 to the 8 to 10 to the minus 2

378

00:16:01,749 --> 00:15:58,399

amps per square centimeter

379

00:16:07,110 --> 00:16:04,550

obviously depends upon the earth's bias

380

00:16:08,389 --> 00:16:07,120

but this dependence is quite flat so to

381

00:16:10,470 --> 00:16:08,399

speak

382

00:16:13,269 --> 00:16:10,480

reverse current doesn't change too much

383

00:16:15,189 --> 00:16:13,279

with the with the reverse bias

384

00:16:18,550 --> 00:16:15,199

at least below the the

385

00:16:20,470 --> 00:16:18,560

breakdown voltage but in our device

386

00:16:22,470 --> 00:16:20,480

we are very far from the breakdown

387

00:16:24,389 --> 00:16:22,480

voltage

388

00:16:26,470 --> 00:16:24,399

the reverse leakage current also depends

389

00:16:27,500 --> 00:16:26,480

upon the material used in the junction

390

00:16:29,749 --> 00:16:27,510

preparation

391

00:16:31,910 --> 00:16:29,759

[Music]

392

00:16:34,389 --> 00:16:31,920

for instance annealing seems to increase

393

00:16:37,110 --> 00:16:34,399

the reverse leakage current

394

00:16:39,350 --> 00:16:37,120

and it also depends upon the temperature

395

00:16:41,910 --> 00:16:39,360

the idea is that the temperature the the

396

00:16:43,990 --> 00:16:41,920

greater is the reverse current

397

00:16:47,110 --> 00:16:44,000

and also depends upon the the width of

398

00:16:48,470 --> 00:16:47,120

the depletion region  $x_d$

399

00:16:50,790 --> 00:16:48,480

since the thinner is the region the

400

00:16:53,189 --> 00:16:50,800

greater is the reverse current due to

401  
00:16:57,829 --> 00:16:53,199  
the tunneling effect

402  
00:16:59,990 --> 00:16:57,839  
so we see that even under a small bias

403  
00:17:02,470 --> 00:17:00,000  
a non-zero current can cross the

404  
00:17:06,870 --> 00:17:02,480  
junction even in the wrong direction so

405  
00:17:09,990 --> 00:17:08,390  
okay

406  
00:17:12,949 --> 00:17:10,000  
we finally come to my numerical

407  
00:17:15,750 --> 00:17:12,959  
simulation and results

408  
00:17:17,750 --> 00:17:15,760  
i mathematically model it

409  
00:17:19,350 --> 00:17:17,760  
as fact that this is

410  
00:17:21,669 --> 00:17:19,360  
and

411  
00:17:24,549 --> 00:17:21,679  
for the work function coating

412  
00:17:27,429 --> 00:17:24,559  
i have chosen the silver caesium oxide

413  
00:17:28,789 --> 00:17:27,439

photocatal it is a well-known photocatal

414

00:17:30,630 --> 00:17:28,799

material

415

00:17:33,830 --> 00:17:30,640

and it is known in the literature to

416

00:17:36,470 --> 00:17:33,840

have a work function of nearly 0.7

417

00:17:38,549 --> 00:17:36,480

electron volts or 0.8 electro volts

418

00:17:40,390 --> 00:17:38,559

the inner and the outer

419

00:17:42,230 --> 00:17:40,400

spheres are made of metal with a work

420

00:17:45,190 --> 00:17:42,240

function

421

00:17:48,710 --> 00:17:45,200

equal to 4 electron volts

422

00:17:49,669 --> 00:17:48,720

the model of the dcc is 40 centimeters

423

00:17:51,990 --> 00:17:49,679

wide

424

00:17:53,909 --> 00:17:52,000

and as you may see

425

00:17:54,789 --> 00:17:53,919

the ratio between the outer and the

426  
00:17:59,029 --> 00:17:54,799  
inner

427  
00:18:00,789 --> 00:17:59,039  
radius is taken to be equal to two

428  
00:18:02,789 --> 00:18:00,799  
because it can be proven

429  
00:18:05,430 --> 00:18:02,799  
that this choices

430  
00:18:07,590 --> 00:18:05,440  
maximizes the the charging speed for an

431  
00:18:09,990 --> 00:18:07,600  
open circuit dcc

432  
00:18:12,549 --> 00:18:10,000  
um but the the charging speed is not a

433  
00:18:13,830 --> 00:18:12,559  
crucial feature here

434  
00:18:15,909 --> 00:18:13,840  
it's important

435  
00:18:19,350 --> 00:18:15,919  
is the power output of a short circuit

436  
00:18:21,430 --> 00:18:19,360  
vcc uh we show you in a moment

437  
00:18:23,350 --> 00:18:21,440  
another important parameter is the of

438  
00:18:25,110 --> 00:18:23,360

this for the simulation is

439

00:18:27,029 --> 00:18:25,120

is the quantum efficiency of the

440

00:18:29,590 --> 00:18:27,039

materials

441

00:18:31,510 --> 00:18:29,600

quantum efficiency is roughly the ratio

442

00:18:33,590 --> 00:18:31,520

between the the number of electrons

443

00:18:35,350 --> 00:18:33,600

extracted by the radiation

444

00:18:37,270 --> 00:18:35,360

and the number of photons impinging on

445

00:18:38,789 --> 00:18:37,280

the on the material on the surface of

446

00:18:41,750 --> 00:18:38,799

the blades

447

00:18:44,950 --> 00:18:41,760

and it is clearly  $\mu\text{m}$

448

00:18:49,110 --> 00:18:44,960

frequency dependent parameter and i have

449

00:18:51,990 --> 00:18:49,120

plugged in the equation only mean values

450

00:18:54,950 --> 00:18:52,000

over over frequency

451  
00:18:58,390 --> 00:18:54,960  
and i have used the quite conservative

452  
00:19:00,470 --> 00:18:58,400  
there is for heater one and eta two

453  
00:19:03,190 --> 00:19:00,480  
according to the literature a more

454  
00:19:05,350 --> 00:19:03,200  
realistic value for eta one for the the

455  
00:19:07,430 --> 00:19:05,360  
quantum efficiency of the

456  
00:19:09,750 --> 00:19:07,440  
silver system of side coating

457  
00:19:10,870 --> 00:19:09,760  
will be 10 to the minus three

458  
00:19:13,909 --> 00:19:10,880  
and

459  
00:19:17,669 --> 00:19:13,919  
eta 2 equal to 1

460  
00:19:21,590 --> 00:19:17,679  
is surely not realistic i i

461  
00:19:25,750 --> 00:19:24,150  
that does not exist any material with

462  
00:19:31,590 --> 00:19:25,760  
the work with the quantum mechanics

463  
00:19:31,600 --> 00:19:35,909

well sorry

464

00:19:38,470 --> 00:19:37,110

um

465

00:19:39,909 --> 00:19:38,480

well

466

00:19:42,390 --> 00:19:39,919

my interest at the time of the

467

00:19:44,789 --> 00:19:42,400

simulation was to explore the the worst

468

00:19:46,549 --> 00:19:44,799

case scenario and and to see if a i

469

00:19:48,549 --> 00:19:46,559

could i could get something different

470

00:19:50,950 --> 00:19:48,559

from zero and

471

00:19:53,590 --> 00:19:50,960

it seems to be the case as we i showed

472

00:19:55,669 --> 00:19:53,600

you in a moment

473

00:19:58,230 --> 00:19:55,679

okay

474

00:20:00,789 --> 00:19:58,240

this graph shows the the charging

475

00:20:03,110 --> 00:20:00,799

profile of an open circuit dcc

476

00:20:05,510 --> 00:20:03,120

as you may see even with

477

00:20:08,230 --> 00:20:05,520

the previous very conservative value

478

00:20:10,149 --> 00:20:08,240

values for quantum efficiency

479

00:20:11,990 --> 00:20:10,159

it is expected to reach a voltage of

480

00:20:14,390 --> 00:20:12,000

nearly 0.3

481

00:20:16,710 --> 00:20:14,400

volts in less than 2 hours

482

00:20:18,870 --> 00:20:16,720

more or less

483

00:20:20,630 --> 00:20:18,880

with more realistic values for the

484

00:20:23,190 --> 00:20:20,640

quantum efficiencies

485

00:20:24,789 --> 00:20:23,200

the same voltage is probably rigid in a

486

00:20:27,110 --> 00:20:24,799

few minutes

487

00:20:29,750 --> 00:20:27,120

and here you may see uh

488

00:20:31,830 --> 00:20:29,760

for the sake of completeness

489

00:20:36,630 --> 00:20:31,840

the differential equation that governs

490

00:20:41,190 --> 00:20:38,470

okay now let's

491

00:20:43,270 --> 00:20:41,200

let's see the more interesting case of a

492

00:20:44,310 --> 00:20:43,280

short circuit tcc

493

00:20:47,110 --> 00:20:44,320

and

494

00:20:49,669 --> 00:20:47,120

the graph shows the power output

495

00:20:52,710 --> 00:20:49,679

per unit area of the inner sphere

496

00:20:55,510 --> 00:20:52,720

sphere versus the steady state

497

00:20:57,990 --> 00:20:55,520

voltage across the vcc and the resistor

498

00:21:03,830 --> 00:21:00,630

by tuning the value of the external

499

00:21:04,520 --> 00:21:03,840

resistance  $r$  we can maximize the power

500

00:21:06,630 --> 00:21:04,530

output

501  
00:21:09,350 --> 00:21:06,640

[Music]

502  
00:21:13,270 --> 00:21:09,360  
the maximum is obtained

503  
00:21:16,390 --> 00:21:15,510  
volts across the resistance of the order

504  
00:21:19,110 --> 00:21:16,400  
of

505  
00:21:21,590 --> 00:21:19,120  
10 to the 10 ohms

506  
00:21:24,710 --> 00:21:21,600  
and the the value of the

507  
00:21:27,750 --> 00:21:24,720  
the power output of this model pcc is of

508  
00:21:29,190 --> 00:21:27,760  
the order of 10 to the minus for 14

509  
00:21:31,990 --> 00:21:29,200  
watts

510  
00:21:33,830 --> 00:21:32,000  
this way this value may appear and

511  
00:21:36,310 --> 00:21:33,840  
in fact in fact is

512  
00:21:38,149 --> 00:21:36,320  
a bit disappointing

513  
00:21:39,830 --> 00:21:38,159

and

514

00:21:42,710 --> 00:21:39,840

the current design

515

00:21:45,190 --> 00:21:42,720

surely has no hope to have an immediate

516

00:21:47,110 --> 00:21:45,200

application to the real world

517

00:21:49,270 --> 00:21:47,120

however as i said before the main goal

518

00:21:51,350 --> 00:21:49,280

of this work was to prove the geology

519

00:21:52,710 --> 00:21:51,360

the theoretical validity of the basic

520

00:21:55,029 --> 00:21:52,720

idea

521

00:21:57,430 --> 00:21:55,039

uh you know i believe that

522

00:21:59,750 --> 00:21:57,440

if we can experimentally and

523

00:22:00,549 --> 00:21:59,760

unambiguously confirmed

524

00:22:03,830 --> 00:22:00,559

the

525

00:22:06,230 --> 00:22:03,840

functioning of this design

526  
00:22:07,909 --> 00:22:06,240  
we we would have an incentive to study

527  
00:22:12,149 --> 00:22:07,919  
and work on a more

528  
00:22:15,909 --> 00:22:14,149  
okay let me finish my

529  
00:22:18,070 --> 00:22:15,919  
my presentation

530  
00:22:21,510 --> 00:22:18,080  
with some basic and i'm i'm sure

531  
00:22:23,110 --> 00:22:21,520  
unsurprising prescription for a future

532  
00:22:24,710 --> 00:22:23,120  
experimental test of

533  
00:22:27,350 --> 00:22:24,720  
this design

534  
00:22:30,149 --> 00:22:27,360  
in order to to be sure

535  
00:22:31,029 --> 00:22:30,159  
that the tcc works as expected we we

536  
00:22:33,510 --> 00:22:31,039  
need to

537  
00:22:35,669 --> 00:22:33,520  
to cut every external disturbance like

538  
00:22:37,909 --> 00:22:35,679

for instance man-made and

539

00:22:40,950 --> 00:22:37,919

natural electromagnetic fields

540

00:22:42,549 --> 00:22:40,960

natural reactivity and cosmic particles

541

00:22:43,669 --> 00:22:42,559

and so on

542

00:22:45,909 --> 00:22:43,679

and i am

543

00:22:49,350 --> 00:22:45,919

pretty confident that this could be done

544

00:22:50,950 --> 00:22:49,360

with proper proper shielding

545

00:22:53,110 --> 00:22:50,960

you must also avoid

546

00:22:55,190 --> 00:22:53,120

any non-uniformity

547

00:22:57,190 --> 00:22:55,200

of the ambient temperature around the

548

00:22:59,909 --> 00:22:57,200

device and the measuring

549

00:23:02,310 --> 00:22:59,919

instruments in order to prevent

550

00:23:03,669 --> 00:23:02,320

any thermoelectric effect

551  
00:23:05,990 --> 00:23:03,679  
and

552  
00:23:09,909 --> 00:23:06,000  
also a prescription

553  
00:23:11,430 --> 00:23:09,919  
peculiar to this case may be that of uh

554  
00:23:14,070 --> 00:23:11,440  
placing

555  
00:23:15,590 --> 00:23:14,080  
side by side two tcc's identical in

556  
00:23:17,190 --> 00:23:15,600  
every respect

557  
00:23:20,310 --> 00:23:17,200  
exception made for

558  
00:23:22,710 --> 00:23:20,320  
the fact that one does not have the the

559  
00:23:23,830 --> 00:23:22,720  
the lower function coating

560  
00:23:26,870 --> 00:23:23,840  
you know

561  
00:23:28,789 --> 00:23:26,880  
that prescription should should allow

562  
00:23:30,470 --> 00:23:28,799  
discriminating between the the real

563  
00:23:32,310 --> 00:23:30,480

contribution

564

00:23:34,070 --> 00:23:32,320  
of the terminic emission

565

00:23:36,710 --> 00:23:34,080  
and the

566

00:23:37,830 --> 00:23:36,720  
the background noise

567

00:23:40,630 --> 00:23:37,840  
uh

568

00:23:43,190 --> 00:23:40,640  
finally just a few words

569

00:23:45,269 --> 00:23:43,200  
on the measuring equipment as we have

570

00:23:46,870 --> 00:23:45,279  
seen in the previous slide the the

571

00:23:48,789 --> 00:23:46,880  
magnitude

572

00:23:52,710 --> 00:23:48,799  
of the resistance in the short circuit

573

00:23:54,310 --> 00:23:52,720  
dcc must be very high very high

574

00:23:56,630 --> 00:23:54,320  
to have a

575

00:23:58,549 --> 00:23:56,640  
measurable volt across the device

576  
00:24:00,230 --> 00:23:58,559  
and so in order to detect something

577  
00:24:01,990 --> 00:24:00,240  
different from zero

578  
00:24:04,070 --> 00:24:02,000  
we will need

579  
00:24:07,110 --> 00:24:04,080  
an ultra high input impedance

580  
00:24:09,430 --> 00:24:07,120  
electrometer and uh

581  
00:24:13,269 --> 00:24:09,440  
i know that on the market is available

582  
00:24:15,190 --> 00:24:13,279  
with one hitley 65 14 that

583  
00:24:17,669 --> 00:24:15,200  
has

584  
00:24:22,310 --> 00:24:17,679  
an ultra high impedance of the order of

585  
00:24:26,310 --> 00:24:24,950  
okay here you may see some selected

586  
00:24:30,470 --> 00:24:26,320  
references

587  
00:24:31,750 --> 00:24:30,480  
to my work on the on the tcc and

588  
00:24:36,390 --> 00:24:31,760

i am finished

589

00:24:36,400 --> 00:24:42,470

wonderful thank you germano

590

00:24:47,430 --> 00:24:44,470

okay um

591

00:24:49,430 --> 00:24:47,440

you you ended excuse me you ended quite

592

00:24:50,789 --> 00:24:49,440

early so we have a great deal of time

593

00:24:52,470 --> 00:24:50,799

for questions

594

00:24:54,230 --> 00:24:52,480

um okay

595

00:25:03,190 --> 00:24:54,240

so

596

00:25:05,510 --> 00:25:03,200

would you like to start with questions

597

00:25:08,870 --> 00:25:05,520

uh yes my hand however went up for the

598

00:25:11,190 --> 00:25:08,880

last lecture i said i apologize but i

599

00:25:13,510 --> 00:25:11,200

think i have an important point perhaps

600

00:25:16,070 --> 00:25:13,520

to contribute to the last lecture okay

601  
00:25:18,230 --> 00:25:16,080  
that would be possible sure

602  
00:25:20,630 --> 00:25:18,240  
uh when you're talking about kel when

603  
00:25:22,870 --> 00:25:20,640  
you're talking about kirschkov's laws

604  
00:25:24,390 --> 00:25:22,880  
you're in this funny domain between the

605  
00:25:26,390 --> 00:25:24,400  
ee

606  
00:25:27,909 --> 00:25:26,400  
uh who dropped out of physics because he

607  
00:25:29,990 --> 00:25:27,919  
couldn't handle the math and the

608  
00:25:31,830 --> 00:25:30,000  
physicists i'm only being very humorous

609  
00:25:33,269 --> 00:25:31,840  
about it but at any rate but i am

610  
00:25:35,669 --> 00:25:33,279  
serious and that when you're at a

611  
00:25:38,070 --> 00:25:35,679  
circuit kirshkov level

612  
00:25:40,390 --> 00:25:38,080  
uh all of a sudden a bunch of physics

613  
00:25:42,549 --> 00:25:40,400

tends to drop away and it's not

614

00:25:44,870 --> 00:25:42,559

considered and in our work at the

615

00:25:46,310 --> 00:25:44,880

intelligent institute we we love this

616

00:25:48,549 --> 00:25:46,320

capacitor problem i thought the

617

00:25:50,390 --> 00:25:48,559

presentation was incredible and i think

618

00:25:52,710 --> 00:25:50,400

it's going to lead to a lot of important

619

00:25:54,149 --> 00:25:52,720

things at any rate let me get to the

620

00:25:56,230 --> 00:25:54,159

point and that is that when you're doing

621

00:25:57,669 --> 00:25:56,240

kirchhoff's law you've got to realize

622

00:26:00,149 --> 00:25:57,679

you're dealing with it across the

623

00:26:01,990 --> 00:26:00,159

resistor or the or any element

624

00:26:10,789 --> 00:26:02,000

you have a

625

00:26:12,630 --> 00:26:10,799

now we got to remember og electric field

626

00:26:14,230 --> 00:26:12,640

uh we really can't talk about we got to

627

00:26:15,350 --> 00:26:14,240

talk about the electrons right the

628

00:26:17,590 --> 00:26:15,360

electrons and therefore they're

629

00:26:19,269 --> 00:26:17,600

accelerating faster as they go through

630

00:26:21,990 --> 00:26:19,279

the electric field they're not all at

631

00:26:23,350 --> 00:26:22,000

the same speed and some of them can get

632

00:26:24,950 --> 00:26:23,360

quite fast

633

00:26:27,029 --> 00:26:24,960

then of course you've got the flow of

634

00:26:29,350 --> 00:26:27,039

like the newton pendulums hitting one

635

00:26:31,830 --> 00:26:29,360

another that kind of a group velocity

636

00:26:33,990 --> 00:26:31,840

versus the actual phase phase velocity

637

00:26:36,310 --> 00:26:34,000

versus group velocity and then you get a

638

00:26:38,310 --> 00:26:36,320

whole bunch of other electromagnetic

639

00:26:40,230 --> 00:26:38,320

effects and then of course by now you

640

00:26:41,669 --> 00:26:40,240

know i'm a time space guy and so

641

00:26:44,390 --> 00:26:41,679

therefore i'm always thinking out of

642

00:26:47,510 --> 00:26:44,400

photons but of a photon is nothing more

643

00:26:49,269 --> 00:26:47,520

than an accelerated charge uh

644

00:26:51,029 --> 00:26:49,279

communicating to another accelerated

645

00:26:53,029 --> 00:26:51,039

charge so all i'm saying is that i think

646

00:26:55,830 --> 00:26:53,039

if those elements can be brought into

647

00:26:57,750 --> 00:26:55,840

this namely the electric field

648

00:26:59,430 --> 00:26:57,760

the uh whatever you i don't believe in

649

00:27:01,590 --> 00:26:59,440

fields but the electric field the the

650

00:27:03,909 --> 00:27:01,600

but mainly the effect of of accelerated

651  
00:27:04,950 --> 00:27:03,919  
charges to accelerated charges we might

652  
00:27:06,390 --> 00:27:04,960  
and of course

653  
00:27:08,470 --> 00:27:06,400  
all everything you're talking about in

654  
00:27:10,870 --> 00:27:08,480  
thermal is nothing more than accelerated

655  
00:27:12,710 --> 00:27:10,880  
charges talking to accelerated charges

656  
00:27:15,350 --> 00:27:12,720  
if you can start to think at that model

657  
00:27:19,190 --> 00:27:15,360  
level you're now at a commonality where

658  
00:27:21,190 --> 00:27:19,200  
this unuseful energy is the same as the

659  
00:27:24,230 --> 00:27:21,200  
so-called useful energy it just has a

660  
00:27:25,830 --> 00:27:24,240  
different time space nature to it and

661  
00:27:27,830 --> 00:27:25,840  
and the way in which these accelerated

662  
00:27:29,909 --> 00:27:27,840  
charges which we're calling photons

663  
00:27:32,389 --> 00:27:29,919

communicate from one charged particle to

664

00:27:35,350 --> 00:27:32,399

another so getting back to it kirschkov

665

00:27:37,669 --> 00:27:35,360

laws involves fields because the voltage

666

00:27:39,269 --> 00:27:37,679

changes it causes therefore a different

667

00:27:40,950 --> 00:27:39,279

speed of the electrons traveling through

668

00:27:43,110 --> 00:27:40,960

these circuits they're not traveling at

669

00:27:44,870 --> 00:27:43,120

the same speed and i would love to see

670

00:27:48,230 --> 00:27:44,880

this consideration brought into this

671

00:27:50,950 --> 00:27:48,240

wonderful work and see what comes out

672

00:27:53,510 --> 00:27:50,960

germano would you like to comment

673

00:27:54,789 --> 00:27:53,520

okay yes thank you for the questions

674

00:27:56,870 --> 00:27:54,799

well

675

00:27:59,669 --> 00:27:56,880

i i i agree with you that

676

00:28:02,210 --> 00:27:59,679

my analysis that you see you may see now

677

00:28:03,430 --> 00:28:02,220

on on the screen is probably um

678

00:28:05,350 --> 00:28:03,440

[Music]

679

00:28:07,590 --> 00:28:05,360

too simple okay

680

00:28:09,909 --> 00:28:07,600

and i agree with you that we we need to

681

00:28:10,789 --> 00:28:09,919

put into the into consideration

682

00:28:13,190 --> 00:28:10,799

other

683

00:28:15,350 --> 00:28:13,200

factors that

684

00:28:17,830 --> 00:28:15,360

may have an effect on

685

00:28:19,110 --> 00:28:17,840

on the final results of the

686

00:28:21,750 --> 00:28:19,120

calculation

687

00:28:24,710 --> 00:28:21,760

and

688

00:28:26,470 --> 00:28:24,720

for this reason i myself i am i am the

689

00:28:29,590 --> 00:28:26,480

first person who

690

00:28:32,230 --> 00:28:29,600

in fact do not believe too much to this

691

00:28:35,510 --> 00:28:32,240

calculation to these results which are

692

00:28:37,990 --> 00:28:35,520

mainly theoretical results okay so

693

00:28:38,950 --> 00:28:38,000

what i want to stress is try

694

00:28:39,830 --> 00:28:38,960

to

695

00:28:41,269 --> 00:28:39,840

in

696

00:28:43,510 --> 00:28:41,279

physical implement and check

697

00:28:44,470 --> 00:28:43,520

experimentally this design in order to

698

00:28:47,190 --> 00:28:44,480

see

699

00:28:49,430 --> 00:28:47,200

taking all the prescription i i say

700

00:28:52,310 --> 00:28:49,440

before in the last in

701  
00:28:53,750 --> 00:28:52,320  
the penultimate slide in order to

702  
00:28:57,029 --> 00:28:53,760  
to be sure that

703  
00:29:00,950 --> 00:28:57,039  
the device work as uh as expected okay

704  
00:29:02,710 --> 00:29:00,960  
um i agree with the with the robert that

705  
00:29:04,389 --> 00:29:02,720  
using only uh

706  
00:29:05,830 --> 00:29:04,399  
the cash of law and

707  
00:29:08,070 --> 00:29:05,840  
neglecting some

708  
00:29:09,190 --> 00:29:08,080  
factors that

709  
00:29:11,909 --> 00:29:09,200  
they can

710  
00:29:14,310 --> 00:29:11,919  
maybe must be taken into account okay in

711  
00:29:16,230 --> 00:29:14,320  
the calculation of educational law uh

712  
00:29:18,630 --> 00:29:16,240  
could change the picture

713  
00:29:20,870 --> 00:29:18,640

and this is the reason why i

714

00:29:23,029 --> 00:29:20,880

i just presented this this

715

00:29:26,789 --> 00:29:23,039

simple analysis and

716

00:29:29,350 --> 00:29:26,799

simulation and medical simulation but

717

00:29:31,430 --> 00:29:29,360

my goal my targeting my future target is

718

00:29:34,470 --> 00:29:31,440

to to try to

719

00:29:35,990 --> 00:29:34,480

actually test check experimentally okay

720

00:29:39,029 --> 00:29:36,000

the

721

00:29:44,230 --> 00:29:40,630

thank you thank you very much for your

722

00:29:47,190 --> 00:29:44,240

response but uh this was also primarily

723

00:29:51,830 --> 00:29:47,200

uh to paul uh thibaut and uh if he's

724

00:29:58,470 --> 00:29:52,630

uh

725

00:30:00,549 --> 00:29:58,480

think you know a lot of what we've done

726

00:30:02,630 --> 00:30:00,559

really i think was first done kind of in

727

00:30:03,909 --> 00:30:02,640

the optics community where they really

728

00:30:06,549 --> 00:30:03,919

looked at

729

00:30:08,310 --> 00:30:06,559

uh noise and um

730

00:30:09,909 --> 00:30:08,320

the different effects that that can

731

00:30:11,909 --> 00:30:09,919

happen there and actually sarandra

732

00:30:13,029 --> 00:30:11,919

saying it was part of our group is kind

733

00:30:16,470 --> 00:30:13,039

of a

734

00:30:18,389 --> 00:30:16,480

uh you know skilled in that art and so

735

00:30:20,630 --> 00:30:18,399

um you know i basically i agree with you

736

00:30:22,149 --> 00:30:20,640

and i think that the um

737

00:30:23,269 --> 00:30:22,159

you know i think that that field

738

00:30:26,950 --> 00:30:23,279

probably

739

00:30:29,350 --> 00:30:26,960

uh can get uh to do more fundamental uh

740

00:30:31,510 --> 00:30:29,360

look at these things

741

00:30:32,310 --> 00:30:31,520

thank you

742

00:30:34,470 --> 00:30:32,320

okay

743

00:30:35,430 --> 00:30:34,480

thank you um i'd like to call on david

744

00:30:40,389 --> 00:30:35,440

milller

745

00:30:40,399 --> 00:30:46,789

david are you there

746

00:30:53,669 --> 00:30:48,070

okay

747

00:30:57,110 --> 00:30:53,679

to do then is just uh kind of wait wait

748

00:30:59,669 --> 00:30:57,120

for david to get on i'll i'll exert um

749

00:31:01,909 --> 00:30:59,679

the privilege of the chair um germano i

750

00:31:04,389 --> 00:31:01,919

have a couple of questions um concerning

751

00:31:06,549 --> 00:31:04,399

your your talk first of all um

752

00:31:08,230 --> 00:31:06,559

the steady state voltage that you're

753

00:31:12,070 --> 00:31:08,240

you're claiming it looks like it's

754

00:31:13,430 --> 00:31:12,080

around 30 uh millivolts and that's

755

00:31:15,669 --> 00:31:13,440

roughly the thermal

756

00:31:18,389 --> 00:31:15,679

uh voltage that you'd expect from

757

00:31:19,909 --> 00:31:18,399

setting  $kT$  equals to  $qV$  is that

758

00:31:22,230 --> 00:31:19,919

coincidence or

759

00:31:25,110 --> 00:31:22,240

is there is that is that is there a

760

00:31:25,120 --> 00:31:28,630

well i i believe that

761

00:31:30,950 --> 00:31:29,830

i don't know if

762

00:31:33,830 --> 00:31:30,960

there is a

763

00:31:35,350 --> 00:31:33,840

if it is a coincidence but

764

00:32:16,950 --> 00:31:35,360

i

765

00:32:19,190 --> 00:32:16,960

okay yeah

766

00:32:20,389 --> 00:32:19,200

yeah we'll just please share that again

767

00:32:22,870 --> 00:32:20,399

because i have a

768

00:32:24,230 --> 00:32:22,880

more fun another fundamental question

769

00:32:26,870 --> 00:32:24,240

okay this one

770

00:32:29,350 --> 00:32:26,880

yeah that's that's good okay so um you

771

00:32:31,590 --> 00:32:29,360

you have a a horseshoe here which looks

772

00:32:34,710 --> 00:32:31,600

very much like upside down version of

773

00:32:37,269 --> 00:32:34,720

horseshoes that i had were using in um

774

00:32:38,470 --> 00:32:37,279

and solid state versions of uh

775

00:32:41,190 --> 00:32:38,480

challenges

776

00:32:44,389 --> 00:32:41,200

and the junction one that you have here

777

00:32:46,630 --> 00:32:44,399

um would be the depletion region yeah

778

00:32:47,669 --> 00:32:46,640

between two semiconductors and the j2

779

00:32:50,870 --> 00:32:47,679

gap

780

00:32:53,110 --> 00:32:50,880

um but um you're correct that the that

781

00:32:55,830 --> 00:32:53,120

when when you first join these junctions

782

00:32:58,230 --> 00:32:55,840

that the in the upper junction j2 you

783

00:33:00,470 --> 00:32:58,240

don't initially immediately get charges

784

00:33:02,310 --> 00:33:00,480

but in the end you have to

785

00:33:04,549 --> 00:33:02,320

um and that's that's demanded by

786

00:33:06,389 --> 00:33:04,559

faraday's law or conservation of energy

787

00:33:08,310 --> 00:33:06,399

kirchhoff's law in other words if you

788

00:33:11,590 --> 00:33:08,320

wish if you take a if you take an

789

00:33:13,990 --> 00:33:11,600

integral around a closed loop

790

00:33:15,590 --> 00:33:14,000

the electric field

791

00:33:17,669 --> 00:33:15,600

net electric field around a closed loop

792

00:33:19,029 --> 00:33:17,679

line integral has to be zero so if you

793

00:33:20,470 --> 00:33:19,039

have an electric field here you have to

794

00:33:22,149 --> 00:33:20,480

have electric field somewhere else in

795

00:33:23,430 --> 00:33:22,159

the system it can't be in the bolt

796

00:33:25,590 --> 00:33:23,440

because that would drive a current

797

00:33:28,789 --> 00:33:25,600

therefore it has to be across the gap

798

00:33:31,110 --> 00:33:28,799

so straight faraday straight maxwell's

799

00:33:32,950 --> 00:33:31,120

equations demands that that in steady

800

00:33:34,149 --> 00:33:32,960

state you have to have charges here on

801  
00:33:37,029 --> 00:33:34,159  
the gap you have to have an electric

802  
00:33:39,110 --> 00:33:37,039  
field here but more than that

803  
00:33:40,870 --> 00:33:39,120  
the electric field has been measured by

804  
00:33:43,350 --> 00:33:40,880  
multiple groups around the world i've

805  
00:33:44,310 --> 00:33:43,360  
i've built these these these junction

806  
00:33:46,389 --> 00:33:44,320  
gaps

807  
00:33:47,830 --> 00:33:46,399  
in semiconductors and multiple

808  
00:33:49,669 --> 00:33:47,840  
independent groups have measured the

809  
00:33:51,269 --> 00:33:49,679  
electric field so in fact there is an

810  
00:33:52,470 --> 00:33:51,279  
electric field here and that's

811  
00:33:54,549 --> 00:33:52,480  
experimentally determined and

812  
00:33:56,310 --> 00:33:54,559  
analytically required if you believe

813  
00:33:57,990 --> 00:33:56,320

maxwell's equations

814

00:33:59,590 --> 00:33:58,000

so um i don't know how you want to

815

00:34:01,669 --> 00:33:59,600

respond if you can respond to that i'd

816

00:34:05,029 --> 00:34:01,679

appreciate it well

817

00:34:10,950 --> 00:34:08,550

what i've i have shown here is that

818

00:34:11,750 --> 00:34:10,960

half of the application of a kirchhoff

819

00:34:13,270 --> 00:34:11,760

law

820

00:34:19,190 --> 00:34:13,280

i

821

00:34:21,669 --> 00:34:19,200

shoe

822

00:34:24,629 --> 00:34:21,679

we can extend this

823

00:34:27,030 --> 00:34:24,639

integral to become a circular integral

824

00:34:27,829 --> 00:34:27,040

across the in general okay

825

00:34:30,149 --> 00:34:27,839

and

826

00:34:32,629 --> 00:34:30,159

but i think that what i have shown here

827

00:34:34,790 --> 00:34:32,639

the fact that the

828

00:34:37,829 --> 00:34:34,800

the work done by all the forces acting

829

00:34:39,669 --> 00:34:37,839

upon the text electron across  $j_1$  is

830

00:34:42,149 --> 00:34:39,679

still the same also in the in the case

831

00:34:43,589 --> 00:34:42,159

of a circular of  $um$

832

00:34:44,950 --> 00:34:43,599

closer the

833

00:34:45,750 --> 00:34:44,960

integrals okay

834

00:34:48,950 --> 00:34:45,760

and

835

00:34:49,990 --> 00:34:48,960

you should

836

00:34:53,190 --> 00:34:50,000

according

837

00:34:55,669 --> 00:34:53,200

this is my my position okay

838

00:34:58,310 --> 00:34:55,679

should be also equal to zero because you

839

00:35:00,630 --> 00:34:58,320

see it is equal to zero the the the work

840

00:35:03,589 --> 00:35:00,640

the the wall work the overall work done

841

00:35:05,750 --> 00:35:03,599

by all the forces across  $j_1$  okay and

842

00:35:06,710 --> 00:35:05,760

because in in the balance of

843

00:35:11,990 --> 00:35:06,720

in

844

00:35:15,270 --> 00:35:12,000

the electric force due to the the built

845

00:35:17,670 --> 00:35:15,280

in electric field across  $j_1$  but also

846

00:35:19,510 --> 00:35:17,680

the diffusion forces that must be always

847

00:35:21,990 --> 00:35:19,520

there

848

00:35:23,829 --> 00:35:22,000

must be always present and the forces

849

00:35:25,910 --> 00:35:23,839

the diffusion forces

850

00:35:29,030 --> 00:35:25,920

should be equal and opposite to the the

851

00:35:32,150 --> 00:35:29,040

electric field across j1 because

852

00:35:35,349 --> 00:35:32,160

if one is if one could switch could

853

00:35:37,349 --> 00:35:35,359

switch off the these diffusion forces

854

00:35:40,550 --> 00:35:37,359

the built-in electric field will go to

855

00:35:42,790 --> 00:35:40,560

zero immediately okay yeah

856

00:35:45,750 --> 00:35:42,800

i am i agree with you that

857

00:35:47,510 --> 00:35:45,760

the electric field has been

858

00:35:50,630 --> 00:35:47,520

measured

859

00:35:51,510 --> 00:35:50,640

yeah

860

00:35:53,910 --> 00:35:51,520

i'm

861

00:35:56,630 --> 00:35:53,920

now thinking of of the

862

00:35:59,270 --> 00:35:56,640

the use of the kelvin kelvin probe

863

00:36:01,670 --> 00:35:59,280

system to to to measure the this field

864

00:36:04,150 --> 00:36:01,680

probably right well the kelvin probes

865

00:36:06,230 --> 00:36:04,160

were used to measure yeah that j2

866

00:36:08,470 --> 00:36:06,240

electric field the thing is though is in

867

00:36:11,270 --> 00:36:08,480

terms of the forces in the in the in the

868

00:36:13,589 --> 00:36:11,280

lower gap j1 okay

869

00:36:14,870 --> 00:36:13,599

you have i mean the electric field that

870

00:36:16,470 --> 00:36:14,880

builds up there in the first place is

871

00:36:17,910 --> 00:36:16,480

due to diffusion cross-diffusion of

872

00:36:18,950 --> 00:36:17,920

charges at least in the semiconductor

873

00:36:21,109 --> 00:36:18,960

case

874

00:36:22,550 --> 00:36:21,119

and and in terms of diffusion forces if

875

00:36:23,990 --> 00:36:22,560

you're talking about brownian motion

876

00:36:25,430 --> 00:36:24,000

that that's uh

877

00:36:27,510 --> 00:36:25,440

that average force is zero and you have

878

00:36:29,750 --> 00:36:27,520

to do a time average of it which gives

879

00:36:31,670 --> 00:36:29,760

you zero there so um that needs to be

880

00:36:34,310 --> 00:36:31,680

this this has to be done delicately this

881

00:36:35,510 --> 00:36:34,320

uh this internal force

882

00:36:38,310 --> 00:36:35,520

so i think you'll find the average

883

00:36:39,510 --> 00:36:38,320

diffusive force um is either zero the

884

00:36:41,349 --> 00:36:39,520

way you're if you're if i'm

885

00:36:42,470 --> 00:36:41,359

understanding it correctly or else is

886

00:36:43,910 --> 00:36:42,480

being double counted because the

887

00:36:46,230 --> 00:36:43,920

electric field of the built-in the

888

00:36:50,470 --> 00:36:46,240

built-in electric field is the result of

889

00:36:55,030 --> 00:36:53,109

okay and diffusion force necessarily

890

00:36:56,150 --> 00:36:55,040

transient because you know electrons

891

00:36:57,270 --> 00:36:56,160

move from one side to the other and then

892

00:36:59,430 --> 00:36:57,280

you have a counter potential that

893

00:37:02,310 --> 00:36:59,440

cancel out the initial potential

894

00:37:04,390 --> 00:37:02,320

difference so then at like long times

895

00:37:06,790 --> 00:37:04,400

you'd expect no diffusion force

896

00:37:08,790 --> 00:37:06,800

well yeah i i'm just kind of i'm fuzzy

897

00:37:10,950 --> 00:37:08,800

on what the diffusion force is here the

898

00:37:12,950 --> 00:37:10,960

electric the built-in uh potential at

899

00:37:14,069 --> 00:37:12,960

least when it comes to semiconductors

900

00:37:16,230 --> 00:37:14,079

they're not talking about metals here

901  
00:37:18,310 --> 00:37:16,240  
but semiconductors is the result of

902  
00:37:19,910 --> 00:37:18,320  
diffusion in the first place right

903  
00:37:21,349 --> 00:37:19,920  
you're you're trading electrostatic

904  
00:37:23,109 --> 00:37:21,359  
you're trading chemical potential

905  
00:37:24,470 --> 00:37:23,119  
difference for electrostatic potential

906  
00:37:25,750 --> 00:37:24,480  
difference there

907  
00:37:27,109 --> 00:37:25,760  
so if you're throwing in another

908  
00:37:29,430 --> 00:37:27,119  
diffusion force that would be a

909  
00:37:31,109 --> 00:37:29,440  
fluctuating force which has a time

910  
00:37:34,069 --> 00:37:31,119  
average of zero as you're saying i

911  
00:37:36,150 --> 00:37:34,079  
believe that that's correct yeah so

912  
00:37:37,589 --> 00:37:36,160  
anyways it's an interesting proposal and

913  
00:37:39,109 --> 00:37:37,599

i think yeah the measurements should be

914

00:37:41,990 --> 00:37:39,119

made yeah

915

00:37:43,990 --> 00:37:42,000

definitely yeah

916

00:37:45,190 --> 00:37:44,000

for the medals yeah

917

00:37:47,030 --> 00:37:45,200

so

918

00:37:48,790 --> 00:37:47,040

other other questions on david are you

919

00:37:51,990 --> 00:37:48,800

back

920

00:37:54,310 --> 00:37:52,000

sorry hands up garrett i think you were

921

00:37:56,870 --> 00:37:54,320

yeah you had your hands up too damn

922

00:37:58,950 --> 00:37:56,880

uh david put his question in the chat

923

00:38:02,230 --> 00:37:58,960

because his mic isn't working

924

00:38:04,710 --> 00:38:02,240

uh he he says can um

925

00:38:08,470 --> 00:38:04,720

jomano please address how much current

926  
00:38:10,310 --> 00:38:08,480  
would go up with increased temperature

927  
00:38:11,270 --> 00:38:10,320  
okay thank you okay

928  
00:38:12,470 --> 00:38:11,280  
okay

929  
00:38:16,230 --> 00:38:12,480  
well

930  
00:38:18,630 --> 00:38:16,240  
i have in the simulation i have done uh

931  
00:38:20,069 --> 00:38:18,640  
i used also i made the calculation also

932  
00:38:22,069 --> 00:38:20,079  
for uh

933  
00:38:23,270 --> 00:38:22,079  
three for two factor different

934  
00:38:26,510 --> 00:38:23,280  
temperature

935  
00:38:28,790 --> 00:38:26,520  
uh 300 kelvin 20 to

936  
00:38:31,270 --> 00:38:28,800  
296 kelvin

937  
00:38:32,790 --> 00:38:31,280  
in order to give an idea an ink of how

938  
00:38:35,190 --> 00:38:32,800

his uh

939

00:38:36,950 --> 00:38:35,200

in this case the voltage across the the

940

00:38:41,430 --> 00:38:36,960

open circuit necessity

941

00:38:43,829 --> 00:38:41,440

uh change with temperature and um

942

00:38:44,950 --> 00:38:43,839

well i didn't

943

00:38:47,829 --> 00:38:44,960

i didn't

944

00:38:49,270 --> 00:38:47,839

do they has called the calculation

945

00:38:50,630 --> 00:38:49,280

about the the

946

00:38:53,510 --> 00:38:50,640

current

947

00:38:57,910 --> 00:38:56,150

well i i don't know but

948

00:39:00,470 --> 00:38:57,920

i don't know how the dependence of the

949

00:39:01,990 --> 00:39:00,480

current is with temperature uh i should

950

00:39:05,349 --> 00:39:02,000

may i should

951  
00:39:07,990 --> 00:39:05,359  
redo the calculation in order to see

952  
00:39:09,990 --> 00:39:08,000  
how the the current across the the short

953  
00:39:11,910 --> 00:39:10,000  
circuit cc change with the with the

954  
00:39:15,109 --> 00:39:11,920  
temperature

955  
00:39:18,390 --> 00:39:15,119  
but i believe that the

956  
00:39:19,829 --> 00:39:18,400  
the trend is similar to this factor uh

957  
00:39:20,790 --> 00:39:19,839  
multiplying the

958  
00:39:22,790 --> 00:39:20,800  
the

959  
00:39:24,310 --> 00:39:22,800  
this this equation okay

960  
00:39:27,270 --> 00:39:24,320  
so it

961  
00:39:30,550 --> 00:39:27,280  
should scale with the the third power of

962  
00:39:33,270 --> 00:39:31,670  
okay

963  
00:39:34,710 --> 00:39:33,280

good

964

00:39:36,710 --> 00:39:34,720

other questions

965

00:39:37,670 --> 00:39:36,720

garrett did you have a question

966

00:39:40,870 --> 00:39:37,680

yes

967

00:39:43,589 --> 00:39:40,880

um so you talk about power but then you

968

00:39:46,230 --> 00:39:43,599

also mentioned needing to use a very

969

00:39:47,670 --> 00:39:46,240

high impedance volt meter to measure

970

00:39:50,710 --> 00:39:47,680

this and

971

00:39:53,270 --> 00:39:50,720

kelvin probe another example

972

00:39:56,630 --> 00:39:53,280

i like to think of

973

00:39:57,990 --> 00:39:56,640

two types of second law violations the

974

00:40:02,310 --> 00:39:58,000

the

975

00:40:03,829 --> 00:40:02,320

violation

976  
00:40:06,630 --> 00:40:03,839  
and so

977  
00:40:09,109 --> 00:40:06,640  
for me a soft violation would be

978  
00:40:10,710 --> 00:40:09,119  
where you produce a potential difference

979  
00:40:11,990 --> 00:40:10,720  
but you're not actually getting work out

980  
00:40:13,030 --> 00:40:12,000  
of it

981  
00:40:14,550 --> 00:40:13,040  
and

982  
00:40:16,390 --> 00:40:14,560  
i wonder

983  
00:40:20,150 --> 00:40:16,400  
is this

984  
00:40:22,710 --> 00:40:20,160  
perhaps a soft violation in which you're

985  
00:40:25,270 --> 00:40:22,720  
distorting something but it's not clear

986  
00:40:28,309 --> 00:40:25,280  
that we could get substantial continuous

987  
00:40:32,870 --> 00:40:30,309  
okay um

988  
00:40:37,430 --> 00:40:32,880

well i mean that

989

00:40:41,670 --> 00:40:39,589

a cd current should flow across the

990

00:40:44,470 --> 00:40:41,680

resistor so

991

00:40:47,190 --> 00:40:44,480

even if it is a tiny power output it

992

00:40:49,670 --> 00:40:47,200

should be a continuous uh

993

00:40:53,270 --> 00:40:49,680

power electrical power output

994

00:40:55,589 --> 00:40:53,280

and what they this is how i see

995

00:40:56,710 --> 00:40:55,599

the behavior of this pcc

996

00:40:58,470 --> 00:40:56,720

uh

997

00:41:00,230 --> 00:40:58,480

these two spheres

998

00:41:02,790 --> 00:41:00,240

subtract uh

999

00:41:06,790 --> 00:41:02,800

thermal energy from the the hermitage

1000

00:41:09,030 --> 00:41:06,800

and transform this thermal energy in a

1001  
00:41:12,150 --> 00:41:09,040  
current that claw that passed across the

1002  
00:41:16,710 --> 00:41:12,160  
resistor so i believe that it is uh i i

1003  
00:41:19,349 --> 00:41:16,720  
think that if this uh design works

1004  
00:41:20,390 --> 00:41:19,359  
probably it works

1005  
00:41:22,470 --> 00:41:20,400  
violating

1006  
00:41:24,069 --> 00:41:22,480  
in a strong way the second law of

1007  
00:41:27,750 --> 00:41:24,079  
thermodynamic

1008  
00:41:30,069 --> 00:41:27,760  
this is my my

1009  
00:41:32,309 --> 00:41:30,079  
my idea

1010  
00:41:37,829 --> 00:41:34,790  
the problem with this design is as you

1011  
00:41:41,030 --> 00:41:37,839  
may see is the the the very teeny tiny

1012  
00:41:42,470 --> 00:41:41,040  
power output that is

1013  
00:41:45,750 --> 00:41:42,480

too close to the

1014

00:41:49,430 --> 00:41:45,760

the background noise to be detected and

1015

00:41:51,030 --> 00:41:49,440

in an ambiguously uh

1016

00:41:53,270 --> 00:41:51,040

detected

1017

00:41:54,230 --> 00:41:53,280

it's a it's an interesting issue how

1018

00:41:55,109 --> 00:41:54,240

much

1019

00:41:57,750 --> 00:41:55,119

power

1020

00:42:00,470 --> 00:41:57,760

can really be obtained or if nature is

1021

00:42:02,790 --> 00:42:00,480

is kind of limiting this to these small

1022

00:42:04,790 --> 00:42:02,800

numbers for example even with

1023

00:42:05,589 --> 00:42:04,800

paul thibodeau's earlier calculation

1024

00:42:09,510 --> 00:42:05,599

about

1025

00:42:12,710 --> 00:42:09,520

getting power out from a diode and

1026  
00:42:13,670 --> 00:42:12,720  
daniel's epicatalysis and so on is there

1027  
00:42:16,230 --> 00:42:13,680  
some

1028  
00:42:17,750 --> 00:42:16,240  
limit that nature has to uh

1029  
00:42:19,109 --> 00:42:17,760  
non-linearity

1030  
00:42:21,270 --> 00:42:19,119  
it ends up

1031  
00:42:24,230 --> 00:42:21,280  
saying yeah you can violate this but

1032  
00:42:26,870 --> 00:42:24,240  
just very soft yeah yeah yeah

1033  
00:42:29,109 --> 00:42:26,880  
i i guess i i the soft and hard

1034  
00:42:30,790 --> 00:42:29,119  
violation i think is i

1035  
00:42:32,550 --> 00:42:30,800  
i'm wondering whether that's somewhat of

1036  
00:42:34,710 --> 00:42:32,560  
a red herring um

1037  
00:42:36,230 --> 00:42:34,720  
in in the sense that

1038  
00:42:39,750 --> 00:42:36,240

there's more than one way to skin a cat

1039

00:42:41,030 --> 00:42:39,760

i mean if you're if if

1040

00:42:41,910 --> 00:42:41,040

it may look

1041

00:42:44,630 --> 00:42:41,920

more

1042

00:42:46,309 --> 00:42:44,640

in

1043

00:42:48,470 --> 00:42:46,319

and then you probably should consider

1044

00:42:51,030 --> 00:42:48,480

thermal noise then nyquist or johnson

1045

00:42:53,510 --> 00:42:51,040

noise to to compete here but on the

1046

00:42:54,950 --> 00:42:53,520

other hand if you go again back to that

1047

00:42:56,309 --> 00:42:54,960

slide five

1048

00:42:59,430 --> 00:42:56,319

there's more than there are other ways

1049

00:43:02,150 --> 00:42:59,440

of extracting that energy and

1050

00:43:04,710 --> 00:43:02,160

there have been propositions for in the

1051  
00:43:05,910 --> 00:43:04,720  
semiconductor case of using the gap two

1052  
00:43:07,829 --> 00:43:05,920  
electric fields to drive

1053  
00:43:10,550 --> 00:43:07,839  
electromechanical devices

1054  
00:43:13,109 --> 00:43:10,560  
and and detailed numerical simulations

1055  
00:43:15,270 --> 00:43:13,119  
indicate that that's feasible

1056  
00:43:17,510 --> 00:43:15,280  
and so what may look like a soft

1057  
00:43:19,829 --> 00:43:17,520  
violation in one

1058  
00:43:21,430 --> 00:43:19,839  
in some light if you cast it in a

1059  
00:43:23,750 --> 00:43:21,440  
different light a different kind of work

1060  
00:43:32,309 --> 00:43:23,760  
extraction it becomes the soft violation

1061  
00:43:36,870 --> 00:43:34,150  
i also think zero is just the most

1062  
00:43:39,030 --> 00:43:36,880  
fundamental limit on work extraction so

1063  
00:43:40,230 --> 00:43:39,040

if you can extract anything it seems

1064

00:43:41,829 --> 00:43:40,240

at this point it's no longer a

1065

00:43:44,950 --> 00:43:41,839

fundamental physics problem it's just a

1066

00:43:46,309 --> 00:43:44,960

matter of engineering you know i think

1067

00:43:47,589 --> 00:43:46,319

history shows that we started with all

1068

00:43:49,510 --> 00:43:47,599

these small effects over and over in

1069

00:43:51,190 --> 00:43:49,520

physics with enough kind of money being

1070

00:43:53,750 --> 00:43:51,200

put on a problem you know we have these

1071

00:43:55,510 --> 00:43:53,760

drastic increases right if you just kind

1072

00:43:56,870 --> 00:43:55,520

of bound this once you get over that

1073

00:43:57,910 --> 00:43:56,880

initial violation

1074

00:44:00,230 --> 00:43:57,920

sure

1075

00:44:02,230 --> 00:44:00,240

yeah like for instance some of the more

1076

00:44:03,750 --> 00:44:02,240

recent epic catalysis

1077

00:44:06,390 --> 00:44:03,760

experiments with

1078

00:44:08,950 --> 00:44:06,400

with david miller here at usd those are

1079

00:44:11,030 --> 00:44:08,960

putting out milliwatts now um that's

1080

00:44:12,870 --> 00:44:11,040

that's not i mean it's not large but

1081

00:44:16,470 --> 00:44:12,880

it's more than picowatts

1082

00:44:17,190 --> 00:44:16,480

and milliwatts are are easily measurable

1083

00:44:19,190 --> 00:44:17,200

so

1084

00:44:25,829 --> 00:44:19,200

it's no longer a quantum fluctuation no

1085

00:44:29,990 --> 00:44:28,230

okay other questions um i'm having a

1086

00:44:31,589 --> 00:44:30,000

hard time seeing everyone's hand here so

1087

00:44:33,510 --> 00:44:31,599

if you have a question please just jump

1088

00:44:34,390 --> 00:44:33,520

in and we'll sort it out

1089

00:44:36,950 --> 00:44:34,400

okay

1090

00:44:38,470 --> 00:44:36,960

i have a question to paul tibaldo

1091

00:44:39,670 --> 00:44:38,480

to raise this

1092

00:44:42,710 --> 00:44:39,680

um

1093

00:44:44,390 --> 00:44:42,720

and and uh my question is two question

1094

00:44:45,430 --> 00:44:44,400

or three questions

1095

00:44:47,349 --> 00:44:45,440

even

1096

00:44:50,150 --> 00:44:47,359

uh

1097

00:44:55,990 --> 00:44:50,160

first question how high is the voltage

1098

00:44:59,109 --> 00:44:57,109

uh

1099

00:44:59,990 --> 00:44:59,119

hey hey

1100

00:45:02,390 --> 00:45:00,000

um

1101

00:45:04,150 --> 00:45:02,400

okay did you want to do this okay hold

1102

00:45:06,630 --> 00:45:04,160

on a second you said time this way

1103

00:45:08,790 --> 00:45:06,640

daniel sorry yeah yeah um so let's let's

1104

00:45:11,030 --> 00:45:08,800

border here hold on hold on a second

1105

00:45:13,750 --> 00:45:11,040

paul are there any are there anything

1106

00:45:15,670 --> 00:45:13,760

are there any questions uh of any

1107

00:45:19,349 --> 00:45:15,680

further questions

1108

00:45:22,550 --> 00:45:19,359

for um germano brumo

1109

00:45:32,550 --> 00:45:23,510

okay

1110

00:45:34,230 --> 00:45:32,560

so

1111

00:45:36,390 --> 00:45:34,240

uh i'm not sure i quite followed the

1112

00:45:38,630 --> 00:45:36,400

question so the so the so the graphing

1113

00:45:41,270 --> 00:45:38,640

the small capacitor

1114

00:45:44,790 --> 00:45:41,280

uh has an average voltage of zero but it

1115

00:45:46,790 --> 00:45:44,800

does have large voltage fluctuations

1116

00:45:47,990 --> 00:45:46,800

and if you make that capacitance smaller

1117

00:45:50,550 --> 00:45:48,000

and smaller than the voltage

1118

00:45:53,430 --> 00:45:50,560

fluctuations rise this is kind of a

1119

00:45:56,069 --> 00:45:53,440

well-known phenomenon in fact you see it

1120

00:45:57,829 --> 00:45:56,079

in the semiconductor industry if you

1121

00:45:59,990 --> 00:45:57,839

make these chips

1122

00:46:02,870 --> 00:46:00,000

and you make really small capacitors on

1123

00:46:04,790 --> 00:46:02,880

these chips you have to be aware of the

1124

00:46:07,270 --> 00:46:04,800

the large voltage noise that gets

1125

00:46:09,510 --> 00:46:07,280

generated by them

1126  
00:46:11,710 --> 00:46:09,520  
so i mean the extra energy in this

1127  
00:46:15,910 --> 00:46:11,720  
circuit comes from the

1128  
00:46:17,829 --> 00:46:15,920  
fluctuations of of the graphene

1129  
00:46:18,790 --> 00:46:17,839  
layer isn't it

1130  
00:46:20,069 --> 00:46:18,800  
okay

1131  
00:46:21,990 --> 00:46:20,079  
yes

1132  
00:46:23,589 --> 00:46:22,000  
because as i looked at this at your

1133  
00:46:26,069 --> 00:46:23,599  
presentation

1134  
00:46:26,870 --> 00:46:26,079  
at the very beginning you were you told

1135  
00:46:28,080 --> 00:46:26,880  
that

1136  
00:46:31,190 --> 00:46:28,090  
the um

1137  
00:46:34,069 --> 00:46:31,200  
[Music]

1138  
00:46:36,950 --> 00:46:34,079

that the fluctuations of the graphene

1139

00:46:41,510 --> 00:46:36,960

would change the capacity

1140

00:46:43,109 --> 00:46:41,520

of the capacitor so that the um so that

1141

00:46:46,069 --> 00:46:43,119

the um

1142

00:46:46,870 --> 00:46:46,079

the electrons would be drawn from the

1143

00:46:50,230 --> 00:46:46,880

um

1144

00:46:52,630 --> 00:46:50,240

from this battery in one or another

1145

00:46:55,510 --> 00:46:52,640

direction depending on

1146

00:46:56,950 --> 00:46:55,520

um yeah the direction right

1147

00:46:59,030 --> 00:46:56,960

and um

1148

00:47:01,829 --> 00:46:59,040

actually

1149

00:47:03,990 --> 00:47:01,839

this would be drawing the um electron

1150

00:47:07,750 --> 00:47:04,000

from the battery and

1151

00:47:09,670 --> 00:47:07,760

uh transporting it to the capacitor

1152

00:47:11,190 --> 00:47:09,680

all right okay yeah great okay i i'm

1153

00:47:13,190 --> 00:47:11,200

with you now so that's more in the

1154

00:47:15,109 --> 00:47:13,200

deterministic case

1155

00:47:18,230 --> 00:47:15,119

we've done an extremely detailed

1156

00:47:19,109 --> 00:47:18,240

analysis of the deterministic case

1157

00:47:21,589 --> 00:47:19,119

and

1158

00:47:24,470 --> 00:47:21,599

that battery if you if you imagine

1159

00:47:26,549 --> 00:47:24,480

replacing that battery with a capacitor

1160

00:47:28,870 --> 00:47:26,559

it's easier to visualize

1161

00:47:30,549 --> 00:47:28,880

then a little bit of charge comes off on

1162

00:47:32,470 --> 00:47:30,559

the forward direction

1163

00:47:34,710 --> 00:47:32,480

and then a little bit of charge goes

1164

00:47:37,190 --> 00:47:34,720

back onto the capacitor in the reverse

1165

00:47:40,069 --> 00:47:37,200

direction and if it's a loss list if

1166

00:47:43,030 --> 00:47:40,079

it's a very low loss system then you

1167

00:47:45,349 --> 00:47:43,040

won't lose any of that charge over time

1168

00:47:47,670 --> 00:47:45,359

and so and in a detailed analysis and

1169

00:47:48,549 --> 00:47:47,680

this includes not only from physics but

1170

00:47:50,950 --> 00:47:48,559

from

1171

00:47:53,510 --> 00:47:50,960

uh kind of the state-of-the-art in

1172

00:47:54,950 --> 00:47:53,520

in engineering um

1173

00:47:57,270 --> 00:47:54,960

circuit analysis

1174

00:47:59,589 --> 00:47:57,280

that battery contributes none of the

1175

00:48:02,549 --> 00:47:59,599

power in fact it's whatever is turning

1176

00:48:04,390 --> 00:48:02,559

the capacitor if you think of a windmill

1177

00:48:06,390 --> 00:48:04,400

it's whatever is turning the windmill

1178

00:48:07,589 --> 00:48:06,400

that's the origin of power

1179

00:48:08,549 --> 00:48:07,599

it's not

1180

00:48:10,870 --> 00:48:08,559

the

1181

00:48:13,510 --> 00:48:10,880

that's

1182

00:48:15,190 --> 00:48:13,520

present in the system or the or in that

1183

00:48:16,630 --> 00:48:15,200

case maybe a magnetic field that's

1184

00:48:17,670 --> 00:48:16,640

present in a system the power isn't

1185

00:48:19,270 --> 00:48:17,680

coming from that it's coming from

1186

00:48:20,390 --> 00:48:19,280

whatever is turning

1187

00:48:23,030 --> 00:48:20,400

that

1188

00:48:23,990 --> 00:48:23,040

windmill or in this case the capacitor

1189

00:48:26,309 --> 00:48:24,000

okay

1190

00:48:29,910 --> 00:48:26,319

but you need if this battery is

1191

00:48:32,069 --> 00:48:29,920

accumulator and not a common normal

1192

00:48:34,549 --> 00:48:32,079

normal battery

1193

00:48:37,589 --> 00:48:34,559

and you want to

1194

00:48:39,829 --> 00:48:37,599

use this um charge you need an initial

1195

00:48:42,309 --> 00:48:39,839

charge in this accumulator

1196

00:48:45,430 --> 00:48:42,319

to um to

1197

00:48:47,990 --> 00:48:45,440

to make it move you through the

1198

00:48:50,950 --> 00:48:48,000

vibration of

1199

00:48:51,829 --> 00:48:50,960

of the um of the layer of the graphene

1200

00:48:52,790 --> 00:48:51,839

layer

1201  
00:48:55,270 --> 00:48:52,800  
isn't it

1202  
00:48:57,990 --> 00:48:55,280  
i'm looking at it as a as an electronic

1203  
00:48:59,750 --> 00:48:58,000  
engineer as a circuit this is circuit

1204  
00:49:03,870 --> 00:48:59,760  
and you have a

1205  
00:49:08,230 --> 00:49:03,880  
battery the battery if it is more than

1206  
00:49:10,950 --> 00:49:08,240  
0.7 voltage so it at the at the first

1207  
00:49:14,549 --> 00:49:10,960  
moment when you switch the circuit

1208  
00:49:19,349 --> 00:49:14,559  
the electron comes and charging through

1209  
00:49:23,829 --> 00:49:19,359  
the diode d1 the capacitor c1

1210  
00:49:30,069 --> 00:49:26,870  
what what really happens is um it the

1211  
00:49:31,829 --> 00:49:30,079  
battery charges the graphing capacitor

1212  
00:49:34,069 --> 00:49:31,839  
up to the voltage and it's a small

1213  
00:49:36,309 --> 00:49:34,079

capacitor so it takes almost no charge

1214

00:49:37,270 --> 00:49:36,319

to do that and then the voltage is zero

1215

00:49:41,030 --> 00:49:37,280

now

1216

00:49:43,589 --> 00:49:41,040

so almost nothing goes into c1

1217

00:49:46,230 --> 00:49:43,599

now as you rotate it there's an ac

1218

00:49:47,670 --> 00:49:46,240

current that's on top of this

1219

00:49:50,309 --> 00:49:47,680

voltage that's sitting there on the

1220

00:49:51,589 --> 00:49:50,319

graphene this is the ac current which is

1221

00:49:54,470 --> 00:49:51,599

charging it

1222

00:49:57,670 --> 00:49:54,480

okay so this capacitor

1223

00:49:59,990 --> 00:49:57,680

c0 is graphing is very small you mean

1224

00:50:02,470 --> 00:50:00,000

okay well yes yes exactly

1225

00:50:04,150 --> 00:50:02,480

okay okay let's wrap it good i'd like to

1226

00:50:07,190 --> 00:50:04,160

redirect back to

1227

00:50:10,309 --> 00:50:07,200

um germano germano are you still here

1228

00:50:12,470 --> 00:50:10,319

okay thank you yeah um yeah yeah so

1229

00:50:14,230 --> 00:50:12,480

germano i'd like to address another

1230

00:50:15,990 --> 00:50:14,240

question if i may just to redirect

1231

00:50:17,829 --> 00:50:16,000

things to this talk um have you

1232

00:50:19,349 --> 00:50:17,839

considered the situation when you have a

1233

00:50:21,430 --> 00:50:19,359

plasma present

1234

00:50:25,190 --> 00:50:21,440

um which can release space charge

1235

00:50:29,190 --> 00:50:26,470

well uh

1236

00:50:31,109 --> 00:50:29,200

actually no i didn't consider

1237

00:50:33,510 --> 00:50:31,119

the presence of plasma

1238

00:50:36,230 --> 00:50:33,520

okay in my design

1239

00:50:39,670 --> 00:50:36,240

uh you are uh alluding to the space

1240

00:50:41,349 --> 00:50:39,680

charge uh between the plates yeah

1241

00:50:43,109 --> 00:50:41,359

yeah

1242

00:50:45,270 --> 00:50:43,119

okay no i did i didn't take into account

1243

00:50:47,670 --> 00:50:45,280

this part but i i

1244

00:50:49,510 --> 00:50:47,680

i know that this should be probably

1245

00:50:52,309 --> 00:50:49,520

included in the in the numerical

1246

00:50:55,030 --> 00:50:52,319

simulation because the

1247

00:50:56,710 --> 00:50:55,040

the presence of the space space charge

1248

00:51:02,390 --> 00:50:56,720

um

1249

00:51:04,790 --> 00:51:02,400

of an open circuit dcc uh

1250

00:51:07,510 --> 00:51:04,800

but i have not included this the

1251

00:51:09,030 --> 00:51:07,520

presence of these charges

1252

00:51:11,670 --> 00:51:09,040

between the players in the in the

1253

00:51:13,109 --> 00:51:11,680

equation in the charging equation

1254

00:51:15,510 --> 00:51:13,119

okay

1255

00:51:16,470 --> 00:51:15,520

and um in terms of power densities do

1256

00:51:18,549 --> 00:51:16,480

you have

1257

00:51:20,069 --> 00:51:18,559

any any estimates or

1258

00:51:21,990 --> 00:51:20,079

feeling for what kind of power densities

1259

00:51:23,829 --> 00:51:22,000

you could achieve if you had small

1260

00:51:25,349 --> 00:51:23,839

enough devices the ones you're proposing

1261

00:51:27,670 --> 00:51:25,359

may be fairly large but if you can

1262

00:51:28,220 --> 00:51:27,680

miniaturize them

1263

00:51:29,670 --> 00:51:28,230

well

1264

00:51:31,910 --> 00:51:29,680

[Music]

1265

00:51:34,230 --> 00:51:31,920

let me share again my

1266

00:51:35,430 --> 00:51:34,240

my presentation because i want to show

1267

00:51:38,470 --> 00:51:35,440

you

1268

00:51:39,510 --> 00:51:38,480

well the the last graph

1269

00:51:41,109 --> 00:51:39,520

this one

1270

00:51:42,630 --> 00:51:41,119

is actually

1271

00:51:45,589 --> 00:51:42,640

the the

1272

00:51:47,990 --> 00:51:45,599

sort of specific or power

1273

00:51:50,710 --> 00:51:48,000

watts per square centimeter

1274

00:51:53,030 --> 00:51:50,720

that can be obtained with the

1275

00:51:56,069 --> 00:51:53,040

with the previous with design

1276  
00:51:59,030 --> 00:51:56,079  
that i have shown in my presentation and

1277  
00:52:00,710 --> 00:51:59,040  
also with the the equations

1278  
00:52:03,030 --> 00:52:00,720  
not taking into account

1279  
00:52:04,950 --> 00:52:03,040  
all the things we have just all the

1280  
00:52:05,829 --> 00:52:04,960  
suggestions

1281  
00:52:07,990 --> 00:52:05,839  
you

1282  
00:52:09,510 --> 00:52:08,000  
gave me but

1283  
00:52:12,950 --> 00:52:09,520  
i i

1284  
00:52:15,190 --> 00:52:12,960  
do not have much hope to have

1285  
00:52:17,990 --> 00:52:15,200  
power i power with many small devices

1286  
00:52:20,069 --> 00:52:18,000  
because as you may see the specific or

1287  
00:52:22,230 --> 00:52:20,079  
the power density of the

1288  
00:52:23,910 --> 00:52:22,240

for this specific design is of the order

1289

00:52:25,750 --> 00:52:23,920

10 to the minus

1290

00:52:27,829 --> 00:52:25,760

17 so

1291

00:52:30,950 --> 00:52:27,839

in order to have a microscopic

1292

00:52:34,150 --> 00:52:30,960

production power we we should need not a

1293

00:52:36,470 --> 00:52:34,160

huge tcc but

1294

00:52:37,990 --> 00:52:36,480

moderately small pcc

1295

00:52:39,190 --> 00:52:38,000

connected together

1296

00:52:41,510 --> 00:52:39,200

um

1297

00:52:42,390 --> 00:52:41,520

in series or

1298

00:52:45,190 --> 00:52:42,400

one

1299

00:52:52,230 --> 00:52:48,630

i think that this design cannot be

1300

00:52:54,230 --> 00:52:52,240

mean naturalized okay okay

1301

00:52:57,270 --> 00:52:54,240

right affordable country

1302

00:53:00,549 --> 00:52:57,280

okay well thank you um are there other

1303

00:53:06,309 --> 00:53:02,390

okay well we're coming to the end of the

1304

00:53:08,390 --> 00:53:06,319

the hour and i believe lunch uh is next

1305

00:53:10,230 --> 00:53:08,400

is that right uh gareth

1306

00:53:13,430 --> 00:53:10,240

okay so i think we'll have maybe a few

1307

00:53:15,910 --> 00:53:13,440

minute jump on on that but let's let's

1308

00:53:18,630 --> 00:53:15,920

uh thank uh dr dabramo again thank you

1309

00:53:20,549 --> 00:53:18,640

for uh for a stimulating talk thanks