



1
00:00:10,879 --> 00:00:05,920

[Music]

2
00:00:16,369 --> 00:00:10,889

okay my talk is about the physical basis

3
00:00:18,410 --> 00:00:16,379

for nonlocality and first of all we

4
00:00:23,689 --> 00:00:18,420

should make clear that nonlocality

5
00:00:27,820 --> 00:00:23,699

is non-local causality the background to

6
00:00:30,410 --> 00:00:27,830

this diagram here is a spacetime diagram

7
00:00:34,220 --> 00:00:30,420

showing the separation of Toole art

8
00:00:35,930 --> 00:00:34,230

light particles in space going in

9
00:00:42,590 --> 00:00:35,940

opposite directions from each other and

10
00:00:45,080 --> 00:00:42,600

moving forward in time local causality

11
00:00:49,430 --> 00:00:45,090

says that the cause of these two

12
00:00:53,720 --> 00:00:49,440

particles is at the common source which

13
00:00:55,310 --> 00:00:53,730

is right there at the center non-local

14

00:01:00,580 --> 00:00:55,320

causality says that the cause is

15

00:01:05,000 --> 00:01:00,590

elsewhere picture a baseball in flight

16

00:01:07,399 --> 00:01:05,010

to going to the op field is the

17

00:01:15,800 --> 00:01:07,409

trajectory of the baseball caused by the

18

00:01:21,080 --> 00:01:15,810

batter or by the glove that catches the

19

00:01:21,649 --> 00:01:21,090

fly ball food for thought here's what

20

00:01:26,390 --> 00:01:21,659

we'll do

21

00:01:29,630 --> 00:01:26,400

I'll give you a nutshell description of

22

00:01:32,630 --> 00:01:29,640

Bell's Theorem show you a conceptual

23

00:01:39,700 --> 00:01:32,640

entangled particles experiment involving

24

00:01:43,039 --> 00:01:39,710

two polarized photons which is based on

25

00:01:47,090 --> 00:01:43,049

original experiments done to test the

26
00:01:50,810 --> 00:01:47,100
Bell's Theorem concept by Friedman and

27
00:01:55,429 --> 00:01:50,820
Claus ER in Berkeley and famously by

28
00:01:57,920 --> 00:01:55,439
Alanis Bey in France will discuss the

29
00:02:00,380 --> 00:01:57,930
quantum probabilities for the

30
00:02:02,780 --> 00:02:00,390
measurement outcome and then we'll

31
00:02:06,230 --> 00:02:02,790
discuss the local causality constraints

32
00:02:08,900 --> 00:02:06,240
on those outcomes finally we'll talk

33
00:02:11,600 --> 00:02:08,910
about non-local causality and the

34
00:02:13,089 --> 00:02:11,610
implications for time reversal of cause

35
00:02:18,440 --> 00:02:13,099
and effect

36
00:02:34,790 --> 00:02:18,450
Bell's Theorem says that under certain

37
00:02:38,600 --> 00:02:36,740
well I'll just read predictions of

38
00:02:41,990 --> 00:02:38,610

measurement outcomes for certain

39

00:02:45,590 --> 00:02:42,000

entangled states are inconsistent with

40

00:02:48,890 --> 00:02:45,600

local causality Bell's Theorem was

41

00:02:52,610 --> 00:02:48,900

published nearly fifty years ago in the

42

00:02:55,370 --> 00:02:52,620

journal physics and it was the first

43

00:02:57,650 --> 00:02:55,380

issue of the journal and the journal

44

00:03:00,590 --> 00:02:57,660

interestingly enough folded after that

45

00:03:03,800 --> 00:03:00,600

first issue and for the next decade

46

00:03:07,280 --> 00:03:03,810

Bell's issue Bell sphere theorem was

47

00:03:10,300 --> 00:03:07,290

rather underwhelming the mathematical

48

00:03:14,330 --> 00:03:10,310

inequality was experimentally tested and

49

00:03:16,790 --> 00:03:14,340

it has consistently been found that

50

00:03:21,200 --> 00:03:16,800

quantum mechanics rules and local

51
00:03:25,430 --> 00:03:21,210
causality often fails present

52
00:03:27,980 --> 00:03:25,440
demonstration of bells inequality due to

53
00:03:33,080 --> 00:03:27,990
henry staff i will follow his analysis

54
00:03:35,120 --> 00:03:33,090
it was published in July of 1977 so this

55
00:03:38,840 --> 00:03:35,130
is all pretty old stuff here's the

56
00:03:42,560 --> 00:03:38,850
experimental setup we have a vibrating

57
00:03:44,690 --> 00:03:42,570
atom in a hot vapor in the middle it

58
00:03:47,060 --> 00:03:44,700
emits two photons going in opposite

59
00:03:51,620 --> 00:03:47,070
directions they are both polarized in

60
00:03:53,780 --> 00:03:51,630
the same plane one up and one down the

61
00:03:58,220 --> 00:03:53,790
direction of polarization is a

62
00:04:01,370 --> 00:03:58,230
superposition of all directions until a

63
00:04:05,110 --> 00:04:01,380

measurement is made and then there is

64

00:04:10,280 --> 00:04:05,120

just one direction of polarization the

65

00:04:12,530 --> 00:04:10,290

polarizer angles the polarizer axes are

66

00:04:15,380 --> 00:04:12,540

at an angle of θ with each other and

67

00:04:20,860 --> 00:04:15,390

we will be referring to θ during the

68

00:04:24,940 --> 00:04:20,870

discussion of the analysis the photons

69

00:04:28,520 --> 00:04:24,950

incident on the polarisers are either

70

00:04:31,760 --> 00:04:28,530

transmitted or absorbed if they are

71

00:04:35,000 --> 00:04:31,770

transmitted a single polarization state

72

00:04:39,890 --> 00:04:35,010

comes out and is detected by the

73

00:04:42,320 --> 00:04:39,900

detector well I've got rocks in my head

74

00:04:44,750 --> 00:04:42,330

for sure that's the success what's going

75

00:04:46,340 --> 00:04:44,760

on this morning either that I don't

76
00:04:48,770 --> 00:04:46,350
understand Bell's Theorem but I believe

77
00:04:53,450 --> 00:04:48,780
I do understand Bell's Theorem

78
00:04:56,570 --> 00:04:53,460
and I am not bothered by the time

79
00:05:00,380 --> 00:04:56,580
reversal of cause and effect which is

80
00:05:03,230 --> 00:05:00,390
where Bell's Theorem leads me that first

81
00:05:07,190 --> 00:05:03,240
statement I got out of physics today

82
00:05:09,940 --> 00:05:07,200
magazine a number of years ago the

83
00:05:13,310 --> 00:05:09,950
second statement is more famously

84
00:05:14,990 --> 00:05:13,320
attributed to Albert Einstein is the

85
00:05:18,980 --> 00:05:15,000
moon only there when I'm looking at it

86
00:05:23,860 --> 00:05:18,990
was his rebellion against the idea that

87
00:05:27,050 --> 00:05:23,870
the active formation of a state can be

88
00:05:33,740 --> 00:05:27,060

affected by a passive a passive

89

00:05:36,740 --> 00:05:33,750

observation of that state these symbols

90

00:05:39,350 --> 00:05:36,750

are the symbols that we were you will

91

00:05:43,220 --> 00:05:39,360

use to demonstrate the four outcomes

92

00:05:46,070 --> 00:05:43,230

four possible outcomes of photon

93

00:05:48,620 --> 00:05:46,080

incidents on the polarisers the two

94

00:05:54,290 --> 00:05:48,630

circles represent the front and rear

95

00:05:56,360 --> 00:05:54,300

polarisers the the blank or white open

96

00:06:00,260 --> 00:05:56,370

circle represents the transmission of a

97

00:06:05,780 --> 00:06:00,270

photon the shaded circle represents the

98

00:06:08,540 --> 00:06:05,790

absorption of a photon the upper-left

99

00:06:11,960 --> 00:06:08,550

corner is a coincidence measurement in

100

00:06:16,160 --> 00:06:11,970

which both photons are transmitted the

101
00:06:18,980 --> 00:06:16,170
lower right corner is a null measurement

102
00:06:24,170 --> 00:06:18,990
where both photons are absorbed the

103
00:06:27,110 --> 00:06:24,180
other two are mixed measurements these

104
00:06:32,200 --> 00:06:27,120
are the symbols that we will use to show

105
00:06:35,000 --> 00:06:32,210
the orientation of the polarizer x' the

106
00:06:38,840 --> 00:06:35,010
arrows will show schematically what the

107
00:06:43,420 --> 00:06:38,850
orientations are the angle θ is

108
00:06:47,360 --> 00:06:43,430
shown off to the left numerically if the

109
00:06:48,860 --> 00:06:47,370
circles are shaded green the results are

110
00:06:52,220 --> 00:06:48,870
due to quantum mechanics

111
00:06:55,670 --> 00:06:52,230
if the circles circles are shaded pink

112
00:06:59,750 --> 00:06:55,680
look almost purple here it's due to

113
00:07:01,640 --> 00:06:59,760

local causality here are the results for

114

00:07:05,240 --> 00:07:01,650

quantum mechanical measurement

115

00:07:09,469 --> 00:07:05,250

abilities the four large boxes are

116

00:07:13,659 --> 00:07:09,479

associated with the four polarizer angle

117

00:07:17,240 --> 00:07:13,669

settings these are chosen to display an

118

00:07:22,100 --> 00:07:17,250

inconsistency between quantum mechanics

119

00:07:25,159 --> 00:07:22,110

and local causality the four small boxes

120

00:07:27,529 --> 00:07:25,169

represent the four outcomes of a two

121

00:07:34,090 --> 00:07:27,539

photon incidence measurement that we

122

00:07:41,029 --> 00:07:34,100

discussed before by way of an example

123

00:07:44,360 --> 00:07:41,039

the upper right the two 50% are obtained

124

00:07:48,200 --> 00:07:44,370

when you have the polarisers aligned and

125

00:07:50,540 --> 00:07:48,210

you expect the photons which are both

126
00:07:54,680 --> 00:07:50,550
polarized in the same state to either be

127
00:07:59,150 --> 00:07:54,690
both transmitted or both rejected both

128
00:08:03,409 --> 00:07:59,160
absorb with equal probability well

129
00:08:06,589 --> 00:08:03,419
here's how we demonstrate the effects of

130
00:08:09,800 --> 00:08:06,599
local causality I won't go through this

131
00:08:12,680 --> 00:08:09,810
in great detail but what we do is we

132
00:08:16,430 --> 00:08:12,690
change the polarizer angles one at a

133
00:08:20,300 --> 00:08:16,440
time and as we change the polarizer

134
00:08:24,320 --> 00:08:20,310
angles we look at the effects the

135
00:08:27,439 --> 00:08:24,330
changes in the events from coincidence

136
00:08:30,290 --> 00:08:27,449
measurements to mixed measurements down

137
00:08:32,510 --> 00:08:30,300
to null measurements we fall we do this

138
00:08:42,920 --> 00:08:32,520

in two ways we follow the red arrows and

139

00:08:45,920 --> 00:08:42,930

the blue arrows now when we when we

140

00:08:49,880 --> 00:08:45,930

change a polarizer angle we assume that

141

00:08:52,780 --> 00:08:49,890

the very same exact set of photons is

142

00:08:57,079 --> 00:08:52,790

still incident on the two polarizers

143

00:09:00,740 --> 00:08:57,089

so the photons due to local causality

144

00:09:03,650 --> 00:09:00,750

the photons are like real objects when

145

00:09:05,920 --> 00:09:03,660

they strike the untrained polarizer they

146

00:09:08,600 --> 00:09:05,930

will transmit exactly as they did before

147

00:09:10,940 --> 00:09:08,610

when they strike the polarizer that has

148

00:09:13,069 --> 00:09:10,950

been changed they will be partially

149

00:09:14,800 --> 00:09:13,079

blocked because of the misalignment of

150

00:09:18,519 --> 00:09:14,810

the polarizer

151

00:09:21,640 --> 00:09:18,529

we follow the red arrows around the

152

00:09:26,290 --> 00:09:21,650

logic will tell us that if we assume

153

00:09:28,510 --> 00:09:26,300

that quantum mechanics is obeyed and the

154

00:09:32,560 --> 00:09:28,520

result is compatible with quantum

155

00:09:37,990 --> 00:09:32,570

mechanics that the fraction of events

156

00:09:40,600 --> 00:09:38,000

changed from coincidence in the upper

157

00:09:44,110 --> 00:09:40,610

left to no events in the lower right

158

00:09:47,320 --> 00:09:44,120

that fraction must be less than 25% if

159

00:09:51,329 --> 00:09:47,330

we follow the blue arrows around the

160

00:09:54,640 --> 00:09:51,339

logic tells us that that fraction F is

161

00:09:57,040 --> 00:09:54,650

constrained by the difference in n_1 and

162

00:10:02,440 --> 00:09:57,050

n_2 which are the two new probabilities

163

00:10:06,060 --> 00:10:02,450

due to local causality here are the

164

00:10:08,380 --> 00:10:06,070

results for quantum mechanics on the top

165

00:10:12,460 --> 00:10:08,390

showing the bottom two polarizer

166

00:10:15,730 --> 00:10:12,470

settings for quantum mechanics and for

167

00:10:18,610 --> 00:10:15,740

local causality the local causality

168

00:10:21,250 --> 00:10:18,620

numbers less than 38 percent and so

169

00:10:23,020 --> 00:10:21,260

forth are derived out to break Li from

170

00:10:24,670 --> 00:10:23,030

the constraints the inequality

171

00:10:29,980 --> 00:10:24,680

constraint that I showed you on the last

172

00:10:34,920 --> 00:10:29,990

side slide and you can see that the the

173

00:10:39,160 --> 00:10:34,930

quantum mechanical numbers such as 42%

174

00:10:42,820 --> 00:10:39,170

42.7% for the coincidence measurements

175

00:10:47,650 --> 00:10:42,830

do not fit within the upper boundary for

176

00:10:50,579 --> 00:10:47,660

the for the local causality constraints

177

00:10:54,090 --> 00:10:50,589

so this shows that you that for a

178

00:10:57,090 --> 00:10:54,100

particular set of polarizer settings

179

00:11:00,790 --> 00:10:57,100

quantum mechanics is incompatible with

180

00:11:06,070 --> 00:11:00,800

local causality so what does this mean

181

00:11:08,710 --> 00:11:06,080

as far as causality is concerned if the

182

00:11:12,160 --> 00:11:08,720

cause is not at the source where is it

183

00:11:15,790 --> 00:11:12,170

is it with the observe ation is it at

184

00:11:19,600 --> 00:11:15,800

the detector one hypothesis the common

185

00:11:23,320 --> 00:11:19,610

explanation for this is that the two two

186

00:11:25,480 --> 00:11:23,330

for two photons are form a single

187

00:11:30,170 --> 00:11:25,490

quantum system a superposition of states

188

00:11:36,690 --> 00:11:33,840

the system immediately falls into a

189

00:11:39,840 --> 00:11:36,700

sting single state and that appears at

190

00:11:42,829 --> 00:11:39,850

both detector 1 and detector 2 instantly

191

00:11:46,079 --> 00:11:42,839

this doesn't explain to us very well

192

00:11:52,230 --> 00:11:46,089

what really happens in terms of space

193

00:11:54,360 --> 00:11:52,240

and time one explanation is that the

194

00:11:56,370 --> 00:11:54,370

source and the two detectors could be

195

00:12:01,490 --> 00:11:56,380

connected in some way in an interaction

196

00:12:06,870 --> 00:12:01,500

and that that detection could cause the

197

00:12:09,870 --> 00:12:06,880

that yeah that detection could cause the

198

00:12:16,440 --> 00:12:09,880

photons to be transmitted in the proper

199

00:12:18,680 --> 00:12:16,450

form too to obey quantum mechanics this

200

00:12:21,480 --> 00:12:18,690

would result in a superluminal

201
00:12:23,400 --> 00:12:21,490
transmission of information from

202
00:12:26,210 --> 00:12:23,410
detector 1 to detector 2 through the

203
00:12:29,870 --> 00:12:26,220
source faster than the speed of light

204
00:12:32,610 --> 00:12:29,880
the thing at the top is a palindrome

205
00:12:35,550 --> 00:12:32,620
which reads the same for word as it does

206
00:12:39,120 --> 00:12:35,560
backwards and here I'm proposing that we

207
00:12:41,280 --> 00:12:39,130
have another hypothesis was a time

208
00:12:44,340 --> 00:12:41,290
reversal of cause and effect

209
00:12:49,970 --> 00:12:44,350
we have detector one has a causal event

210
00:12:52,380 --> 00:12:49,980
which causes the appearance of a single

211
00:12:55,350 --> 00:12:52,390
polarization state which then wrote

212
00:12:57,660 --> 00:12:55,360
retro causally will propagate back to

213
00:13:00,449 --> 00:12:57,670

the source and cause that same

214

00:13:03,710 --> 00:13:00,459

polarization state to appear at the

215

00:13:07,050 --> 00:13:03,720

source which then comes forward to

216

00:13:10,680 --> 00:13:07,060

detector 2 this is time reversal of

217

00:13:13,980 --> 00:13:10,690

cause and effect and physicists go wild

218

00:13:17,329 --> 00:13:13,990

over this they just cannot encompass

219

00:13:20,689 --> 00:13:17,339

that however I like this because

220

00:13:26,730 --> 00:13:20,699

everything stays within the light cone

221

00:13:29,670 --> 00:13:26,740

everything is contiguous and it is

222

00:13:31,769 --> 00:13:29,680

relativistically invariant and this

223

00:13:34,050 --> 00:13:31,779

contrast was something that Pamela said

224

00:13:39,720 --> 00:13:34,060

earlier this morning that it doesn't

225

00:13:40,940 --> 00:13:39,730

satisfy relativity this scheme does the

226

00:13:48,570 --> 00:13:40,950

relativistic

227

00:13:54,210 --> 00:13:48,580

transformations will retain the same the

228

00:13:56,850 --> 00:13:54,220

same state finally you have to act ask

229

00:14:01,620 --> 00:13:56,860

which detector is causal and which is

230

00:14:04,410 --> 00:14:01,630

affected and I my hypothesis is that the

231

00:14:11,580 --> 00:14:04,420

both detectors participate in causality

232

00:14:13,560 --> 00:14:11,590

and if you have an emergence of a of a

233

00:14:16,920 --> 00:14:13,570

strong effect at either of the two

234

00:14:21,560 --> 00:14:16,930

detectors this thing can emerge on the

235

00:14:26,580 --> 00:14:21,570

macroscopic level and would cause a

236

00:14:30,150 --> 00:14:26,590

paranormal effect to occur so I submit

237

00:14:37,830 --> 00:14:30,160

that this is this is a source of

238

00:14:39,650 --> 00:14:37,840

paranormal effects I also submit that my

239

00:14:42,530 --> 00:14:39,660

time is up

240

00:14:44,930 --> 00:14:42,540

and I quit okay I'm open to questions

241

00:14:52,550 --> 00:14:44,940

and then we can go onto our non-local

242

00:14:55,280 --> 00:14:52,560

lunches if there are any questions I

243

00:14:57,950 --> 00:14:55,290

hope they're the right ones we do have a

244

00:15:00,260 --> 00:14:57,960

few minutes for questions even though

245

00:15:02,060 --> 00:15:00,270

our stomachs are growling yeah it must

246

00:15:09,350 --> 00:15:02,070

have been the reason I decided at 12

247

00:15:11,300 --> 00:15:09,360

o'clock we have to go eat okay well I

248

00:15:13,010 --> 00:15:11,310

thought that was very interesting data

249

00:15:14,270 --> 00:15:13,020

and I wondered if you had considered the

250

00:15:16,730 --> 00:15:14,280

possibility that there would be a

251
00:15:19,010 --> 00:15:16,740
quantum mechanical coupling or

252
00:15:21,550 --> 00:15:19,020
entanglement between the consciousness

253
00:15:25,510 --> 00:15:21,560
of the experimenter and the detectors

254
00:15:28,790 --> 00:15:25,520
something I didn't quite get to is that

255
00:15:31,190 --> 00:15:28,800
detector one may abet may be affected by

256
00:15:34,100 --> 00:15:31,200
what I call conscious observational

257
00:15:37,430 --> 00:15:34,110
causality and which others have called

258
00:15:40,640 --> 00:15:37,440
mental intention so that consciousness

259
00:15:43,250 --> 00:15:40,650
enters in at one or the other of the

260
00:15:45,230 --> 00:15:43,260
detectors one of the other sites causes

261
00:15:49,850 --> 00:15:45,240
a reversal of time and effect to

262
00:15:52,430 --> 00:15:49,860
propagate forward to the other site say

263
00:15:53,890 --> 00:15:52,440

detector to hope that answers that

264

00:15:56,540 --> 00:15:53,900

question

265

00:15:59,240 --> 00:15:56,550

if you read the many people that have

266

00:16:03,200 --> 00:15:59,250

commented on this whole argument you'll

267

00:16:05,270 --> 00:16:03,210

find a lot of people say that the bells

268

00:16:07,490 --> 00:16:05,280

inequality and ass pay experiments

269

00:16:10,400 --> 00:16:07,500

proved that Einsteins argument an EPR

270

00:16:13,040 --> 00:16:10,410

that quantum mechanics is incomplete was

271

00:16:17,330 --> 00:16:13,050

correct but you'll find just as many

272

00:16:20,030 --> 00:16:17,340

physicists say it's incorrect is quantum

273

00:16:23,150 --> 00:16:20,040

mechanics complete or not in your

274

00:16:27,710 --> 00:16:23,160

opinion no I don't believe it is

275

00:16:30,410 --> 00:16:27,720

complete because we do not have at this

276

00:16:33,110 --> 00:16:30,420

point an explanation for the randomness

277

00:16:35,270 --> 00:16:33,120

of cause of causality that occurs in

278

00:16:38,200 --> 00:16:35,280

quantum mechanics I believe that that

279

00:16:41,960 --> 00:16:38,210

randomness is connected with the

280

00:16:45,110 --> 00:16:41,970

conscious underworld so to speak the

281

00:16:47,450 --> 00:16:45,120

collective unconscious and and the

282

00:16:53,180 --> 00:16:47,460

consciousness that pervades our whole

283

00:16:56,120 --> 00:16:53,190

being so the simple answer is that it is

284

00:16:58,490 --> 00:16:56,130

complete but we need to branch off in

285

00:17:02,540 --> 00:16:58,500

another direction to find an alternate

286

00:17:05,929 --> 00:17:02,550

theory so for people googling all this

287

00:17:09,520 --> 00:17:05,939

there's Feynman wheeler to look up and

288

00:17:12,140 --> 00:17:09,530

Cramer transactional and I wonder if

289

00:17:15,520 --> 00:17:12,150

this you're just applying that to

290

00:17:19,819 --> 00:17:15,530

paranormal or is this a separate thing

291

00:17:24,260 --> 00:17:19,829

the Fineman wheeler work as I know it

292

00:17:28,210 --> 00:17:24,270

did involve a an advanced wave and a

293

00:17:31,460 --> 00:17:28,220

wave involving an

294

00:17:35,050 --> 00:17:31,470

electromagnetic interaction the advanced

295

00:17:38,690 --> 00:17:35,060

wave being the time reversed portion of

296

00:17:41,720 --> 00:17:38,700

cause-and-effect Fineman himself was

297

00:17:49,550 --> 00:17:41,730

unhappy with the outcome of that and he

298

00:17:52,100 --> 00:17:49,560

went on to to renormalization I believe

299

00:17:56,240 --> 00:17:52,110

as an alternative answer but I believe

300

00:17:58,640 --> 00:17:56,250

that the Fineman work on on the

301
00:18:01,910 --> 00:17:58,650
advancement on the advanced wave was

302
00:18:08,840 --> 00:18:01,920
valid and parallels what I've described

303
00:18:11,210 --> 00:18:08,850
here is that okay hi thanks for a good

304
00:18:13,670 --> 00:18:11,220
presentation I wonder if you're aware of

305
00:18:15,770 --> 00:18:13,680
the joy Kristen's paper from Oxford last

306
00:18:18,050 --> 00:18:15,780
year on upper bounds on quantum

307
00:18:18,770 --> 00:18:18,060
correlations and if you have any

308
00:18:20,750 --> 00:18:18,780
thoughts on that

309
00:18:25,820 --> 00:18:20,760
especially on what are the upper bounds

310
00:18:28,070 --> 00:18:25,830
for quantum correlations no I'm not

311
00:18:29,510 --> 00:18:28,080
familiar with that unless you lead me a

312
00:18:32,510 --> 00:18:29,520
little further I don't think I can

313
00:18:38,120 --> 00:18:32,520

comment on it if we're short on time

314

00:18:40,480 --> 00:18:38,130

maybe we should discuss it thank you