

1

00:00:00,000 --> 00:00:03,250  
(bright ambient music)

2

00:00:08,910 --> 00:00:10,470  
- Hello, everyone and welcome back

3

00:00:10,470 --> 00:00:12,540  
to "Conversations at the Perimeter."

4

00:00:12,540 --> 00:00:14,730  
On this episode, Lauren  
and I had the pleasure

5

00:00:14,730 --> 00:00:16,470  
of chatting with Shohini Ghose.

6

00:00:16,470 --> 00:00:18,660  
She's a professor in quantum science

7

00:00:18,660 --> 00:00:21,600  
at Wilfrid Laurier University  
right here in Waterloo,

8

00:00:21,600 --> 00:00:22,890  
and she's also the founder

9

00:00:22,890 --> 00:00:25,860  
of the Laurier Centre  
for Women in Science.

10

00:00:25,860 --> 00:00:27,960  
She takes Lauren and I on a little journey

11

00:00:27,960 --> 00:00:29,790  
through the world of quantum mechanics

12

00:00:29,790 --> 00:00:33,172  
and quantum information through

concepts like entanglement

13

00:00:33,172 --> 00:00:35,910  
and superposition, and her favorite,

14

00:00:35,910 --> 00:00:38,003  
quantum phenomenon uncertainty.

15

00:00:38,003 --> 00:00:41,220  
– Shohini also tells us a lot  
about the concept of identity,

16

00:00:41,220 --> 00:00:43,170  
both in science and society,

17

00:00:43,170 --> 00:00:45,510  
and what I really love  
about Shohini's work

18

00:00:45,510 --> 00:00:48,060  
is that a lot of her  
insights are fundamentally

19

00:00:48,060 --> 00:00:50,220  
at the intersection of quantum science

20

00:00:50,220 --> 00:00:52,500  
and inclusion and diversity work.

21

00:00:52,500 --> 00:00:55,680  
She also tells us about a book  
that she has coming out soon

22

00:00:55,680 --> 00:00:57,120  
that I can't wait to read.

23

00:00:57,120 --> 00:00:59,010  
– We've been looking forward  
to chatting with Shohini

24

00:00:59,010 --> 00:01:01,410  
for quite a while now, and  
it does not disappoint.

25

00:01:01,410 --> 00:01:03,180  
It was a very inspiring conversation.

26

00:01:03,180 --> 00:01:04,860  
So, without any further ado,

27

00:01:04,860 --> 00:01:06,873  
let's jump in and hear from Shohini.

28

00:01:09,630 --> 00:01:10,463  
- Hi, Shohini.

29

00:01:10,463 --> 00:01:11,970  
Thank you so much for joining us

30

00:01:11,970 --> 00:01:13,950  
for "Conversations at the Perimeter."

31

00:01:13,950 --> 00:01:15,360  
- Thanks for having me.

32

00:01:15,360 --> 00:01:17,340  
- Before I even ask you any questions,

33

00:01:17,340 --> 00:01:19,620  
I just feel like I have to  
tell you that I've just been

34

00:01:19,620 --> 00:01:22,290  
such a huge admirer of your  
work for so many years,

35

00:01:22,290 --> 00:01:25,050

and ever since we started  
talking about this show,

36

00:01:25,050 --> 00:01:26,970  
you've been right at the  
top of the list of people

37

00:01:26,970 --> 00:01:27,960  
I wanted to talk to,

38

00:01:27,960 --> 00:01:30,284  
so I just wanted to tell  
you that I've been excited

39

00:01:30,284 --> 00:01:33,060  
about this conversation ever  
since I heard you were coming.

40

00:01:33,060 --> 00:01:34,380  
- Thanks so much, you're very kind.

41

00:01:34,380 --> 00:01:36,120  
- I'm gonna add ditto to that,

42

00:01:36,120 --> 00:01:38,340  
because I remember we first met years ago,

43

00:01:38,340 --> 00:01:40,770  
but I remember seeing your  
TED Talk for the first time

44

00:01:40,770 --> 00:01:42,750  
and now I realize that  
5 million other people

45

00:01:42,750 --> 00:01:44,760  
have seen it as well, which  
is, yeah, it's pretty,

46

00:01:44,760 --> 00:01:46,200  
there's a big community of us out there

47  
00:01:46,200 --> 00:01:47,970  
who are fans of your work.

48  
00:01:47,970 --> 00:01:49,890  
- Thank you so much,  
and I'm a big fan of PI,

49  
00:01:49,890 --> 00:01:50,723  
so this is great.

50  
00:01:50,723 --> 00:01:53,100  
We're a mutual appreciation society.

51  
00:01:53,100 --> 00:01:54,690  
- We're all excited today.

52  
00:01:54,690 --> 00:01:55,523  
- Yes.

53  
00:01:55,523 --> 00:01:57,870  
- So to start, I thought  
maybe you can just tell us

54  
00:01:57,870 --> 00:02:00,690  
about the types of problems  
that you're most interested

55  
00:02:00,690 --> 00:02:02,970  
in studying in your work.

56  
00:02:02,970 --> 00:02:05,185  
- I have a broad range of  
interests, I would say,

57  
00:02:05,185 --> 00:02:08,580  
but I guess the thing that

perhaps ties it all together

58

00:02:08,580 --> 00:02:10,320  
is I'm a big fan of uncertainty.

59

00:02:10,320 --> 00:02:12,150  
I'm more interested in what we don't know

60

00:02:12,150 --> 00:02:13,680  
than what we do know, which in a way,

61

00:02:13,680 --> 00:02:15,870  
it's kind of like being  
right at that boundary

62

00:02:15,870 --> 00:02:17,820  
of what we call research, which is all,

63

00:02:17,820 --> 00:02:19,890  
if you think about it, no  
matter what area you're in,

64

00:02:19,890 --> 00:02:21,682  
it's about pushing that boundary.

65

00:02:21,682 --> 00:02:26,172  
So, within that very broad  
umbrella of what do we not know

66

00:02:26,172 --> 00:02:28,860  
is a lot of stuff, in fact  
most things we don't know,

67

00:02:28,860 --> 00:02:32,580  
I think, and in physics,  
that obviously leads it

68

00:02:32,580 --> 00:02:35,550  
naturally into quantum

for me, where of course,

69

00:02:35,550 --> 00:02:37,860  
not knowing has a entirely  
different meaning,

70

00:02:37,860 --> 00:02:39,960  
where the idea of uncertainty

71

00:02:39,960 --> 00:02:42,240  
is baked into the theory itself,

72

00:02:42,240 --> 00:02:44,250  
so that took me to a whole new level

73

00:02:44,250 --> 00:02:48,030  
when I started out exploring  
this idea of uncertainty

74

00:02:48,030 --> 00:02:50,460  
and not knowing and knowledge in general

75

00:02:50,460 --> 00:02:52,350  
and how we describe the universe,

76

00:02:52,350 --> 00:02:54,750  
but that, of course,  
also extends to questions

77

00:02:54,750 --> 00:02:57,480  
of uncertainty about  
who we are and questions

78

00:02:57,480 --> 00:03:00,210  
around identity and society  
and all of that is, of course,

79

00:03:00,210 --> 00:03:01,920  
very, very much intermingled.

80

00:03:01,920 --> 00:03:03,660

All of those areas actually interest me,

81

00:03:03,660 --> 00:03:08,191

and that's what I focus on in various research projects now.

82

00:03:08,191 --> 00:03:09,750

- Thinking of uncertainty,

83

00:03:09,750 --> 00:03:11,310

I think when you first hear that word,

84

00:03:11,310 --> 00:03:13,620

you can think of it as maybe a weakness,

85

00:03:13,620 --> 00:03:15,720

but are there ways that we can frame this

86

00:03:15,720 --> 00:03:16,975

as actually a strength?

87

00:03:16,975 --> 00:03:18,900

- Absolutely, so this has been,

88

00:03:18,900 --> 00:03:21,120

I think for me, also a personal evolution

89

00:03:21,120 --> 00:03:24,450

where being uncertain sometimes is absolutely worrying.

90

00:03:24,450 --> 00:03:25,410

There's no doubt.

91

00:03:25,410 --> 00:03:27,660

It would be nice if we



could predict our lives

92

00:03:27,660 --> 00:03:30,150  
and our careers, for example,  
and things like this.

93

00:03:30,150 --> 00:03:31,680  
We can't actually predict any of it,

94

00:03:31,680 --> 00:03:33,420  
and that's not necessarily a bad thing.

95

00:03:33,420 --> 00:03:36,780  
So for me, I guess quantum  
has really taught me deeply

96

00:03:36,780 --> 00:03:38,823  
that there is power to uncertainty,

97

00:03:38,823 --> 00:03:41,280  
that the universe itself is telling us,

98

00:03:41,280 --> 00:03:44,850  
stop with all of this  
precision measurements

99

00:03:44,850 --> 00:03:47,746  
and stop with trying to know it all.

100

00:03:47,746 --> 00:03:51,150  
The universe is saying, yeah,  
let's not be know-it-alls,

101

00:03:51,150 --> 00:03:52,800  
and that's not a bad thing in the sense

102

00:03:52,800 --> 00:03:55,920  
that we now of course  
have started harnessing

103

00:03:55,920 --> 00:03:57,780

quantum uncertainty and all of these weird

104

00:03:57,780 --> 00:04:00,660

quantum properties that we largely ignored

105

00:04:00,660 --> 00:04:02,460

since the beginning of the theory,

106

00:04:02,460 --> 00:04:05,100

which was developed

over a century ago now,

107

00:04:05,100 --> 00:04:08,430

but only recently have we

really started exploring

108

00:04:08,430 --> 00:04:11,250

and digging deeply into

the stranger properties

109

00:04:11,250 --> 00:04:12,930

of superposition, entanglement,

110

00:04:12,930 --> 00:04:15,930

all of which have quantum

uncertainty underlying them,

111

00:04:15,930 --> 00:04:17,760

and realizing that these are knobs

112

00:04:17,760 --> 00:04:20,181

and they are powerful

tools that we can use

113

00:04:20,181 --> 00:04:24,120

to not only do information processing,

114

00:04:24,120 --> 00:04:26,160  
which is of course a field  
of quantum computing,

115

00:04:26,160 --> 00:04:30,042  
but also to dig deeper into  
what the universe really is,

116

00:04:30,042 --> 00:04:32,538  
what exists, what doesn't.

117

00:04:32,538 --> 00:04:33,510  
That to me is really, it blows  
my mind to think about that

118

00:04:35,910 --> 00:04:38,430  
we actually have tools to  
even ask those questions,

119

00:04:38,430 --> 00:04:39,630  
let alone answer them.

120

00:04:39,630 --> 00:04:42,060  
- For someone who loves  
uncertainty, it seems like quantum

121

00:04:42,060 --> 00:04:44,057  
is the perfect field for you to be in.

122

00:04:44,057 --> 00:04:45,750  
- Right?  
- In your TED Talk,

123

00:04:45,750 --> 00:04:47,490  
you said something that  
made the audience laugh.

124

00:04:47,490 --> 00:04:50,010  
You said if you are confused by quantum,

125

00:04:50,010 --> 00:04:51,780  
don't worry, you're getting it.

126

00:04:51,780 --> 00:04:53,040  
Can you elaborate on what you meant

127

00:04:53,040 --> 00:04:54,870  
by don't worry about the weirdness

128

00:04:54,870 --> 00:04:57,000  
because it's sort of  
inherent to this field?

129

00:04:57,000 --> 00:04:57,833  
- Absolutely.

130

00:04:57,833 --> 00:04:59,970  
So I actually wanted to  
flip the script a little,

131

00:04:59,970 --> 00:05:02,760  
because I think there's, of  
course other much more famous,

132

00:05:02,760 --> 00:05:04,800  
smarter people have said  
that and pointed out

133

00:05:04,800 --> 00:05:07,080  
that you shouldn't be  
avoiding quantum uncertainty.

134

00:05:07,080 --> 00:05:09,270  
If you're confused by  
quantum, join the club,

135

00:05:09,270 --> 00:05:11,967  
but more in a, oh, we're

stuck with it kind of way,

136

00:05:11,967 --> 00:05:15,720  
just shut up and calculate  
approach, but for me,

137

00:05:15,720 --> 00:05:18,390  
I wanted to flip it and  
say, no, that's exciting.

138

00:05:18,390 --> 00:05:21,930  
It's exciting to know  
that we cannot ignore

139

00:05:21,930 --> 00:05:24,441  
all of this fluid universe that we live in

140

00:05:24,441 --> 00:05:26,640  
and perhaps we should embrace it,

141

00:05:26,640 --> 00:05:28,560  
so that's where I was going with that.

142

00:05:28,560 --> 00:05:31,680  
- You also use terms like  
entanglement and superposition,

143

00:05:31,680 --> 00:05:34,440  
which are those terms  
are, I think, at the heart

144

00:05:34,440 --> 00:05:37,620  
of what a lot of people find  
so vexing about quantum theory.

145

00:05:37,620 --> 00:05:40,770  
Can you help us get a  
grasp on those ideas?

146

00:05:40,770 --> 00:05:42,690  
- Probably not, because  
of course if you do,

147  
00:05:42,690 --> 00:05:43,923  
then you're not getting it.

148  
00:05:43,923 --> 00:05:45,150  
Only when you're confused.

149  
00:05:45,150 --> 00:05:46,090  
- Help me lose my grasp on them.

150  
00:05:46,090 --> 00:05:48,480  
- Okay, I'll do my best.

151  
00:05:48,480 --> 00:05:49,313  
That I can do.

152  
00:05:50,340 --> 00:05:52,410  
- So the theory is essentially

153  
00:05:52,410 --> 00:05:53,910  
what we call a probabilistic theory,

154  
00:05:53,910 --> 00:05:57,390  
meaning the fundamental description  
of any quantum particle,

155  
00:05:57,390 --> 00:05:59,580  
whether it's electrons or photons

156  
00:05:59,580 --> 00:06:02,820  
or any of these particles  
that we don't even see,

157  
00:06:02,820 --> 00:06:07,820  
is that we cannot actually  
know every quantity precisely,

158  
00:06:08,340 --> 00:06:10,260  
so if we wanted to know where it's going,

159  
00:06:10,260 --> 00:06:14,310  
then we don't know where  
it's located or vice versa.

160  
00:06:14,310 --> 00:06:16,860  
There's this sort of  
balancing act all the time,

161  
00:06:16,860 --> 00:06:18,990  
and it doesn't matter how  
well we try to measure,

162  
00:06:18,990 --> 00:06:20,010  
we just can't.

163  
00:06:20,010 --> 00:06:23,070  
That's really what it means to  
be fundamentally unknowable.

164  
00:06:23,070 --> 00:06:24,990  
All we can do is talk about the likelihood

165  
00:06:24,990 --> 00:06:27,210  
of all of these different properties.

166  
00:06:27,210 --> 00:06:29,010  
- And that's only the  
case in the quantum realm.

167  
00:06:29,010 --> 00:06:32,310  
That's not the case in our  
sort of day-to-day existence?

168  
00:06:32,310 --> 00:06:34,830  
- That's a great question

because ultimately,

169

00:06:34,830 --> 00:06:36,450  
we are made up of quantum particles,

170

00:06:36,450 --> 00:06:38,070  
electrons and atoms and so on,

171

00:06:38,070 --> 00:06:41,850  
so we're up the chain, and  
at some point seems like

172

00:06:41,850 --> 00:06:44,427  
we do seem to know more  
precisely where we are

173

00:06:44,427 --> 00:06:46,636  
and what we're doing, to some extent.

174

00:06:46,636 --> 00:06:50,520  
I mean, we even make GPS  
instruments to tell us these things

175

00:06:50,520 --> 00:06:52,380  
and our phones tell us even these days,

176

00:06:52,380 --> 00:06:55,200  
so the fundamental question is why is it

177

00:06:55,200 --> 00:06:57,960  
that at the quantum level,  
that idea of uncertainty

178

00:06:57,960 --> 00:06:59,220  
plays a much bigger role?

179

00:06:59,220 --> 00:07:01,950  
It's not that we don't have  
uncertainty at our scale,



180

00:07:01,950 --> 00:07:04,650  
it's just the scale is  
different, so at our macro scale,

181

00:07:04,650 --> 00:07:07,800  
somehow quantum uncertainty  
doesn't seem to play a role,

182

00:07:07,800 --> 00:07:10,618  
and there are many other  
processes that actually

183

00:07:10,618 --> 00:07:13,523  
sort of wash out and  
wipe out quantum features

184

00:07:13,523 --> 00:07:16,236  
such as entanglement  
and other cool things,

185

00:07:16,236 --> 00:07:17,506  
and at the quantum level,

186

00:07:17,506 --> 00:07:19,980  
if we have just these isolated particles

187

00:07:19,980 --> 00:07:21,930  
that are not talking to  
the rest of the universe

188

00:07:21,930 --> 00:07:24,210  
and we can sort of observe  
them and play with them,

189

00:07:24,210 --> 00:07:25,860  
then we start seeing that these effects

190

00:07:25,860 --> 00:07:28,906

are big on that scale, so  
that's really what's happening.

191

00:07:28,906 --> 00:07:31,650  
- You've mentioned quantum  
entanglement a couple of times,

192

00:07:31,650 --> 00:07:34,290  
and I was thinking a  
little bit about your work

193

00:07:34,290 --> 00:07:35,280  
before this conversation.

194

00:07:35,280 --> 00:07:37,650  
I work in quantum matter,  
and I think the goal

195

00:07:37,650 --> 00:07:38,970  
of explaining quantum entanglement

196

00:07:38,970 --> 00:07:41,070  
is something we have in  
common, and I have to say,

197

00:07:41,070 --> 00:07:43,410  
I always have a really  
hard time explaining it

198

00:07:43,410 --> 00:07:45,360  
to someone outside of the field.

199

00:07:45,360 --> 00:07:47,876  
Do you have a good way of explaining it

200

00:07:47,876 --> 00:07:50,460  
to someone that's new to the concept?

201

00:07:50,460 --> 00:07:54,390

- I have some way, but this  
is why I cleverly said,

202

00:07:54,390 --> 00:07:56,100  
well, if you're confused, that's fine,

203

00:07:56,100 --> 00:07:59,610  
because then I have a  
way out, being too big.

204

00:07:59,610 --> 00:08:00,805  
- You're hedging your bets a little bit.

205

00:08:00,805 --> 00:08:02,895  
- Right, but that being said,

206

00:08:02,895 --> 00:08:05,100  
a lot of times you hear that entanglement

207

00:08:05,100 --> 00:08:07,380  
is about how there's  
some instant connection

208

00:08:07,380 --> 00:08:08,850  
and there's something faster than light.

209

00:08:08,850 --> 00:08:10,230  
That's not actually true.

210

00:08:10,230 --> 00:08:12,990  
Of course, we have to be  
clear that there's no way

211

00:08:12,990 --> 00:08:15,450  
to use entanglement or a connection

212

00:08:15,450 --> 00:08:17,506  
between two quantum particles

213  
00:08:17,506 --> 00:08:19,800  
to communicate faster than light

214  
00:08:19,800 --> 00:08:22,216  
or transfer information faster than light,

215  
00:08:22,216 --> 00:08:25,440  
so there are limits to  
what entanglement can do,

216  
00:08:25,440 --> 00:08:28,110  
but it is true that it's about  
connection between particles,

217  
00:08:28,110 --> 00:08:30,300  
that part is true, or  
what's really amazing,

218  
00:08:30,300 --> 00:08:33,360  
and the part that's different  
from regular connection,

219  
00:08:33,360 --> 00:08:35,460  
for example, you can  
think about connection

220  
00:08:35,460 --> 00:08:37,080  
as some kind of pairing, right?

221  
00:08:37,080 --> 00:08:39,900  
For example, a left glove and  
right glove, that's paired,

222  
00:08:39,900 --> 00:08:40,924  
or a knife and a fork.

223  
00:08:40,924 --> 00:08:43,580  
Those things are not  
surprising entanglement.

224

00:08:43,580 --> 00:08:46,143

We don't call them entangled cutlery

225

00:08:46,143 --> 00:08:47,790

because actually they're not.

226

00:08:47,790 --> 00:08:49,477

- Well, I will from now on.

227

00:08:49,477 --> 00:08:54,270

- Maybe, but there is something extra about the way

228

00:08:54,270 --> 00:08:56,610

that connection, the pairing works at the quantum level

229

00:08:56,610 --> 00:08:58,350

of electrons or photons and so on,

230

00:08:58,350 --> 00:09:01,500

and that is that not only is there this pairing of,

231

00:09:01,500 --> 00:09:04,020

let's say, this is going back to cutlery,

232

00:09:04,020 --> 00:09:05,610

if one of the electrons is like a knife,

233

00:09:05,610 --> 00:09:07,140

the other one's a fork, sure,

234

00:09:07,140 --> 00:09:09,750

but what's interesting is that both of them already

235

00:09:09,750 --> 00:09:13,110  
at the individual level have  
that uncertain fluid identity,

236

00:09:13,110 --> 00:09:15,600  
so it's not clear which one is  
a knife, which one is a fork.

237

00:09:15,600 --> 00:09:18,003  
In fact, they have this  
sort of possibility

238

00:09:18,003 --> 00:09:21,060  
of being knife or fork,  
but we don't know for sure,

239

00:09:21,060 --> 00:09:24,090  
so it's this combination  
where we don't know

240

00:09:24,090 --> 00:09:27,060  
which is a knife and which is  
a fork, but if one is a knife,

241

00:09:27,060 --> 00:09:28,650  
the other one's instantly a fork

242

00:09:28,650 --> 00:09:31,309  
no matter where they are on  
opposite ends of the universe,

243

00:09:31,309 --> 00:09:34,415  
so it's that balance between  
having that probabilistic

244

00:09:34,415 --> 00:09:39,415  
fluid identity combined with  
perfect connection and pairing.

245

00:09:39,570 --> 00:09:41,730

That's what's missing in  
regular knives and forks,

246

00:09:41,730 --> 00:09:43,680  
because they are not that fluid,

247

00:09:43,680 --> 00:09:45,750  
which is probably a good  
thing when you're eating,

248

00:09:45,750 --> 00:09:50,250  
but not as powerful as  
quantum knives and forks

249

00:09:50,250 --> 00:09:52,230  
because those can be used for tools

250

00:09:52,230 --> 00:09:55,500  
to do novel kinds of application and such.

251

00:09:55,500 --> 00:09:57,090  
I don't know, I dunno if  
that was clear or not,

252

00:09:57,090 --> 00:09:58,530  
but that's the way I like.

253

00:09:58,530 --> 00:10:00,780  
- It's the first knife and  
fork analogy I've heard

254

00:10:00,780 --> 00:10:05,010  
for entanglement, and I know  
that entanglement is a concept

255

00:10:05,010 --> 00:10:07,833  
that has racked people's brains  
for a century or so, right,

256

00:10:07,833 --> 00:10:10,742  
that we're not the only people  
who have been confused by it,

257  
00:10:10,742 --> 00:10:13,830  
but this bears out in experiment  
and over and over again.

258  
00:10:13,830 --> 00:10:15,720  
We see that it's a real thing.

259  
00:10:15,720 --> 00:10:17,520  
So how does that differ  
from superposition,

260  
00:10:17,520 --> 00:10:20,490  
which is the other sort of  
uniquely quantum phenomenon

261  
00:10:20,490 --> 00:10:21,870  
that you mentioned?

262  
00:10:21,870 --> 00:10:23,070  
- Well, they're connected in the sense

263  
00:10:23,070 --> 00:10:27,180  
that we typically talk about  
superposition as this idea

264  
00:10:27,180 --> 00:10:30,600  
of not having to choose one or the other.

265  
00:10:30,600 --> 00:10:34,050  
Superposition is the and  
rather than the or description

266  
00:10:34,050 --> 00:10:37,830  
where we talk about how  
maybe we should talk instead



267

00:10:37,830 --> 00:10:39,180  
of knife before get back into

268

00:10:39,180 --> 00:10:40,650  
maybe quantum computing language,

269

00:10:40,650 --> 00:10:42,450  
where the knife would  
probably be called a zero

270

00:10:42,450 --> 00:10:44,070  
and the fork would be called a one.

271

00:10:44,070 --> 00:10:46,319  
So instead of talking about zero or one,

272

00:10:46,319 --> 00:10:48,238  
we would talk about probabilities,

273

00:10:48,238 --> 00:10:50,610  
some kind of a description that allows us

274

00:10:50,610 --> 00:10:54,360  
to talk about probability of  
zero and probability of one,

275

00:10:54,360 --> 00:10:55,830  
and that kind of a description

276

00:10:55,830 --> 00:10:59,760  
which encompasses both  
aspects of zero and one

277

00:10:59,760 --> 00:11:01,410  
is what we call the superposition.

278

00:11:01,410 --> 00:11:02,760  
And of course, you can have superpositions

279  
00:11:02,760 --> 00:11:06,120  
of multiple such quantum bits or qubits,

280  
00:11:06,120 --> 00:11:08,460  
and when you get to those  
larger superpositions,

281  
00:11:08,460 --> 00:11:10,350  
some of those types of superpositions

282  
00:11:10,350 --> 00:11:12,678  
that have this characteristic  
connection piece

283  
00:11:12,678 --> 00:11:15,120  
are the ones that we call  
entanglement, so in a way,

284  
00:11:15,120 --> 00:11:17,158  
entanglement is built into superposition.

285  
00:11:17,158 --> 00:11:20,490  
Once you allow yourself to  
think about superposition

286  
00:11:20,490 --> 00:11:23,610  
and describe that,  
entanglement naturally emerges

287  
00:11:23,610 --> 00:11:26,373  
from those descriptions,  
mathematically at least.

288  
00:11:27,240 --> 00:11:30,870  
– You wrote a really nice article  
for "Morals and Machines,"

289  
00:11:30,870 --> 00:11:33,180

and I guess the theme  
was kind of how quantum

290

00:11:33,180 --> 00:11:35,296  
can help us go beyond the binary,

291

00:11:35,296 --> 00:11:38,550  
so I really loved this article  
'cause it was teaching us

292

00:11:38,550 --> 00:11:41,670  
lessons both within science and outside.

293

00:11:41,670 --> 00:11:45,330  
So, what are some of the  
ways that we can learn

294

00:11:45,330 --> 00:11:48,573  
about non-binary thinking  
inspired by quantum mechanics?

295

00:11:49,830 --> 00:11:51,810  
- Well, everything in quantum mechanics

296

00:11:51,810 --> 00:11:55,710  
is about letting go of  
specifics and precision.

297

00:11:55,710 --> 00:11:58,800  
The idea that science and the  
way we think about science

298

00:11:58,800 --> 00:12:00,540  
can impact society is not new.

299

00:12:00,540 --> 00:12:03,840  
As our science evolves, our  
social thinking also evolves,

300

00:12:03,840 --> 00:12:07,050  
and for example, all of you  
know the Industrial Revolution

301  
00:12:07,050 --> 00:12:11,520  
and thinking around precisions  
and mass marketing and scales

302  
00:12:11,520 --> 00:12:14,790  
of how we think about things,  
as well as knowing exactly

303  
00:12:14,790 --> 00:12:17,520  
one thing or another  
that has all absolutely

304  
00:12:17,520 --> 00:12:20,550  
shaped the way we behave socially as well,

305  
00:12:20,550 --> 00:12:24,060  
so to me, it feels like  
whether we like it or not,

306  
00:12:24,060 --> 00:12:26,970  
this whole new revolution  
with new quantum technologies

307  
00:12:26,970 --> 00:12:30,300  
that actually harness these  
stranger properties of quantum,

308  
00:12:30,300 --> 00:12:32,280  
we're already using quantum  
technologies, of course,

309  
00:12:32,280 --> 00:12:33,660  
the laser and electronics,

310  
00:12:33,660 --> 00:12:35,854  
all of that is based on quantum ideas,

311

00:12:35,854 --> 00:12:38,160  
but now we're getting to the parts

312

00:12:38,160 --> 00:12:39,390  
that we were kind of ignoring,

313

00:12:39,390 --> 00:12:40,950  
like the uncertainty and entanglement,

314

00:12:40,950 --> 00:12:43,590  
and once we start building  
that into our technologies

315

00:12:43,590 --> 00:12:45,810  
and we're talking about these ideas more,

316

00:12:45,810 --> 00:12:47,250  
it will absolutely, I think,

317

00:12:47,250 --> 00:12:49,560  
inevitably shape this moving away,

318

00:12:49,560 --> 00:12:53,250  
just like we move away in  
science from zero or one

319

00:12:53,250 --> 00:12:56,970  
and go to zero and one,  
perhaps in society too,

320

00:12:56,970 --> 00:13:00,690  
we will naturally start  
expanding our choices

321

00:13:00,690 --> 00:13:04,110  
from right and wrong to  
a more broader spectrum,

322  
00:13:04,110 --> 00:13:05,700  
and not just right or wrong, yes, no,

323  
00:13:05,700 --> 00:13:09,480  
or anytime we try to have  
this sort of polar opposite

324  
00:13:09,480 --> 00:13:13,110  
kind of thinking, I think  
perhaps that will start evolving

325  
00:13:13,110 --> 00:13:16,050  
and we will get to newer  
ways and newer approaches,

326  
00:13:16,050 --> 00:13:18,330  
which can influence so many  
aspects of our behavior,

327  
00:13:18,330 --> 00:13:21,060  
whether we're choosing what  
we want to eat at a restaurant

328  
00:13:21,060 --> 00:13:23,700  
versus our politics and our policies,

329  
00:13:23,700 --> 00:13:26,689  
and so many, many  
aspects of our identities

330  
00:13:26,689 --> 00:13:29,730  
that honestly we are  
learning more and more

331  
00:13:29,730 --> 00:13:31,710  
are not about just one or the other.

332  
00:13:31,710 --> 00:13:35,340  
We are the intersection of so

many different environments

333

00:13:35,340 --> 00:13:39,210  
and influences and our own  
human characteristics that,

334

00:13:39,210 --> 00:13:40,100  
if you think about it that way,

335

00:13:40,100 --> 00:13:43,290  
it feels narrow that  
we've not really embraced

336

00:13:43,290 --> 00:13:45,120  
that kind of thinking already.

337

00:13:45,120 --> 00:13:47,640  
- Is that why the term revolution comes up

338

00:13:47,640 --> 00:13:49,350  
when we talk about these  
quantum technologies,

339

00:13:49,350 --> 00:13:53,730  
because it's such a fundamentally  
new way of thinking?

340

00:13:53,730 --> 00:13:56,490  
- I think so, I think it  
started as an idea revolution

341

00:13:56,490 --> 00:13:58,860  
rather than about just the technology,

342

00:13:58,860 --> 00:14:02,646  
this idea that you flip  
again the script of saying,

343

00:14:02,646 --> 00:14:05,250

let's ignore what we don't know

344

00:14:05,250 --> 00:14:08,730

to let's embrace not knowing to be a tool,

345

00:14:08,730 --> 00:14:10,080

just like knowing is a tool.

346

00:14:10,080 --> 00:14:11,760

I'm not saying we ignore precision,

347

00:14:11,760 --> 00:14:13,170

of course we do need precision too,

348

00:14:13,170 --> 00:14:16,260

but that the combination is more powerful

349

00:14:16,260 --> 00:14:18,300

than ignoring one or the other,

350

00:14:18,300 --> 00:14:20,010

so I think that's the idea that,

351

00:14:20,010 --> 00:14:24,270

the thinking of embracing  
these as extra tools,

352

00:14:24,270 --> 00:14:27,582

ways that we can deeply  
understand the universe

353

00:14:27,582 --> 00:14:32,010

as well as expand on our  
technologies and our applications,

354

00:14:32,010 --> 00:14:34,260

so I think, yeah, for me  
that's the revolution,



355

00:14:34,260 --> 00:14:36,720  
and maybe it'll eventually  
lead to a bigger revolution

356

00:14:36,720 --> 00:14:38,490  
that I think of as a social revolution,

357

00:14:38,490 --> 00:14:41,100  
'cause technologies always  
end up going in ways

358

00:14:41,100 --> 00:14:43,950  
that we definitely can't  
control, which is a little scary,

359

00:14:43,950 --> 00:14:45,960  
but it always changes everything.

360

00:14:45,960 --> 00:14:48,900  
- So you would call this a  
quantum social revolution?

361

00:14:48,900 --> 00:14:49,860  
- I think it will be.

362

00:14:49,860 --> 00:14:52,110  
The question is what kind  
of of social revolution,

363

00:14:52,110 --> 00:14:55,260  
one that can be, perhaps we engage in it

364

00:14:55,260 --> 00:14:57,630  
in a more knowing way where we understand,

365

00:14:57,630 --> 00:14:59,880  
in the history of science and technology,

366

00:14:59,880 --> 00:15:02,100  
the way society develops hand-in-hand

367  
00:15:02,100 --> 00:15:05,490  
with technology gives us  
a lot of ways to learn

368  
00:15:05,490 --> 00:15:09,120  
how we could perhaps  
shape this next revolution

369  
00:15:09,120 --> 00:15:10,770  
rather than just get  
caught up in the flow.

370  
00:15:10,770 --> 00:15:12,945  
We will be anyway, but  
what if we could actually

371  
00:15:12,945 --> 00:15:17,820  
choose to be more structured  
and more, for example,

372  
00:15:17,820 --> 00:15:19,677  
deliberate and inclusive, for example,

373  
00:15:19,677 --> 00:15:22,950  
in the way we embrace and  
use these technologies,

374  
00:15:22,950 --> 00:15:25,080  
who has access to these technologies?

375  
00:15:25,080 --> 00:15:27,840  
That would be kind of a  
revolutionary approach

376  
00:15:27,840 --> 00:15:30,300  
to a technology  
revolution, which will then

377

00:15:30,300 --> 00:15:32,940

lead to a completely  
radical social revolution.

378

00:15:32,940 --> 00:15:34,290

- It may have been in the same article

379

00:15:34,290 --> 00:15:35,123

that Lauren mentioned,

380

00:15:35,123 --> 00:15:38,857

you wrote that, "Quantum  
information science being new,

381

00:15:38,857 --> 00:15:42,037

"it offers what you called  
a rare opportunity to embed

382

00:15:42,037 --> 00:15:45,517

"inclusive practices from the  
start and build a responsible

383

00:15:45,517 --> 00:15:48,150

"and sustainable roadmap  
for quantum computing,"

384

00:15:48,150 --> 00:15:49,770

so I think that's what  
you were getting at.

385

00:15:49,770 --> 00:15:50,603

We have a chance,

386

00:15:50,603 --> 00:15:52,320

because in the broad  
sweep of human history,

387

00:15:52,320 --> 00:15:54,900

quantum theory is  
basically a brand new thing

388

00:15:54,900 --> 00:15:55,740  
in the past century,

389

00:15:55,740 --> 00:15:59,400  
and we haven't quite developed  
our intuitions and mindsets.

390

00:15:59,400 --> 00:16:01,260  
Do you think that's something  
that will come over time?

391

00:16:01,260 --> 00:16:05,683  
Quantum will seem more natural  
to us, more intuitive to us,

392

00:16:05,683 --> 00:16:08,645  
and we'll be able to build  
our sort of social practices

393

00:16:08,645 --> 00:16:10,530  
around that kind of thinking?

394

00:16:10,530 --> 00:16:12,180  
- I don't know if it'll  
become more intuitive,

395

00:16:12,180 --> 00:16:13,143  
because the reality is

396

00:16:13,143 --> 00:16:16,320  
that we are not probabilistic  
creatures ourselves

397

00:16:16,320 --> 00:16:18,300  
in the sense that our  
thinking is actually,

398  
00:16:18,300 --> 00:16:20,970  
because we're pretty vague often, right?

399  
00:16:20,970 --> 00:16:23,640  
We're not always about  
the way we would, perhaps,

400  
00:16:23,640 --> 00:16:25,920  
imagine a true artificial intelligent

401  
00:16:25,920 --> 00:16:27,780  
based on binary computing, you know,

402  
00:16:27,780 --> 00:16:28,950  
yes and no kind of choices.

403  
00:16:28,950 --> 00:16:30,390  
We don't actually think that way,

404  
00:16:30,390 --> 00:16:33,840  
so we do naturally already  
have some of these qualities,

405  
00:16:33,840 --> 00:16:36,360  
but we don't consciously acknowledge them,

406  
00:16:36,360 --> 00:16:39,900  
so perhaps that part  
will become more natural

407  
00:16:39,900 --> 00:16:42,990  
where we allow ourselves  
to explore our thinking

408  
00:16:42,990 --> 00:16:46,950  
and how we make decisions  
and how we behave.

409

00:16:46,950 --> 00:16:50,333  
Whether or not that will be  
more intuitive, I don't know,

410  
00:16:50,333 --> 00:16:53,340  
but perhaps it'll become more widespread.

411  
00:16:53,340 --> 00:16:55,230  
- Can you think of  
examples of how we could,

412  
00:16:55,230 --> 00:16:56,790  
in the field of quantum computing,

413  
00:16:56,790 --> 00:16:59,010  
develop the field in a  
way that's more inclusive

414  
00:16:59,010 --> 00:17:00,990  
and sort of egalitarian than, let's say,

415  
00:17:00,990 --> 00:17:03,660  
an older branch of science like chemistry?

416  
00:17:03,660 --> 00:17:04,650  
- Sure, absolutely.

417  
00:17:04,650 --> 00:17:06,390  
In fact, that's part of what I wanted

418  
00:17:06,390 --> 00:17:07,640  
to write that article for.

419  
00:17:07,640 --> 00:17:09,630  
Often what we do with technology,

420  
00:17:09,630 --> 00:17:10,950  
especially on the science side,

421  
00:17:10,950 --> 00:17:12,510  
and I'm sure we've all been guilty of it,

422  
00:17:12,510 --> 00:17:13,680  
is that we are so curious.

423  
00:17:13,680 --> 00:17:16,110  
We're like, let's just try  
it and see what happens.

424  
00:17:16,110 --> 00:17:17,587  
What if we did this, why  
don't we do this now,

425  
00:17:17,587 --> 00:17:20,940  
why don't we build this thing,  
which is fun because that is,

426  
00:17:20,940 --> 00:17:23,610  
we are inherently curious,  
which is wonderful,

427  
00:17:23,610 --> 00:17:26,580  
but what if we could ask  
the what if questions

428  
00:17:26,580 --> 00:17:30,510  
and also include those who  
ask what will happen next,

429  
00:17:30,510 --> 00:17:32,070  
because that too is a creative process

430  
00:17:32,070 --> 00:17:34,650  
because you can't quite  
predict it until it happens,

431  
00:17:34,650 --> 00:17:38,550  
and humans are very

unpredictable, so maybe we learn

432

00:17:38,550 --> 00:17:41,250  
more about how to predict human  
behavior too in the future,

433

00:17:41,250 --> 00:17:44,490  
but for now, there are  
experts who will understand

434

00:17:44,490 --> 00:17:47,647  
human behavior, perhaps  
just the way I study physics

435

00:17:47,647 --> 00:17:48,900  
and the laws of physics.

436

00:17:48,900 --> 00:17:51,180  
There's others who study social sciences

437

00:17:51,180 --> 00:17:54,930  
and things like identity and inclusion,

438

00:17:54,930 --> 00:17:59,010  
and often me as a physicist  
will perhaps not think

439

00:17:59,010 --> 00:18:01,770  
they should be part of whatever  
is the research project

440

00:18:01,770 --> 00:18:04,350  
I'm doing to build this  
new quantum application

441

00:18:04,350 --> 00:18:06,300  
to do something with healthcare,

442

00:18:06,300 --> 00:18:08,790



so, but healthcare would impact humans,

443

00:18:08,790 --> 00:18:10,950

so perhaps we should  
get some human experts

444

00:18:10,950 --> 00:18:13,140

into that kind of  
research and development.

445

00:18:13,140 --> 00:18:16,320

So that's one example of where  
we could be more deliberate.

446

00:18:16,320 --> 00:18:17,610

As we develop the technology,

447

00:18:17,610 --> 00:18:20,310

we don't have to limit what  
we do, but we should ask,

448

00:18:20,310 --> 00:18:21,151

what's the impact?

449

00:18:21,151 --> 00:18:22,316

Who's using it?

450

00:18:22,316 --> 00:18:24,270

Why are we doing this?

451

00:18:24,270 --> 00:18:25,260

Where will it lead?

452

00:18:25,260 --> 00:18:28,080

What's the environmental  
kinds of concerns we have?

453

00:18:28,080 --> 00:18:29,040

Is it sustainable?

454

00:18:29,040 --> 00:18:30,210  
There's so many other questions

455

00:18:30,210 --> 00:18:32,970  
that we don't typically  
ask all at the same time.

456

00:18:32,970 --> 00:18:34,440  
Wouldn't it be nice if we could do that

457

00:18:34,440 --> 00:18:36,630  
in a more structured fashion?

458

00:18:36,630 --> 00:18:38,160  
- The Industrial Revolution,

459

00:18:38,160 --> 00:18:40,980  
we know that it essentially  
built the 20th century

460

00:18:40,980 --> 00:18:42,540  
and into the 21st century,

461

00:18:42,540 --> 00:18:45,240  
but it had some serious repercussions

462

00:18:45,240 --> 00:18:47,340  
for our environment and for our health.

463

00:18:47,340 --> 00:18:48,598  
Some good, lots bad.

464

00:18:48,598 --> 00:18:51,450  
Are you sort of proposing  
that quantum information

465

00:18:51,450 --> 00:18:54,510

is a field that's so young  
that it would kind of

466

00:18:54,510 --> 00:18:56,670  
be like going back to the start  
of the Industrial Revolution

467

00:18:56,670 --> 00:18:59,580  
and saying we could plan  
ahead a little bit better

468

00:18:59,580 --> 00:19:01,513  
and have fewer of the  
negative repercussions?

469

00:19:01,513 --> 00:19:03,900  
Do we have the wisdom of hindsight now

470

00:19:03,900 --> 00:19:05,873  
with a new revolution that's starting?

471

00:19:05,873 --> 00:19:08,130  
- That's exactly the kind of what if game

472

00:19:08,130 --> 00:19:09,510  
that would be great to play.

473

00:19:09,510 --> 00:19:11,940  
What if we could go back to the beginning

474

00:19:11,940 --> 00:19:13,326  
of the Industrial Revolution

475

00:19:13,326 --> 00:19:15,690  
and make a few decisions, key decisions?

476

00:19:15,690 --> 00:19:18,870  
What would we have decided,  
knowing everything we know now?

477

00:19:18,870 --> 00:19:20,247

What would we have done different?

478

00:19:20,247 --> 00:19:22,770

And from that kind of an exercise,

479

00:19:22,770 --> 00:19:26,275

can we learn something about  
starting this new revolution

480

00:19:26,275 --> 00:19:30,163

and ask what if we use  
those kinds of lessons

481

00:19:30,163 --> 00:19:32,190

to try to put into place

482

00:19:32,190 --> 00:19:34,560

whatever are those key  
decisions and policies?

483

00:19:34,560 --> 00:19:37,110

It would require, obviously,  
some kind of ability

484

00:19:37,110 --> 00:19:39,900

to predict where we're going  
and we'll never get that right,

485

00:19:39,900 --> 00:19:41,100

because there's just no way.

486

00:19:41,100 --> 00:19:43,320

- But history does have  
some guidance for us.

487

00:19:43,320 --> 00:19:44,153

- Exactly.

488

00:19:44,153 --> 00:19:45,150

Right now, our approach

489

00:19:45,150 --> 00:19:47,070

is we don't even look back at history.

490

00:19:47,070 --> 00:19:49,800

We know Industrial Revolution happened, but that's about it.

491

00:19:49,800 --> 00:19:52,106

We don't really take it as a lesson

492

00:19:52,106 --> 00:19:54,330

that we now use for the future.

493

00:19:54,330 --> 00:19:57,122

There are, as I said, expert scholars who do actually

494

00:19:57,122 --> 00:19:59,970

think about history, think about political science

495

00:19:59,970 --> 00:20:02,238

and their causalities and correlations,

496

00:20:02,238 --> 00:20:04,740

so I think it's happening,

497

00:20:04,740 --> 00:20:07,110

but we don't necessarily then include that

498

00:20:07,110 --> 00:20:08,790

as we roll out the technologies.

499

00:20:08,790 --> 00:20:10,230

It's all being done in silos,

500

00:20:10,230 --> 00:20:12,600  
which has always been kind  
of a problem with research,

501

00:20:12,600 --> 00:20:15,720  
so here's a chance for  
us to break those silos.

502

00:20:15,720 --> 00:20:18,060  
- Are there particular tips or strategies

503

00:20:18,060 --> 00:20:20,520  
that you think the leaders and developers

504

00:20:20,520 --> 00:20:22,320  
of these technologies should have in mind

505

00:20:22,320 --> 00:20:24,953  
as they roll out new devices?

506

00:20:24,953 --> 00:20:27,930  
- If there's a leader  
who's in a policy meeting,

507

00:20:27,930 --> 00:20:30,330  
first thing's first:  
look around the table.

508

00:20:30,330 --> 00:20:32,310  
Who's at the table and who's missing?

509

00:20:32,310 --> 00:20:35,040  
That would be number one  
step, and it's amazing

510

00:20:35,040 --> 00:20:36,960  
how much you can learn

just from that alone,

511

00:20:36,960 --> 00:20:38,880  
because I don't think there's  
going to be one person

512

00:20:38,880 --> 00:20:41,190  
who will be able to make  
all the right decisions,

513

00:20:41,190 --> 00:20:45,150  
so find the team that can really  
bring in all of the skills

514

00:20:45,150 --> 00:20:48,510  
and the expertise you might  
want to think about, at least.

515

00:20:48,510 --> 00:20:49,800  
So I don't have all the answers,

516

00:20:49,800 --> 00:20:51,480  
so that's part of the problem.

517

00:20:51,480 --> 00:20:53,430  
I would wanna look  
around the table and say,

518

00:20:53,430 --> 00:20:55,980  
who would I collect to answer  
all these wonderful questions?

519

00:20:55,980 --> 00:20:59,340  
But just right now, in the few  
minutes we've been talking,

520

00:20:59,340 --> 00:21:01,974  
we've had so many  
questions that I feel like

521

00:21:01,974 --> 00:21:05,565

would need a lot of time to  
even explore and understand

522

00:21:05,565 --> 00:21:09,060

how we would go about actually rolling out

523

00:21:09,060 --> 00:21:11,490

a more deliberate approach to technology,

524

00:21:11,490 --> 00:21:12,780

and it doesn't have to be just quantum.

525

00:21:12,780 --> 00:21:15,750

Quantum is one example  
where it's a young field,

526

00:21:15,750 --> 00:21:18,930

so we have that chance,  
but so is machine learning,

527

00:21:18,930 --> 00:21:20,340

and there's, they're  
probably going to intersect.

528

00:21:20,340 --> 00:21:23,250

They already are, to some level,  
so this could be something

529

00:21:23,250 --> 00:21:26,706

that becomes a framework  
of how we as a society

530

00:21:26,706 --> 00:21:29,400

engage with technology going forward.

531

00:21:29,400 --> 00:21:30,360

- In this conversation,



532

00:21:30,360 --> 00:21:32,940  
we've been using the  
word identity many times.

533

00:21:32,940 --> 00:21:35,370  
I think you first started  
talking about the identity

534

00:21:35,370 --> 00:21:36,990  
of a fork or a knife or a spoon,

535

00:21:36,990 --> 00:21:38,430  
and then of course we can also think

536

00:21:38,430 --> 00:21:40,590  
of this in a more personal context,

537

00:21:40,590 --> 00:21:43,800  
but it seems like this is  
a pretty fundamental word

538

00:21:43,800 --> 00:21:45,390  
to a lot of the things  
that you're thinking about.

539

00:21:45,390 --> 00:21:47,700  
Can you tell us a little  
bit more about identity

540

00:21:47,700 --> 00:21:50,790  
and why you think it's so  
important to be considering?

541

00:21:50,790 --> 00:21:53,700  
- It's something that's  
central in, both to our,

542

00:21:53,700 --> 00:21:55,590  
to the physical world that we interact

543

00:21:55,590 --> 00:21:59,956  
and to our social spaces and  
just more broadly everywhere,

544

00:21:59,956 --> 00:22:03,060  
whatever we do, it's about  
how we interact with it,

545

00:22:03,060 --> 00:22:06,300  
whether it's other human  
beings or with other objects

546

00:22:06,300 --> 00:22:08,400  
or even our imaginations

547

00:22:08,400 --> 00:22:11,190  
and even things that are  
not there that don't exist.

548

00:22:11,190 --> 00:22:13,890  
Everything is about that  
interaction and then engagement,

549

00:22:13,890 --> 00:22:16,530  
and that has everything  
to do with who we are

550

00:22:16,530 --> 00:22:20,250  
and what shapes us, so to me  
it is really an important piece

551

00:22:20,250 --> 00:22:22,830  
that connects many of the projects

552

00:22:22,830 --> 00:22:25,470  
that I work on personally,  
where, other than physics,

553

00:22:25,470 --> 00:22:28,290  
I do think a lot about  
who I am too as a person,

554  
00:22:28,290 --> 00:22:30,840  
because whenever we meet new people

555  
00:22:30,840 --> 00:22:33,180  
and we introduce ourselves,  
we have, we say hi,

556  
00:22:33,180 --> 00:22:36,090  
my name is so and so and  
I am such and such, right?

557  
00:22:36,090 --> 00:22:37,500  
And who am I, right?

558  
00:22:37,500 --> 00:22:39,930  
For one thing, the fact  
that am is the key word

559  
00:22:39,930 --> 00:22:41,160  
is already interesting.

560  
00:22:41,160 --> 00:22:44,730  
Instead of telling people  
what I do or what I love

561  
00:22:44,730 --> 00:22:47,730  
or what I'm interested in,  
we always lead with the,

562  
00:22:47,730 --> 00:22:50,370  
this is what I am, which  
honestly seems like, again,

563  
00:22:50,370 --> 00:22:53,580  
one of these very known  
concepts where somehow,

564

00:22:53,580 --> 00:22:56,010

I'm supposed to already know that I am,

565

00:22:56,010 --> 00:22:58,110

there is no room for uncertainty there.

566

00:22:58,110 --> 00:22:59,520

I am such and such.

567

00:22:59,520 --> 00:23:00,818

So, this is what I mean.

568

00:23:00,818 --> 00:23:04,172

It's built in, this idea  
of knowing everything,

569

00:23:04,172 --> 00:23:08,190

so questioning that  
automatically means questioning

570

00:23:08,190 --> 00:23:09,420

not just my own identity,

571

00:23:09,420 --> 00:23:11,970

but what does society mean about who I am,

572

00:23:11,970 --> 00:23:13,577

and whether I'm a physicist,

573

00:23:13,577 --> 00:23:16,046

or let's say I'm an immigrant to Canada,

574

00:23:16,046 --> 00:23:20,727

or a woman or a certain age,  
or I have certain abilities,

575

00:23:22,260 --> 00:23:25,483

whether I'm healthy or  
if I, whether I have.

576

00:23:25,483 --> 00:23:27,450  
There's so many things, I can't even think

577

00:23:27,450 --> 00:23:29,490  
about all the different  
identities we have,

578

00:23:29,490 --> 00:23:32,190  
so to me it's important to explore that,

579

00:23:32,190 --> 00:23:35,160  
and it can't really be  
separated out and say, okay,

580

00:23:35,160 --> 00:23:38,460  
here I do physics here and  
then I think about it here.

581

00:23:38,460 --> 00:23:41,131  
To me they must connect,  
and they always do.

582

00:23:41,131 --> 00:23:43,680  
- It's interesting because  
I think a traditional

583

00:23:43,680 --> 00:23:46,047  
look at science would  
say there's the science

584

00:23:46,047 --> 00:23:48,540  
in one compartment of your life

585

00:23:48,540 --> 00:23:50,520  
and then there's the  
rest, the personal stuff,

586  
00:23:50,520 --> 00:23:53,700  
and at what point in your life or career

587  
00:23:53,700 --> 00:23:56,640  
did you realize that they're  
not separate domains,

588  
00:23:56,640 --> 00:23:59,370  
that they're intermingled like  
that and evolving over time?

589  
00:23:59,370 --> 00:24:02,850  
- I started absolutely  
traditionally as you described,

590  
00:24:02,850 --> 00:24:06,210  
as in thinking about  
everything very separately,

591  
00:24:06,210 --> 00:24:09,120  
and when I was grad student physics,

592  
00:24:09,120 --> 00:24:12,450  
and I've talked about this  
often where I did notice

593  
00:24:12,450 --> 00:24:13,920  
that it was kind of lonely,

594  
00:24:13,920 --> 00:24:15,960  
because there weren't that  
many women in the room

595  
00:24:15,960 --> 00:24:18,060  
and there were certainly  
not many people of color.

596  
00:24:18,060 --> 00:24:22,020  
I did all of my grad studies

in the US in the Midwest,

597

00:24:22,020 --> 00:24:24,060

but back then I thought, okay, who cares?

598

00:24:24,060 --> 00:24:25,260

That's not relevant.

599

00:24:25,260 --> 00:24:26,730

I'm in a physics classroom,

600

00:24:26,730 --> 00:24:29,040

I'm doing physics work,  
so if I do great physics,

601

00:24:29,040 --> 00:24:30,630

nothing else is relevant.

602

00:24:30,630 --> 00:24:33,180

That was my approach,  
that if I do physics,

603

00:24:33,180 --> 00:24:34,830

that's going to be everything,

604

00:24:34,830 --> 00:24:38,370

and it took a long time for  
me to eventually realize

605

00:24:38,370 --> 00:24:41,160

that it's not just about whether  
I do good physics or not,

606

00:24:41,160 --> 00:24:45,540

because it's not who I am and  
how I'm perceived does matter,

607

00:24:45,540 --> 00:24:48,330

and it's not necessarily always

even a level playing field

608

00:24:48,330 --> 00:24:51,180  
in terms of how your  
work is perceived or not,

609

00:24:51,180 --> 00:24:54,450  
so even if I do great work,  
perhaps it won't really

610

00:24:54,450 --> 00:24:57,810  
get acknowledged, depending  
on who we are and who's there,

611

00:24:57,810 --> 00:24:59,820  
and the fact that there are few women

612

00:24:59,820 --> 00:25:03,420  
and there's challenges,  
absolutely systemic barriers

613

00:25:03,420 --> 00:25:05,550  
and challenges and biases that we all have

614

00:25:05,550 --> 00:25:08,730  
that impact how we can do our physics

615

00:25:08,730 --> 00:25:11,013  
or whatever other area  
that we're talking about.

616

00:25:11,013 --> 00:25:14,160  
So that's how it started  
evolving, where I'm like, okay,

617

00:25:14,160 --> 00:25:17,640  
I'm forced to face it in my  
own career and in my own life,

618



00:25:17,640 --> 00:25:20,160  
and then I realized that  
it's not just me alone.

619  
00:25:20,160 --> 00:25:22,050  
So the more I thought about  
it, the more I'm like,

620  
00:25:22,050 --> 00:25:25,140  
I don't know much about  
what it means to be a woman

621  
00:25:25,140 --> 00:25:27,360  
or a physicist and all of  
these identity questions.

622  
00:25:27,360 --> 00:25:29,220  
I'm not an expert on any of that.

623  
00:25:29,220 --> 00:25:31,830  
And all universities do  
exactly what you describe,

624  
00:25:31,830 --> 00:25:34,830  
which is separate out, okay,  
you go into the arts degree

625  
00:25:34,830 --> 00:25:37,200  
or the science degree,  
everything is very separate,

626  
00:25:37,200 --> 00:25:41,040  
so I didn't know students  
who were able to discuss

627  
00:25:41,040 --> 00:25:44,040  
these kinds of questions,  
and we're told to ignore it,

628  
00:25:44,040 --> 00:25:48,541

so I was a very well  
programed science student.

629

00:25:48,541 --> 00:25:50,522

It took a while to break out and realize,

630

00:25:50,522 --> 00:25:52,366

well, maybe I should go find others

631

00:25:52,366 --> 00:25:55,080

who know more about this,

which, it didn't happen

632

00:25:55,080 --> 00:25:57,810

until my early days as

a junior faculty member

633

00:25:57,810 --> 00:26:00,510

that I got to interact

with other researchers

634

00:26:00,510 --> 00:26:03,660

from other faculties who were  
in psychology, social science,

635

00:26:03,660 --> 00:26:05,706

gender studies, and that

really opened my eyes

636

00:26:05,706 --> 00:26:08,400

and I realized, yes, there's

research, there's expertise,

637

00:26:08,400 --> 00:26:11,550

I can understand more about

these kinds of questions

638

00:26:11,550 --> 00:26:15,000

of context, and it went

from there to eventually

639  
00:26:15,000 --> 00:26:17,058  
realizing I have to deprogram myself

640  
00:26:17,058 --> 00:26:19,952  
and try to think more holistically,

641  
00:26:19,952 --> 00:26:22,560  
and it does align with my physics

642  
00:26:22,560 --> 00:26:24,750  
in the sense that that's what  
I'm doing already in quantum,

643  
00:26:24,750 --> 00:26:28,140  
where I'm deep programming  
from the zero or one

644  
00:26:28,140 --> 00:26:30,840  
and trying to embrace this  
new framework of computing

645  
00:26:30,840 --> 00:26:34,290  
and new way of thinking, which  
could absolutely be expanded

646  
00:26:34,290 --> 00:26:36,210  
to new ways of being broader

647  
00:26:36,210 --> 00:26:39,600  
and intersecting all of  
these different aspects, so.

648  
00:26:39,600 --> 00:26:41,884  
- Well, we also had a  
question that was sent in

649  
00:26:41,884 --> 00:26:45,300  
about how you find this

balance in your work

650

00:26:45,300 --> 00:26:47,580

or how you incorporate some  
of these different ideas

651

00:26:47,580 --> 00:26:48,540

at the same time.

652

00:26:48,540 --> 00:26:51,120

So this question was  
sent in by Priyal Bordia,

653

00:26:51,120 --> 00:26:54,870

who just completed her  
undergraduate degree in physics

654

00:26:54,870 --> 00:26:56,670

from Mumbai University.

655

00:26:56,670 --> 00:27:00,157

She asked, "Being a physicist  
and a strong advocate

656

00:27:00,157 --> 00:27:02,947

"of inclusion, diversity,  
equity and accessibility,

657

00:27:02,947 --> 00:27:05,857

"what were or are the  
challenges that you faced

658

00:27:05,857 --> 00:27:08,077

"or are still facing to maintain balance

659

00:27:08,077 --> 00:27:10,738

"between the different  
types of work that you do?"

660

00:27:10,738 --> 00:27:12,390  
- Great question.

661  
00:27:12,390 --> 00:27:16,380  
So I'll answer by saying  
I don't see it necessarily

662  
00:27:16,380 --> 00:27:20,730  
as a balance, as in there's  
some ideal proportion

663  
00:27:20,730 --> 00:27:24,840  
of 30% of this and 70% of  
that, or on Tuesday it's that,

664  
00:27:24,840 --> 00:27:26,100  
and then Wednesday it's something else.

665  
00:27:26,100 --> 00:27:27,630  
- That's the urge for certainty

666  
00:27:27,630 --> 00:27:29,760  
that is contrary to  
the quantum urge, yeah.

667  
00:27:29,760 --> 00:27:33,210  
- Exactly, and this kind  
of leads into similar

668  
00:27:33,210 --> 00:27:35,610  
kinds of questions come  
up with work-life balance,

669  
00:27:35,610 --> 00:27:37,590  
because a lot of, I  
don't see my work really

670  
00:27:37,590 --> 00:27:40,140  
as work-life balance because  
it's all work-work to me,

671  
00:27:40,140 --> 00:27:42,865  
but, so I don't have  
balance, in other words.

672  
00:27:42,865 --> 00:27:46,590  
So this idea of here's a bar,  
we've already decided it,

673  
00:27:46,590 --> 00:27:49,290  
we've set it, because we  
know it and now we'll all try

674  
00:27:49,290 --> 00:27:52,183  
to strive for it, which bars  
are great, but you gotta,

675  
00:27:52,183 --> 00:27:55,080  
I mean, I think of bars as  
aspirational, to be honest,

676  
00:27:55,080 --> 00:27:57,030  
which is we all need aspirations,

677  
00:27:57,030 --> 00:27:59,869  
but reality is much more messy,

678  
00:27:59,869 --> 00:28:04,841  
which to me exactly aligns with  
reality is much more fluid.

679  
00:28:04,841 --> 00:28:07,560  
So going forward, to me  
it's not about thinking,

680  
00:28:07,560 --> 00:28:09,240  
well, did I achieve the balance now

681  
00:28:09,240 --> 00:28:12,390

between the physics thing and  
gender identity questions,

682

00:28:12,390 --> 00:28:13,500  
anything like that.

683

00:28:13,500 --> 00:28:16,800  
Because they're so mixed  
together, they're a superposition.

684

00:28:16,800 --> 00:28:19,410  
I'm sorry, I just had to go there.

685

00:28:19,410 --> 00:28:23,850  
And balance to me is about  
whatever feels right.

686

00:28:23,850 --> 00:28:25,890  
So my bar is really not about

687

00:28:25,890 --> 00:28:28,110  
whether things are in proportion.

688

00:28:28,110 --> 00:28:32,220  
My bar is am I achieving my  
goals of what I would set

689

00:28:32,220 --> 00:28:33,720  
as this is where I wanna be?

690

00:28:33,720 --> 00:28:34,920  
What's my purpose?

691

00:28:34,920 --> 00:28:35,894  
Where do I wanna go?

692

00:28:35,894 --> 00:28:38,940  
What do I wanna do,  
and does it satisfy me?

693

00:28:38,940 --> 00:28:43,940

So, those are my ways of  
trying to evaluate and assess

694

00:28:44,160 --> 00:28:47,940

where I want to be rather than  
go for that balance question.

695

00:28:47,940 --> 00:28:49,020

- Directly related to that,

696

00:28:49,020 --> 00:28:51,810

we do have a question from  
a young woman named Summer,

697

00:28:51,810 --> 00:28:53,490

so could we play that?

698

00:28:53,490 --> 00:28:56,310

- Hi Shohini, I'm Summer from  
Waterloo, and I'm wondering

699

00:28:56,310 --> 00:28:58,590

if you have words of  
inspiration for young women

700

00:28:58,590 --> 00:29:01,293

looking to pursue an  
exciting career in science?

701

00:29:02,490 --> 00:29:03,840

- Wow, thanks, Summer.

702

00:29:03,840 --> 00:29:08,730

I'm not sure about what would  
be an inspiring thing to say,

703

00:29:08,730 --> 00:29:12,570



but I can say that for in my  
own life, as I just mentioned,

704

00:29:12,570 --> 00:29:17,550

I switched away from trying  
to think about who I am

705

00:29:17,550 --> 00:29:21,023

to what I wanna do, so I would  
suggest think about that.

706

00:29:21,023 --> 00:29:22,812

What do you want to do?

707

00:29:22,812 --> 00:29:26,220

Is it something that you feel  
you can contribute something?

708

00:29:26,220 --> 00:29:29,113

Will it help the world  
in some way, even better,

709

00:29:29,113 --> 00:29:30,840

and are you good at it?

710

00:29:30,840 --> 00:29:34,500

Then even better, if you can  
put those three things together

711

00:29:34,500 --> 00:29:36,402

as you follow a career in science,

712

00:29:36,402 --> 00:29:41,280

then I think you'll find a very  
satisfying project, perhaps,

713

00:29:41,280 --> 00:29:43,380

or somebody who you can talk to

714

00:29:43,380 --> 00:29:45,834  
that would help with  
those kinds of questions,

715  
00:29:45,834 --> 00:29:47,790  
or an example where you're like, yeah,

716  
00:29:47,790 --> 00:29:49,530  
they did something that's really great.

717  
00:29:49,530 --> 00:29:52,100  
I wanna do that, rather  
than I wanna be that.

718  
00:29:52,100 --> 00:29:54,660  
So that's one thing I would  
say, and the other thing is,

719  
00:29:54,660 --> 00:29:58,226  
as a scientist in a  
career in science myself,

720  
00:29:58,226 --> 00:30:00,690  
being a woman and a person of color,

721  
00:30:00,690 --> 00:30:02,640  
these have been, of course, important,

722  
00:30:02,640 --> 00:30:05,400  
but I wanna tell everybody who's out there

723  
00:30:05,400 --> 00:30:08,454  
who's feeling like I did often  
in classes where I'm alone.

724  
00:30:08,454 --> 00:30:10,750  
I would say, you are actually not alone.

725  
00:30:10,750 --> 00:30:13,140

I remember hearing this  
actually in a conference.

726

00:30:13,140 --> 00:30:14,250  
Somebody else mentioned that you know,

727

00:30:14,250 --> 00:30:17,430  
if all of the so-called  
minorities in science

728

00:30:17,430 --> 00:30:19,620  
or any other fields got together,

729

00:30:19,620 --> 00:30:21,990  
they're really no longer  
a minority, right?

730

00:30:21,990 --> 00:30:24,450  
So, often we feel like we're the only ones

731

00:30:24,450 --> 00:30:27,300  
who are feeling that way  
or, and we feel isolated.

732

00:30:27,300 --> 00:30:30,840  
Loneliness and isolation can  
be two of the biggest factors

733

00:30:30,840 --> 00:30:34,118  
that make us stop following  
our dreams and our goals,

734

00:30:34,118 --> 00:30:36,946  
and in science, for  
sure, that happens a lot

735

00:30:36,946 --> 00:30:39,120  
when you don't see others like you.

736

00:30:39,120 --> 00:30:41,550  
My message is that in  
fact you are not alone.

737  
00:30:41,550 --> 00:30:44,460  
It's not you, it's just  
that we have to do better

738  
00:30:44,460 --> 00:30:45,960  
and build that inclusive community

739  
00:30:45,960 --> 00:30:48,120  
that I keep talking about,  
but you can be part of it.

740  
00:30:48,120 --> 00:30:50,055  
I hope that's inspirational.

741  
00:30:50,055 --> 00:30:52,170  
- Looking back on your own journey

742  
00:30:52,170 --> 00:30:55,020  
towards being the  
physicist that you are now,

743  
00:30:55,020 --> 00:30:58,830  
how did you make the decision  
to pursue this career path?

744  
00:30:58,830 --> 00:31:02,430  
- Well, when I was a kid,  
I was always curious.

745  
00:31:02,430 --> 00:31:05,941  
I was exactly that kid  
who loved "Star Trek."

746  
00:31:05,941 --> 00:31:09,150  
I mean that show, man,  
that must have influenced

747

00:31:09,150 --> 00:31:10,592  
so many kids like me.

748

00:31:10,592 --> 00:31:12,720  
- There are a lot of  
scientists at Perimeter

749

00:31:12,720 --> 00:31:13,553  
who have said the same thing.

750

00:31:13,553 --> 00:31:15,420  
- Right, isn't that incredible?

751

00:31:15,420 --> 00:31:16,530  
I mean, I think they know, though,

752

00:31:16,530 --> 00:31:18,608  
the "Star Trek" crew, right?

753

00:31:18,608 --> 00:31:21,420  
You know, I once went and talked also to,

754

00:31:21,420 --> 00:31:22,620  
this is a bit of a digression,

755

00:31:22,620 --> 00:31:25,440  
but I had a little chat with Neil Gaiman,

756

00:31:25,440 --> 00:31:27,780  
who's the author of the "Sandman" show,

757

00:31:27,780 --> 00:31:29,460  
which is now, well it's now a TV show,

758

00:31:29,460 --> 00:31:31,764  
but back in the day when  
I was a grad student

759

00:31:31,764 --> 00:31:33,630  
when I would get very stressed,

760

00:31:33,630 --> 00:31:35,940  
I read the Sandman comics, right?

761

00:31:35,940 --> 00:31:39,270  
And so I had this chance  
to talk to Neil Gaiman

762

00:31:39,270 --> 00:31:40,650  
and I said, thank you, Neil Gaiman,

763

00:31:40,650 --> 00:31:45,120  
you got me through my  
PhD, and he was so amazed

764

00:31:45,120 --> 00:31:47,520  
because he knew that, of  
course, he had a lot of fans,

765

00:31:47,520 --> 00:31:49,616  
no doubt, but he really felt that

766

00:31:49,616 --> 00:31:54,480  
being able to help with  
keeping me on track in science,

767

00:31:54,480 --> 00:31:57,540  
that was really something that  
he really enjoyed hearing,

768

00:31:57,540 --> 00:31:59,400  
so I feel like we should  
tell the "Star Trek" creators

769

00:31:59,400 --> 00:32:03,032  
how many people have gone

into science because of them,

770

00:32:03,032 --> 00:32:05,463  
but now I've forgotten  
what your question was.

771

00:32:06,630 --> 00:32:08,280  
- I think that you exactly answered it.

772

00:32:08,280 --> 00:32:09,417  
- That was how you got into science.

773

00:32:09,417 --> 00:32:10,950  
- How you got excited about science.

774

00:32:10,950 --> 00:32:12,180  
So it's "Star Trek," right?

775

00:32:12,180 --> 00:32:14,310  
- I'm curious what  
resonated about "Star Trek"

776

00:32:14,310 --> 00:32:16,350  
and was there a character or a storyline

777

00:32:16,350 --> 00:32:17,954  
that stuck in your mind and?

778

00:32:17,954 --> 00:32:22,680  
- It was this vision, just  
the idea that human beings

779

00:32:22,680 --> 00:32:25,883  
altogether with, just working together.

780

00:32:25,883 --> 00:32:27,630  
Each person on the crew

781

00:32:27,630 --> 00:32:29,713  
had their own contribution they made,

782  
00:32:29,713 --> 00:32:33,300  
so there was always something  
where sometimes it was,

783  
00:32:33,300 --> 00:32:37,050  
Sulu and sometimes it was  
Spock and Kirk and so on.

784  
00:32:37,050 --> 00:32:38,280  
Well, Kirk was always a leader,

785  
00:32:38,280 --> 00:32:41,250  
but everybody did have a role to play,

786  
00:32:41,250 --> 00:32:45,270  
and of course, being able  
to see that such a variety

787  
00:32:45,270 --> 00:32:48,210  
of different activities happening in space

788  
00:32:48,210 --> 00:32:51,315  
and being able to transcend  
all of our limited

789  
00:32:51,315 --> 00:32:55,680  
sorts of worries on Earth  
and we'll leave it all behind

790  
00:32:55,680 --> 00:32:59,261  
and think that big, to me,  
that idea was just wonderful.

791  
00:32:59,261 --> 00:33:02,663  
I would just sit there  
with my jaw on the floor



792

00:33:02,663 --> 00:33:04,850  
most of the time, no matter  
what the show was about.

793

00:33:04,850 --> 00:33:07,800  
It was just that being  
able to share in that

794

00:33:07,800 --> 00:33:09,150  
was really special.

795

00:33:09,150 --> 00:33:11,370  
- And how about deciding  
to pursue quantum?

796

00:33:11,370 --> 00:33:14,040  
Is that, was that also somehow  
sparked from "Star Trek,"

797

00:33:14,040 --> 00:33:15,371  
that you decided to explore quantum?

798

00:33:15,371 --> 00:33:18,120  
- You wanna to support  
people, beam them up?

799

00:33:18,120 --> 00:33:20,280  
- I have no idea, I had no idea

800

00:33:20,280 --> 00:33:22,680  
one day I'd be able to sit  
somewhere and say, yeah,

801

00:33:22,680 --> 00:33:25,110  
I just wrote this paper  
about teleportation.

802

00:33:25,110 --> 00:33:29,250  
I mean, oh my gosh, if I could

tell my younger self that.

803

00:33:29,250 --> 00:33:30,212

That would be.

- Yeah, what would she think

804

00:33:30,212 --> 00:33:31,795

if her older self said,

805

00:33:31,795 --> 00:33:34,230

oh, you're studying

teleportation for real.

806

00:33:34,230 --> 00:33:37,841

- She, yeah, you're an

alien from a future world

807

00:33:37,841 --> 00:33:39,903

trying to trick me into something.

808

00:33:40,862 --> 00:33:42,810

- That's the "Star Trek"

skepticism building.

809

00:33:42,810 --> 00:33:43,643

- Exactly.

810

00:33:43,643 --> 00:33:47,220

But no, I think that for

me, quantum, of course,

811

00:33:47,220 --> 00:33:49,620

was not connected back

to when I was a kid.

812

00:33:49,620 --> 00:33:52,950

I did do a summer project

as an undergraduate.

813

00:33:52,950 --> 00:33:55,560  
I highly recommend that,  
if you can get a chance,

814  
00:33:55,560 --> 00:33:57,480  
if you're an undergraduate  
student and you want

815  
00:33:57,480 --> 00:34:02,480  
to explore what science is all  
about, then a summer project

816  
00:34:02,520 --> 00:34:05,451  
is great because in class  
you learn a lot, sure,

817  
00:34:05,451 --> 00:34:08,224  
but you don't get to explore on your own.

818  
00:34:08,224 --> 00:34:11,130  
You don't get to dip your  
toes into these waters

819  
00:34:11,130 --> 00:34:12,570  
where you don't quite know the answer.

820  
00:34:12,570 --> 00:34:14,790  
For me, perhaps, that's  
a moment where I started

821  
00:34:14,790 --> 00:34:17,243  
really understanding, oh, not  
knowing is really fun for me,

822  
00:34:17,243 --> 00:34:20,160  
'cause I didn't know  
anything in that project.

823  
00:34:20,160 --> 00:34:21,780  
My professor was super patient,

824

00:34:21,780 --> 00:34:23,670  
he gave me this calculation to do.

825

00:34:23,670 --> 00:34:26,760  
Later on I realized it  
was about a particular

826

00:34:26,760 --> 00:34:28,260  
quantum Hamiltonian and so on.

827

00:34:28,260 --> 00:34:29,820  
I didn't even know what any of that meant.

828

00:34:29,820 --> 00:34:31,410  
I was just calculating blindly,

829

00:34:31,410 --> 00:34:33,573  
but I kind of had to get the code to work

830

00:34:33,573 --> 00:34:36,870  
and calculate something, and  
I knew there was a new thing,

831

00:34:36,870 --> 00:34:39,360  
and eventually it would  
be used to understand

832

00:34:39,360 --> 00:34:41,490  
something about electrons and so on.

833

00:34:41,490 --> 00:34:44,326  
So that was my first taste of quantum.

834

00:34:44,326 --> 00:34:46,080  
I could do the calculation,

835

00:34:46,080 --> 00:34:49,140

so my professor suggested that I should

836

00:34:49,140 --> 00:34:51,930

perhaps think about  
grad school in quantum,

837

00:34:51,930 --> 00:34:55,740

and that's how it started,  
and once I was in,

838

00:34:55,740 --> 00:34:58,230

I'm like, well yeah, this is for me.

839

00:34:58,230 --> 00:34:59,070

Nobody knows anything

840

00:34:59,070 --> 00:35:00,798

and you're supposed to not know things.

841

00:35:00,798 --> 00:35:02,640

(room laughs)

842

00:35:02,640 --> 00:35:03,473

Obviously.

843

00:35:03,473 --> 00:35:05,370

- You're starting on the right foot.

844

00:35:05,370 --> 00:35:07,320

- Well, we had another  
question that was sent in

845

00:35:07,320 --> 00:35:11,040

kind of of how your research  
has evolved since that time,

846

00:35:11,040 --> 00:35:13,320

and this one was actually  
sent in by a former student

847

00:35:13,320 --> 00:35:16,830

of yours and a former podcast  
guest of ours, Meenu Kumari,

848

00:35:16,830 --> 00:35:20,370

who's a postdoctoral  
researcher here at Perimeter.

849

00:35:20,370 --> 00:35:22,350

- Hi Shohini, this is Meenu.

850

00:35:22,350 --> 00:35:25,650

My question is related to  
your PhD and postoc times.

851

00:35:25,650 --> 00:35:28,230

Given the current revival of  
the field of quantum chaos

852

00:35:28,230 --> 00:35:31,170

in multiple contexts,  
would you like to briefly

853

00:35:31,170 --> 00:35:33,455

tell us a bit about your  
fundamental research

854

00:35:33,455 --> 00:35:36,780

in quantum chaos in your PhD and postdoc?

855

00:35:36,780 --> 00:35:39,363

It would also be great if  
you could first recount

856

00:35:39,363 --> 00:35:41,509

how you started working in this field

857

00:35:41,509 --> 00:35:43,890

in your PhD in the first place.

858

00:35:43,890 --> 00:35:45,270

Thank you.

859

00:35:45,270 --> 00:35:46,830

- Thanks, Meenu.

860

00:35:46,830 --> 00:35:49,030

I'll start with the last  
question with how I started.

861

00:35:49,030 --> 00:35:52,950

So in grad school I was  
working on this one project.

862

00:35:52,950 --> 00:35:53,940

Again, when you start,

863

00:35:53,940 --> 00:35:55,050

you don't quite know what you're doing.

864

00:35:55,050 --> 00:35:57,750

So my professor, this was my  
graduate school professor,

865

00:35:57,750 --> 00:36:00,810

Ivan Deutsch, who was my  
PhD supervisor, he said,

866

00:36:00,810 --> 00:36:03,150

why don't you explore this one system

867

00:36:03,150 --> 00:36:04,950

that we've been thinking  
about for a long time?

868

00:36:04,950 --> 00:36:08,850

It has to do with an electron

again in a particular system

869

00:36:08,850 --> 00:36:11,430  
controlled with certain  
magnets and lasers and so on.

870

00:36:11,430 --> 00:36:12,990  
Why don't you model it  
and try to understand

871

00:36:12,990 --> 00:36:16,260  
what's quantum about it, and  
in order to understand what,

872

00:36:16,260 --> 00:36:17,700  
when something is quantum,

873

00:36:17,700 --> 00:36:20,490  
you want to compare it to  
when it's not quantum, really.

874

00:36:20,490 --> 00:36:23,310  
So his project to me was  
why don't you model it,

875

00:36:23,310 --> 00:36:24,930  
but not as a quantum particle.

876

00:36:24,930 --> 00:36:28,410  
Model it as just a regular  
what we call a classical model,

877

00:36:28,410 --> 00:36:29,790  
so that's what I did.

878

00:36:29,790 --> 00:36:32,730  
I went and wrote down the model  
and I started coding it up,

879



00:36:32,730 --> 00:36:34,380  
trying to see what would the behavior be,

880  
00:36:34,380 --> 00:36:37,320  
what would the trajectories  
look like as this electron

881  
00:36:37,320 --> 00:36:40,410  
feels all these forces,  
a pretend model, really,

882  
00:36:40,410 --> 00:36:42,810  
of classicality, and it wouldn't work.

883  
00:36:42,810 --> 00:36:44,160  
My code, no matter what I did,

884  
00:36:44,160 --> 00:36:46,350  
I kept getting this weird sort of,

885  
00:36:46,350 --> 00:36:48,000  
everything looked random all the time,

886  
00:36:48,000 --> 00:36:49,920  
and when I changed something small,

887  
00:36:49,920 --> 00:36:51,679  
everything again changed a lot.

888  
00:36:51,679 --> 00:36:52,820  
I had no idea.

889  
00:36:52,820 --> 00:36:54,450  
It didn't strike me that, of course,

890  
00:36:54,450 --> 00:36:56,007  
that is the signature of chaos:

891

00:36:56,007 --> 00:36:58,080  
when you change something very small,

892  
00:36:58,080 --> 00:36:59,970  
it's like the butterfly flaps its wings

893  
00:36:59,970 --> 00:37:01,620  
and then you get these storms.

894  
00:37:01,620 --> 00:37:03,900  
That's really what I was  
seeing, but I didn't know it,

895  
00:37:03,900 --> 00:37:07,184  
and luckily, when I showed  
it to my supervisor,

896  
00:37:07,184 --> 00:37:09,090  
there was somebody else in the team

897  
00:37:09,090 --> 00:37:11,723  
who was able to recognize and say, oh,

898  
00:37:11,723 --> 00:37:13,740  
are you sure that's not chaos?

899  
00:37:13,740 --> 00:37:15,690  
So that's how it started,  
and then of course,

900  
00:37:15,690 --> 00:37:18,458  
I went and learned all about  
it, and it indeed it was chaos,

901  
00:37:18,458 --> 00:37:22,050  
and for me that became  
such a key question to me:

902  
00:37:22,050 --> 00:37:24,150

what's quantum about quantum?

903

00:37:24,150 --> 00:37:26,520

So over the years, the  
systems I've studied

904

00:37:26,520 --> 00:37:28,320

to understand chaos have evolved.

905

00:37:28,320 --> 00:37:30,900

Turns out it's still one of  
the open questions in quantum,

906

00:37:30,900 --> 00:37:34,380

as in we don't quite know  
why we have this phenomenon

907

00:37:34,380 --> 00:37:36,750

that we see in the  
weather patterns and so on

908

00:37:36,750 --> 00:37:39,420

at our macro level,  
but we don't quite know

909

00:37:39,420 --> 00:37:42,767

how it manifests at the quantum  
level or if it does at all.

910

00:37:42,767 --> 00:37:45,300

That's a pretty big thing not to know.

911

00:37:45,300 --> 00:37:48,199

See, I'm like, wow, big  
thing that's unknown,

912

00:37:48,199 --> 00:37:50,178

this is like a magnet for me.

913

00:37:50,178 --> 00:37:51,540  
- That's amazing.

914  
00:37:51,540 --> 00:37:55,800  
- Yeah, and so that's why  
I continued in that area,

915  
00:37:55,800 --> 00:37:58,950  
and my next step was to try to  
think of how can we actually

916  
00:37:58,950 --> 00:38:01,140  
even study some of this in the lab

917  
00:38:01,140 --> 00:38:03,481  
rather than just do the  
calculations and simulate it,

918  
00:38:03,481 --> 00:38:07,200  
and luckily at the time, my supervisor,

919  
00:38:07,200 --> 00:38:09,390  
Ivan Deutsch was working quite closely

920  
00:38:09,390 --> 00:38:11,790  
with an experimental  
group led by Poul Jessen

921  
00:38:11,790 --> 00:38:13,380  
at the University of Arizona,

922  
00:38:13,380 --> 00:38:15,241  
so that's how I got  
connected to that group,

923  
00:38:15,241 --> 00:38:18,892  
and over the years we ended  
up developing an experiment

924

00:38:18,892 --> 00:38:20,628  
to try to see what happens

925  
00:38:20,628 --> 00:38:23,340  
when you have these individual electrons

926  
00:38:23,340 --> 00:38:26,610  
that are evolving in this particular model

927  
00:38:26,610 --> 00:38:28,200  
that I had already modeled classically,

928  
00:38:28,200 --> 00:38:30,900  
so classically, we saw  
this chaotic behavior.

929  
00:38:30,900 --> 00:38:32,690  
The question is, could we  
see any glimpse of that

930  
00:38:32,690 --> 00:38:35,548  
at the quantum level in  
the actual experiment?

931  
00:38:35,548 --> 00:38:38,400  
And you know, turns out it's,  
of course, quite difficult.

932  
00:38:38,400 --> 00:38:39,240  
For me, it was easy,

933  
00:38:39,240 --> 00:38:41,673  
I could just change some  
numbers on the computer,

934  
00:38:41,673 --> 00:38:45,075  
but to map that into an  
experiment and do it,

935

00:38:45,075 --> 00:38:47,100  
of course, took a lot of time and effort,

936  
00:38:47,100 --> 00:38:50,915  
and the group at Arizona was  
amazing, but eventually we did,

937  
00:38:50,915 --> 00:38:54,690  
we did an experiment where  
we could actually observe.

938  
00:38:54,690 --> 00:38:57,870  
We took photos of this,  
individual electrons

939  
00:38:57,870 --> 00:38:59,760  
that were evolving in this particular

940  
00:38:59,760 --> 00:39:02,220  
controlled sort of Hamiltonian,

941  
00:39:02,220 --> 00:39:05,160  
which is really just a fancy  
word for a controlled system

942  
00:39:05,160 --> 00:39:07,350  
where we control all  
the lasers and magnets.

943  
00:39:07,350 --> 00:39:11,820  
So we took photos, or images  
really, not real photos,

944  
00:39:11,820 --> 00:39:15,930  
but a way to make a photo of  
what this system is doing,

945  
00:39:15,930 --> 00:39:18,698  
and then you overlay all the  
photos at different times

946

00:39:18,698 --> 00:39:21,150

and put them all together,  
and it's a movie.

947

00:39:21,150 --> 00:39:23,098

So we watched this atom evolve,

948

00:39:23,098 --> 00:39:25,380

whatever these controlled fields were,

949

00:39:25,380 --> 00:39:28,980

and it did actually reflect  
this chaotic behavior,

950

00:39:28,980 --> 00:39:31,200

so it was just wonderful to see that,

951

00:39:31,200 --> 00:39:32,370

and that was the first time anybody

952

00:39:32,370 --> 00:39:34,800

had seen that kind of  
chaos, so, and after that,

953

00:39:34,800 --> 00:39:37,350

of course, that became sort  
of my central focus area

954

00:39:37,350 --> 00:39:39,960

and I'm still working in  
questions on quantum chaos

955

00:39:39,960 --> 00:39:41,640

and different types of systems

956

00:39:41,640 --> 00:39:44,483

and different kinds of  
questions around what happens

957

00:39:44,483 --> 00:39:48,582

when we try to characterize  
something like entanglement,

958

00:39:48,582 --> 00:39:50,790

which we think of as a quantum thing.

959

00:39:50,790 --> 00:39:52,587

What happens to entanglement

960

00:39:52,587 --> 00:39:55,740

when we think about a chaotic system

961

00:39:55,740 --> 00:39:58,530

where there's all of  
this at the macro level,

962

00:39:58,530 --> 00:40:01,890

but entanglement doesn't  
have a classical analog,

963

00:40:01,890 --> 00:40:05,880

so would it have this classical  
chaotic signature at all?

964

00:40:05,880 --> 00:40:08,520

These are open questions,  
and actually, with Meenu,

965

00:40:08,520 --> 00:40:11,010

we've learned a lot about  
these kinds of systems,

966

00:40:11,010 --> 00:40:15,720

and she's herself discovered  
these lovely sort of ways

967

00:40:15,720 --> 00:40:18,180



to think about entanglement and chaos

968

00:40:18,180 --> 00:40:19,140

and how they're connected,

969

00:40:19,140 --> 00:40:20,640

and there's definitely relationships,

970

00:40:20,640 --> 00:40:22,980

so we we're trying to  
generalize some of them.

971

00:40:22,980 --> 00:40:24,960

- When I was rewatching your Ted Talk,

972

00:40:24,960 --> 00:40:26,820

I jotted down a few of my favorite lines,

973

00:40:26,820 --> 00:40:29,363

and this is related to just the enthusiasm

974

00:40:29,363 --> 00:40:31,590

that you speak about this stuff with.

975

00:40:31,590 --> 00:40:34,486

You said it's a lot of fun  
being a quantum physicist,

976

00:40:34,486 --> 00:40:35,894

I highly recommend it,

977

00:40:35,894 --> 00:40:38,220

which got a nice laugh from the audience,

978

00:40:38,220 --> 00:40:39,180

but can you elaborate on that?

979

00:40:39,180 --> 00:40:42,600

Like what, where is the fun in what seems

980

00:40:42,600 --> 00:40:45,450

like really difficult  
math and there's coding

981

00:40:45,450 --> 00:40:49,290

and there's experiments, and  
the line about recommending it,

982

00:40:49,290 --> 00:40:50,670

do you recommend it to anyone or is it,

983

00:40:50,670 --> 00:40:52,700

does it take a certain type of person

984

00:40:52,700 --> 00:40:55,320

to want to dive into  
this certain type of fun?

985

00:40:55,320 --> 00:40:58,713

- Well, I think there's one  
common fundamental requirement

986

00:40:58,713 --> 00:41:00,510

if you want to do quantum,

987

00:41:00,510 --> 00:41:01,890

I guess maybe it's even beyond quantum,

988

00:41:01,890 --> 00:41:03,870

but definitely for quantum,  
since that's my area.

989

00:41:03,870 --> 00:41:06,660

That's you gotta be curious  
and you have to be okay

990

00:41:06,660 --> 00:41:09,810

with not knowing everything,  
as in you have to be okay

991

00:41:09,810 --> 00:41:13,320  
with being right at the edge  
and being frustrated often,

992

00:41:13,320 --> 00:41:16,442  
because our limited minds,  
where we keep seeking intuition,

993

00:41:16,442 --> 00:41:19,140  
it really isn't there,  
so if you happen to be

994

00:41:19,140 --> 00:41:21,810  
the kind of person who  
likes that kind of mystery,

995

00:41:21,810 --> 00:41:25,050  
then I feel like this would  
be a good area for you.

996

00:41:25,050 --> 00:41:28,050  
But fundamentally, yes,  
is there math involved?

997

00:41:28,050 --> 00:41:28,883  
Of course.

998

00:41:28,883 --> 00:41:30,630  
Do you have to do a lot of learning?

999

00:41:30,630 --> 00:41:34,020  
Sure, but if you wanted to,  
let's say, be a ballet dancer,

1000

00:41:34,020 --> 00:41:35,880  
it's not like you're not  
gonna have to put in the work.

1001

00:41:35,880 --> 00:41:36,990

It's not all fun.

1002

00:41:36,990 --> 00:41:39,747

You wanna play basketball,  
that's fun too, but guess what?

1003

00:41:39,747 --> 00:41:41,190

You really wanna play it well,

1004

00:41:41,190 --> 00:41:42,926

you gotta do the work, and  
this is why it's important

1005

00:41:42,926 --> 00:41:45,968

to find that area, whether  
it's quantum or something else,

1006

00:41:45,968 --> 00:41:48,870

find the area that you know  
where you wanna go with it.

1007

00:41:48,870 --> 00:41:49,740

What's the purpose?

1008

00:41:49,740 --> 00:41:51,300

Why did you choose that field?

1009

00:41:51,300 --> 00:41:53,850

Because then, when it  
gets hard and you fail,

1010

00:41:53,850 --> 00:41:56,100

which you will often  
in almost every field,

1011

00:41:56,100 --> 00:41:59,010

certainly quantum, you're

going to have that energy

1012

00:41:59,010 --> 00:42:02,010  
to get up again, because you  
know what your passion is.

1013

00:42:02,010 --> 00:42:04,080  
So that's why people  
talk a lot about passion,

1014

00:42:04,080 --> 00:42:07,342  
because passion is what  
makes you get over failure.

1015

00:42:07,342 --> 00:42:09,480  
- You've hit dead ends  
and had failures, and.

1016

00:42:09,480 --> 00:42:11,370  
- Yeah, it happens a lot, so.

1017

00:42:11,370 --> 00:42:12,300  
- More than success?

1018

00:42:12,300 --> 00:42:13,883  
- Yeah, we write all of our papers

1019

00:42:13,883 --> 00:42:15,900  
and do the presentation that talks about

1020

00:42:15,900 --> 00:42:19,140  
these rare moments of success,  
like watching those movies.

1021

00:42:19,140 --> 00:42:22,890  
We don't write about the six  
years of movie after movie

1022

00:42:22,890 --> 00:42:25,440

where all you see is darkness.

1023

00:42:25,440 --> 00:42:27,160

Imagine papers like that.

1024

00:42:27,160 --> 00:42:28,017

(room laughs)

1025

00:42:28,017 --> 00:42:29,190

- I feel like we should have that.

1026

00:42:29,190 --> 00:42:30,870

- The Journal of Failed Experiments.

1027

00:42:30,870 --> 00:42:31,710

- That would be great.

1028

00:42:31,710 --> 00:42:33,690

- I sometimes think we should  
write about those more,

1029

00:42:33,690 --> 00:42:35,190

though, because sometimes it can actually

1030

00:42:35,190 --> 00:42:36,900

save another person work, first of all,

1031

00:42:36,900 --> 00:42:39,060

but it also can be inspiring to see

1032

00:42:39,060 --> 00:42:41,730

how long it actually  
takes to see the success.

1033

00:42:41,730 --> 00:42:42,563

- I think so.

1034

00:42:42,563 --> 00:42:43,410

- At least we should do a summary.

1035

00:42:43,410 --> 00:42:46,320

In every talk, we should have one slide of

1036

00:42:46,320 --> 00:42:47,970

this is everything that we went through,

1037

00:42:47,970 --> 00:42:49,560

and this was a level of pain.

1038

00:42:49,560 --> 00:42:53,588

We should have a little,  
bar, right, scale for us.

1039

00:42:53,588 --> 00:42:56,220

Everybody's scale would max out, I think.

1040

00:42:56,220 --> 00:42:57,720

- I would love it if in one of your talks,

1041

00:42:57,720 --> 00:43:00,420

you just started with a  
movie that was just darkness.

1042

00:43:00,420 --> 00:43:01,740

- That's such a good idea.

1043

00:43:01,740 --> 00:43:02,800

Maybe I will.

1044

00:43:02,800 --> 00:43:03,900

- Thank you.

1045

00:43:03,900 --> 00:43:06,210

- So for you, what's the  
equivalent of the ballet dancer

1046

00:43:06,210 --> 00:43:08,190  
actually dancing or the basketball player

1047  
00:43:08,190 --> 00:43:09,870  
shooting the winning basket?

1048  
00:43:09,870 --> 00:43:12,544  
Like, what's the equivalent  
for a quantum scientist

1049  
00:43:12,544 --> 00:43:13,886  
in terms of the fun?

1050  
00:43:13,886 --> 00:43:17,310  
- The fun is seeing that non-dark movie,

1051  
00:43:17,310 --> 00:43:19,350  
when you do that, or often it's, I mean,

1052  
00:43:19,350 --> 00:43:21,060  
I was lucky that it was actually a movie,

1053  
00:43:21,060 --> 00:43:25,410  
but often it's one little number  
or something you calculate

1054  
00:43:25,410 --> 00:43:28,770  
or a little plot which  
goes just slightly up

1055  
00:43:28,770 --> 00:43:31,140  
rather than down, those are the moments,

1056  
00:43:31,140 --> 00:43:33,420  
and then there are also these  
other unexpected moments.

1057  
00:43:33,420 --> 00:43:36,990  
So one time, I'd given this



student a calculation to do.

1058

00:43:36,990 --> 00:43:38,730

They came back with the calculation

1059

00:43:38,730 --> 00:43:41,490

and it looked completely wrong  
from what I had expected.

1060

00:43:41,490 --> 00:43:43,452

I'm like, are you sure  
that's even correct?

1061

00:43:43,452 --> 00:43:46,440

Oh wait, it's obviously  
wrong, go and check it again.

1062

00:43:46,440 --> 00:43:48,870

So I checked and came back  
like, it's actually correct.

1063

00:43:48,870 --> 00:43:50,352

I can prove it, here it is.

1064

00:43:50,352 --> 00:43:52,860

And turns out it was correct  
and it was unexpected

1065

00:43:52,860 --> 00:43:56,730

because again, the intuition  
that I had about what to expect

1066

00:43:56,730 --> 00:43:59,250

was completely wrong, and  
what he found was in fact

1067

00:43:59,250 --> 00:44:02,424

so interesting because it  
was not what we expected

1068

00:44:02,424 --> 00:44:04,523  
that we wrote a whole paper about that

1069

00:44:04,523 --> 00:44:06,990  
and why it was completely different,

1070

00:44:06,990 --> 00:44:09,240  
so those moments are just fabulous.

1071

00:44:09,240 --> 00:44:10,883  
- I can see your face light  
up when you talk about it.

1072

00:44:10,883 --> 00:44:13,290  
- Yes, because those are very rare,

1073

00:44:13,290 --> 00:44:16,950  
but days and months or years  
of not getting anywhere,

1074

00:44:16,950 --> 00:44:19,278  
all of it becomes worth  
it when that happens.

1075

00:44:19,278 --> 00:44:22,544  
- And Shohini, in addition  
to being a professor in,

1076

00:44:22,544 --> 00:44:25,440  
working in this quantum research,  
you're also the Director

1077

00:44:25,440 --> 00:44:27,780  
of the Laurier Centre  
for Women in Science.

1078

00:44:27,780 --> 00:44:29,850  
Can you tell us a little  
bit about this center

1079  
00:44:29,850 --> 00:44:32,010  
and what the goals are for it?

1080  
00:44:32,010 --> 00:44:35,460  
- So this center, again,  
arose from this evolution

1081  
00:44:35,460 --> 00:44:38,347  
in my own personal journey  
where I realized that,

1082  
00:44:38,347 --> 00:44:43,020  
to really be engaged in good science,

1083  
00:44:43,020 --> 00:44:46,740  
I have to also engage in  
understanding my own identity,

1084  
00:44:46,740 --> 00:44:48,952  
the context of science  
and things like this.

1085  
00:44:48,952 --> 00:44:52,830  
So the center is unique in that  
we wanted to bring together

1086  
00:44:52,830 --> 00:44:55,140  
scientists like me, and  
not just in physics,

1087  
00:44:55,140 --> 00:44:58,350  
but in all of the natural  
sciences, with social scientists

1088  
00:44:58,350 --> 00:45:00,900  
who did think about questions  
like gender and identity,

1089

00:45:00,900 --> 00:45:02,580  
and this one focused on women in science

1090  
00:45:02,580 --> 00:45:04,740  
just because that was an area

1091  
00:45:04,740 --> 00:45:06,540  
that there were a lot of researchers

1092  
00:45:06,540 --> 00:45:07,830  
that I knew were in the field,

1093  
00:45:07,830 --> 00:45:10,620  
so we brought them in,  
and it was about bringing

1094  
00:45:10,620 --> 00:45:13,742  
those two pieces that were  
usually siloed together

1095  
00:45:13,742 --> 00:45:16,500  
and getting new conversations started

1096  
00:45:16,500 --> 00:45:19,644  
and then developing  
scholarship-based initiatives

1097  
00:45:19,644 --> 00:45:22,770  
to try to be more  
inclusive, and I find out

1098  
00:45:22,770 --> 00:45:25,470  
what the problems are and then  
address them going forward,

1099  
00:45:25,470 --> 00:45:27,527  
so that's what we've  
been doing in the center.

1100

00:45:27,527 --> 00:45:31,110  
- And what are some of the  
key problems you've identified

1101  
00:45:31,110 --> 00:45:33,098  
in some of the solutions  
you've been working towards?

1102  
00:45:33,098 --> 00:45:35,959  
- What we've been focused on,  
actually, for a long time,

1103  
00:45:35,959 --> 00:45:38,712  
is how can we do things like girls camps,

1104  
00:45:38,712 --> 00:45:42,837  
or outreach that interests  
girls in science.

1105  
00:45:42,837 --> 00:45:44,950  
Turns out, girls are quite  
interested in science,

1106  
00:45:44,950 --> 00:45:47,250  
and then there's all the math camps

1107  
00:45:47,250 --> 00:45:49,541  
who try to make girls better at math,

1108  
00:45:49,541 --> 00:45:52,590  
but girls actually are  
outperforming boys at math,

1109  
00:45:52,590 --> 00:45:54,840  
and we're still having  
math camps for girls.

1110  
00:45:54,840 --> 00:45:57,630  
So. what we found is that the initiatives

1111  
00:45:57,630 --> 00:46:00,780  
are often not aligned with  
what is a real problem.

1112  
00:46:00,780 --> 00:46:02,246  
Similarly with things like mentoring,

1113  
00:46:02,246 --> 00:46:05,310  
women are over mentored,  
to be honest, right now,

1114  
00:46:05,310 --> 00:46:09,390  
because it's all about let's  
help and support them somehow.

1115  
00:46:09,390 --> 00:46:11,010  
It's not that that's what's missing,

1116  
00:46:11,010 --> 00:46:14,370  
it's about is the system  
providing enough opportunities

1117  
00:46:14,370 --> 00:46:15,450  
in an equal way?

1118  
00:46:15,450 --> 00:46:18,540  
No amount of mentoring  
will help if already,

1119  
00:46:18,540 --> 00:46:21,360  
there's a totally skewed sort of system

1120  
00:46:21,360 --> 00:46:23,430  
where there's no way for a woman

1121  
00:46:23,430 --> 00:46:25,530  
to climb beyond a certain point.

1122

00:46:25,530 --> 00:46:28,440  
So really what, the discovery was that

1123  
00:46:28,440 --> 00:46:31,860  
there are all kinds of  
systemic barriers and biases

1124  
00:46:31,860 --> 00:46:33,420  
that are not being focused on.

1125  
00:46:33,420 --> 00:46:35,820  
On the other hand, all  
the initiatives are more

1126  
00:46:35,820 --> 00:46:38,910  
about fixing the women rather  
than fixing the system,

1127  
00:46:38,910 --> 00:46:42,690  
so our big model became fix  
the system, not the women.

1128  
00:46:42,690 --> 00:46:44,640  
I think that applies to  
everything that we do.

1129  
00:46:44,640 --> 00:46:47,910  
So for example, we're not  
doing things like math camps.

1130  
00:46:47,910 --> 00:46:50,880  
We are doing mentoring,  
but framing it as something

1131  
00:46:50,880 --> 00:46:54,126  
that's really about adapting  
to a system that is flawed,

1132  
00:46:54,126 --> 00:46:56,160  
so until the system is fixed,

1133  
00:46:56,160 --> 00:46:57,870  
of course we need more of that mentoring

1134  
00:46:57,870 --> 00:47:00,150  
and we need to have that extra help

1135  
00:47:00,150 --> 00:47:02,100  
and support that's missing,

1136  
00:47:02,100 --> 00:47:04,920  
because everybody's not  
starting at the same point

1137  
00:47:04,920 --> 00:47:06,342  
and given the same push,

1138  
00:47:06,342 --> 00:47:09,300  
so that's why we are  
addressing these questions.

1139  
00:47:09,300 --> 00:47:11,580  
But the long term goal is fix the system,

1140  
00:47:11,580 --> 00:47:13,080  
which is why we were involved in things

1141  
00:47:13,080 --> 00:47:15,660  
like Canada's Dimensions Charter,

1142  
00:47:15,660 --> 00:47:19,800  
which is about a systemic  
evaluation across Canada

1143  
00:47:19,800 --> 00:47:21,063  
and trying to build policies,

1144  
00:47:21,063 --> 00:47:25,890



a culture of change rather  
than just individual help.

1145

00:47:25,890 --> 00:47:28,500

- And this problem of  
building a culture of change,

1146

00:47:28,500 --> 00:47:30,932

I think it can sometimes  
feel very overwhelming

1147

00:47:30,932 --> 00:47:33,570

and hard to know exactly what to do,

1148

00:47:33,570 --> 00:47:36,630

but I know for myself  
sometimes some of the moments

1149

00:47:36,630 --> 00:47:38,940

that have felt most  
inspiring is when I realized

1150

00:47:38,940 --> 00:47:43,110

that just a very simple  
change that I could make

1151

00:47:43,110 --> 00:47:45,660

writing something differently  
on a course outline

1152

00:47:45,660 --> 00:47:48,030

or something like this,  
which I can very easily do,

1153

00:47:48,030 --> 00:47:51,030

can actually have a big  
impact on some students

1154

00:47:51,030 --> 00:47:51,960

that I'm working with or something.

1155  
00:47:51,960 --> 00:47:53,940  
Are there any small things like that

1156  
00:47:53,940 --> 00:47:56,730  
that any theoretical  
physicist could implement

1157  
00:47:56,730 --> 00:48:01,140  
to make academic environments  
a little bit more inclusive?

1158  
00:48:01,140 --> 00:48:01,973  
- So many.

1159  
00:48:01,973 --> 00:48:02,979  
Where to start?

1160  
00:48:02,979 --> 00:48:06,330  
We do actually have lists,  
and I'm happy to provide them.

1161  
00:48:06,330 --> 00:48:08,130  
For example, to build  
on what you were saying

1162  
00:48:08,130 --> 00:48:10,140  
about small changes in the classroom,

1163  
00:48:10,140 --> 00:48:12,433  
if you were to open any  
physics textbook today

1164  
00:48:12,433 --> 00:48:15,270  
and look for names of physicists,

1165  
00:48:15,270 --> 00:48:20,270  
you'd find Newton and Einstein  
and perhaps Bohr and Maxwell.

1166

00:48:20,739 --> 00:48:22,980

You will never find a single woman's name.

1167

00:48:22,980 --> 00:48:25,440

Not even Marie Curie is actually included

1168

00:48:25,440 --> 00:48:27,990

in physics textbooks, perhaps

in chemistry textbooks,

1169

00:48:27,990 --> 00:48:30,090

but not physics, so there are zero names,

1170

00:48:30,090 --> 00:48:31,860

so that's one thing that as an educator,

1171

00:48:31,860 --> 00:48:34,230

if you happen to be teaching a course,

1172

00:48:34,230 --> 00:48:36,180

if you look at the topic you're teaching

1173

00:48:36,180 --> 00:48:39,090

and do a little bit of

digging, it'll be amazing

1174

00:48:39,090 --> 00:48:40,980

how many women have contributed

1175

00:48:40,980 --> 00:48:42,660

who are not being mentioned at all,

1176

00:48:42,660 --> 00:48:45,210

and there's so much inspiration

to be had in their stories,

1177

00:48:45,210 --> 00:48:46,890

because typically they did it

1178

00:48:46,890 --> 00:48:49,050  
while they were facing  
many challenges and biases,

1179

00:48:49,050 --> 00:48:50,790  
so that's something that can be done

1180

00:48:50,790 --> 00:48:52,548  
that we can all work on.

1181

00:48:52,548 --> 00:48:55,380  
As a researcher, one  
thing that I've been doing

1182

00:48:55,380 --> 00:48:57,300  
in my own papers is there's always

1183

00:48:57,300 --> 00:48:59,100  
an acknowledgement section that we put in

1184

00:48:59,100 --> 00:49:01,170  
where we thank people  
who were involved in it,

1185

00:49:01,170 --> 00:49:04,140  
and I put in a land acknowledgement,  
so that is documented

1186

00:49:04,140 --> 00:49:07,410  
that we are on this land  
of indigenous peoples,

1187

00:49:07,410 --> 00:49:09,660  
so I think that's  
something we could all do.

1188

00:49:09,660 --> 00:49:11,670

Imagine how many research papers

1189

00:49:11,670 --> 00:49:14,220  
are submitted and  
published every single day.

1190

00:49:14,220 --> 00:49:15,930  
Imagine if we all did that

1191

00:49:15,930 --> 00:49:17,610  
That's true documentation,

1192

00:49:17,610 --> 00:49:20,460  
goes beyond just what we do today,

1193

00:49:20,460 --> 00:49:22,230  
because it's in the record,

1194

00:49:22,230 --> 00:49:26,460  
so that's another example  
where it takes zero effort.

1195

00:49:26,460 --> 00:49:29,641  
Once you have it, you put  
it into all of your papers.

1196

00:49:29,641 --> 00:49:31,950  
- Well, this seems like  
maybe a good time to mention

1197

00:49:31,950 --> 00:49:33,270  
the book that you're working on.

1198

00:49:33,270 --> 00:49:34,983  
Can you tell us about that project?

1199

00:49:34,983 --> 00:49:39,983  
- Yes, so my own effort  
to exactly do my part

1200  
00:49:40,830 --> 00:49:44,010  
to tell these stories about all the women

1201  
00:49:44,010 --> 00:49:47,010  
who have been ignored is to  
sit down and write about them,

1202  
00:49:47,010 --> 00:49:49,757  
so for the pandemic,  
that's been my big project.

1203  
00:49:49,757 --> 00:49:51,465  
- Yeah, that's your lockdown activity?

1204  
00:49:51,465 --> 00:49:54,540  
- Yes, it's the kind of thing  
where I can do it by myself,

1205  
00:49:54,540 --> 00:49:57,870  
so that was good, but I felt  
like I wasn't alone doing it,

1206  
00:49:57,870 --> 00:50:00,720  
just 'cause all these women  
that I was writing about

1207  
00:50:00,720 --> 00:50:03,210  
and researching, they seem  
to be there all the time.

1208  
00:50:03,210 --> 00:50:04,860  
It was really actually very inspirational

1209  
00:50:04,860 --> 00:50:06,765  
and the best therapy, so.

1210  
00:50:06,765 --> 00:50:09,540  
I've been writing about

all these women physicists

1211

00:50:09,540 --> 00:50:11,220

who some of them have,

1212

00:50:11,220 --> 00:50:13,785

we know if you happen to be in the field,

1213

00:50:13,785 --> 00:50:18,150

but they're not widely known  
the way we know Einstein

1214

00:50:18,150 --> 00:50:19,830

or you know Newton and so on.

1215

00:50:19,830 --> 00:50:21,737

So I wanted to tell their stories,

1216

00:50:21,737 --> 00:50:25,530

not just the science they  
did, but also the context,

1217

00:50:25,530 --> 00:50:27,660

and the fact that a lot  
of their experiences

1218

00:50:27,660 --> 00:50:29,250

are still relevant today,

1219

00:50:29,250 --> 00:50:31,440

so I approach it through  
my own experiences.

1220

00:50:31,440 --> 00:50:33,180

So that's what the book is about,

1221

00:50:33,180 --> 00:50:34,980

and it's going to be published next year,

1222

00:50:34,980 --> 00:50:37,350  
and I hope lots of people  
know about lots of women

1223

00:50:37,350 --> 00:50:38,310  
from all around the world

1224

00:50:38,310 --> 00:50:40,530  
who've actually transformed physics.

1225

00:50:40,530 --> 00:50:42,000  
- Without any spoilers,

1226

00:50:42,000 --> 00:50:44,580  
could you maybe tell us  
about one particular woman

1227

00:50:44,580 --> 00:50:46,020  
that you learned about in this process

1228

00:50:46,020 --> 00:50:47,280  
that maybe you didn't know much about,

1229

00:50:47,280 --> 00:50:49,907  
and just a story that  
really resonated with you?

1230

00:50:49,907 --> 00:50:52,219  
- Being born and raised in India,

1231

00:50:52,219 --> 00:50:55,770  
when I was a student, I had  
never heard about this woman,

1232

00:50:55,770 --> 00:50:58,650  
even until quite late in my own career.

1233

00:50:58,650 --> 00:51:02,070



Because I engage a lot with  
trying to understand women

1234

00:51:02,070 --> 00:51:03,630  
role models and trying to find them,

1235

00:51:03,630 --> 00:51:05,640  
that's how I got to know about this woman,

1236

00:51:05,640 --> 00:51:08,490  
but she's really not  
that well known as yet,

1237

00:51:08,490 --> 00:51:09,450  
a little more than before,

1238

00:51:09,450 --> 00:51:12,090  
and her name is Bibha Chowdhuri,  
and it's amazing to me,

1239

00:51:12,090 --> 00:51:14,040  
because she's actually Bengali like I am.

1240

00:51:14,040 --> 00:51:17,010  
She's from Bengal and she  
has this incredible story

1241

00:51:17,010 --> 00:51:20,820  
because she was born and  
raised and did most of her work

1242

00:51:20,820 --> 00:51:22,543  
while India was still a colony.

1243

00:51:22,543 --> 00:51:26,548  
In that context, she got a PhD in physics,

1244

00:51:26,548 --> 00:51:29,730  
worked with two different

Nobel Prize winners,

1245

00:51:29,730 --> 00:51:31,110  
was involved in the discovery

1246

00:51:31,110 --> 00:51:33,870  
of two different fundamental  
particles in nature.

1247

00:51:33,870 --> 00:51:36,840  
Never got acknowledgement for  
any of it, but she published

1248

00:51:36,840 --> 00:51:41,023  
four different articles in  
"Nature" itself, the journal,

1249

00:51:41,023 --> 00:51:44,040  
which is unheard of even  
today to have that many,

1250

00:51:44,040 --> 00:51:46,740  
and she just published  
them back to back. (laughs)

1251

00:51:46,740 --> 00:51:47,670  
I know.

1252

00:51:47,670 --> 00:51:49,652  
She was really an incredible person,

1253

00:51:49,652 --> 00:51:52,230  
and it somehow didn't seem to bother her

1254

00:51:52,230 --> 00:51:54,930  
that she didn't get the  
kind of acknowledgement

1255

00:51:54,930 --> 00:51:58,320

and recognition that others  
were getting for work

1256

00:51:58,320 --> 00:52:00,643  
that she herself was doing,  
and that was, of course,

1257

00:52:00,643 --> 00:52:03,150  
a very common thing, unfortunately,

1258

00:52:03,150 --> 00:52:07,307  
but that combined with  
the context of India

1259

00:52:07,307 --> 00:52:12,000  
under British rule and lack  
of funding, lack of support,

1260

00:52:12,000 --> 00:52:14,430  
lack of infrastructure,  
and yet there she was

1261

00:52:14,430 --> 00:52:16,590  
discovering everything about the universe.

1262

00:52:16,590 --> 00:52:18,910  
And all the women have  
these kinds of huge stories.

1263

00:52:18,910 --> 00:52:21,090  
We're not talking about small discoveries,

1264

00:52:21,090 --> 00:52:23,880  
discoveries at that level  
that we just don't celebrate,

1265

00:52:23,880 --> 00:52:25,140  
which doesn't make sense.

1266

00:52:25,140 --> 00:52:28,590  
Imagine being a little  
girl growing up in India

1267  
00:52:28,590 --> 00:52:31,050  
and not knowing this woman's name.

1268  
00:52:31,050 --> 00:52:32,280  
Mind boggling.

1269  
00:52:32,280 --> 00:52:34,710  
- Does the book have a title yet?

1270  
00:52:34,710 --> 00:52:35,670  
- The working title

1271  
00:52:35,670 --> 00:52:38,790  
is "Invisible," in parenthesis, "Figures."

1272  
00:52:38,790 --> 00:52:41,340  
Of course, it's about shining a light

1273  
00:52:41,340 --> 00:52:43,840  
on all these invisible discoveries.

1274  
00:52:43,840 --> 00:52:46,860  
- So as you said, many of these scientists

1275  
00:52:46,860 --> 00:52:48,600  
have been invisible for many years,

1276  
00:52:48,600 --> 00:52:51,780  
but I guess there's also many other women

1277  
00:52:51,780 --> 00:52:53,610  
who could have been amazing scientists

1278  
00:52:53,610 --> 00:52:56,040

who didn't get to because  
of the systems that we have,

1279

00:52:56,040 --> 00:52:59,010  
so do you have hope that this  
is gonna change in the future,

1280

00:52:59,010 --> 00:53:02,024  
that there can be more women  
that can benefit all of us?

1281

00:53:02,024 --> 00:53:05,520  
- I absolutely have hope,  
but I know that the numbers

1282

00:53:05,520 --> 00:53:08,190  
are quite flat in the  
sense that we haven't

1283

00:53:08,190 --> 00:53:10,860  
seen much of an increase  
over the last decade.

1284

00:53:10,860 --> 00:53:14,460  
It's, there's been some,  
but at the rate we're going,

1285

00:53:14,460 --> 00:53:16,860  
we're talking about a century  
or more before we even get

1286

00:53:16,860 --> 00:53:19,647  
to equal numbers of women at higher ranks,

1287

00:53:19,647 --> 00:53:21,480  
and the thing is it takes time, of course.

1288

00:53:21,480 --> 00:53:24,390  
So for example, right now  
we know in Canada at least,

1289

00:53:24,390 --> 00:53:27,960

that we're roughly at about  
20% of high school students

1290

00:53:27,960 --> 00:53:30,300

when they choose what major they want,

1291

00:53:30,300 --> 00:53:32,310

about 20% choose physics,

1292

00:53:32,310 --> 00:53:35,850

but that means that 10, 20 years later,

1293

00:53:35,850 --> 00:53:37,770

professors in Canada at max,

1294

00:53:37,770 --> 00:53:40,020

unless we get many from outside,

1295

00:53:40,020 --> 00:53:42,930

at max, we're gonna have 20%  
of our physics professors

1296

00:53:42,930 --> 00:53:44,970

are gonna be women, and  
that will be 20 years later,

1297

00:53:44,970 --> 00:53:46,980

so this is why it'll take about a century,

1298

00:53:46,980 --> 00:53:49,260

so we need to start now  
and we need to do it better

1299

00:53:49,260 --> 00:53:50,580

than what we're doing now.

1300

00:53:50,580 --> 00:53:51,420  
Is it changing?

1301  
00:53:51,420 --> 00:53:53,190  
Yes, but not fast enough.

1302  
00:53:53,190 --> 00:53:56,550  
- You mentioned the need, not  
for more mentoring for girls

1303  
00:53:56,550 --> 00:53:59,520  
and young women, but for  
the system to change.

1304  
00:53:59,520 --> 00:54:01,800  
With the effort that's being put into

1305  
00:54:01,800 --> 00:54:03,510  
this sort of systematic  
change, do you think

1306  
00:54:03,510 --> 00:54:06,060  
we're seeing that  
timeline shrink, ideally,

1307  
00:54:06,060 --> 00:54:09,519  
between now and when we  
can see a real positive,

1308  
00:54:09,519 --> 00:54:11,370  
tangible difference?

1309  
00:54:11,370 --> 00:54:13,350  
- I hope so, but I feel like I,

1310  
00:54:13,350 --> 00:54:16,770  
as we've been talking  
throughout our conversation,

1311

00:54:16,770 --> 00:54:19,290  
we can't just say this one  
thing or that one thing,

1312  
00:54:19,290 --> 00:54:21,330  
specifically what will help or not.

1313  
00:54:21,330 --> 00:54:23,340  
It's a mixture of so  
many different factors,

1314  
00:54:23,340 --> 00:54:27,360  
including all of the influences  
on young girls and boys

1315  
00:54:27,360 --> 00:54:29,365  
from outside of even physics, right?

1316  
00:54:29,365 --> 00:54:32,490  
Go to any toy store and go  
look at the girls section

1317  
00:54:32,490 --> 00:54:33,540  
compared to the boys section.

1318  
00:54:33,540 --> 00:54:34,530  
They're not the same.

1319  
00:54:34,530 --> 00:54:36,235  
It makes no sense why  
they should be different,

1320  
00:54:36,235 --> 00:54:39,390  
but they are, so until we can  
change all the toy stores,

1321  
00:54:39,390 --> 00:54:41,470  
all the bookstores, what we see on TV,

1322



00:54:41,470 --> 00:54:44,334  
what we are doing in gatherings,

1323  
00:54:44,334 --> 00:54:47,850  
how parents are interacting  
with their kids,

1324  
00:54:47,850 --> 00:54:49,470  
there's just so many pieces.

1325  
00:54:49,470 --> 00:54:50,970  
Until we can change all of that,

1326  
00:54:50,970 --> 00:54:53,340  
we're not really going to address issues.

1327  
00:54:53,340 --> 00:54:54,960  
Is it possible to speed it up?

1328  
00:54:54,960 --> 00:54:57,270  
It's very difficult,  
let's put it that way,

1329  
00:54:57,270 --> 00:54:59,370  
but that doesn't mean  
we'll give up, of course.

1330  
00:54:59,370 --> 00:55:01,494  
- It's an unsolved  
problem, like you enjoy.

1331  
00:55:01,494 --> 00:55:03,390  
There's uncertainty, so you're.

1332  
00:55:03,390 --> 00:55:06,780  
- It's big and kinda hard  
and challenging, I'm in.

1333  
00:55:06,780 --> 00:55:07,769

- That's amazing.

1334

00:55:07,769 --> 00:55:09,390

- Yeah, I had been planning to ask you

1335

00:55:09,390 --> 00:55:10,470

how you stay motivated

1336

00:55:10,470 --> 00:55:13,290

for such a difficult  
and frustrating problem

1337

00:55:13,290 --> 00:55:15,360

that this is, but I  
think we have the answer.

1338

00:55:15,360 --> 00:55:18,750

You love uncertainty and  
you love hard problems, so.

1339

00:55:18,750 --> 00:55:22,187

- And also I think every  
single young person

1340

00:55:22,187 --> 00:55:27,187

who can take one more step  
towards that to me is a success.

1341

00:55:27,422 --> 00:55:30,599

So sometimes I'll get an  
email from somebody who says,

1342

00:55:30,599 --> 00:55:32,760

oh, I mean, I think I wanna do more

1343

00:55:32,760 --> 00:55:34,380

of what you were talking about.

1344

00:55:34,380 --> 00:55:37,740

That to me is just, it's  
like having turbo engines.

1345  
00:55:37,740 --> 00:55:39,180  
It keeps you going.

1346  
00:55:39,180 --> 00:55:40,620  
So yeah, that's really important.

1347  
00:55:40,620 --> 00:55:42,000  
You know, one person at a time.

1348  
00:55:42,000 --> 00:55:42,930  
We're gonna get there.

1349  
00:55:42,930 --> 00:55:45,270  
- I really love seeing some of the lessons

1350  
00:55:45,270 --> 00:55:46,860  
that you've been able to  
share that really come

1351  
00:55:46,860 --> 00:55:49,680  
from the intersection of making  
environments more inclusive,

1352  
00:55:49,680 --> 00:55:50,940  
but also your quantum work.

1353  
00:55:50,940 --> 00:55:52,770  
We talked about how this can teach us

1354  
00:55:52,770 --> 00:55:55,440  
about not being susceptible  
to binary thinking.

1355  
00:55:55,440 --> 00:55:57,090  
I know you also, in one of your talks,

1356

00:55:57,090 --> 00:55:59,220  
talked about how the universe  
doesn't care about gender,

1357

00:55:59,220 --> 00:56:01,050  
so we shouldn't either, things like this.

1358

00:56:01,050 --> 00:56:03,660  
I mean, are there any other unique lessons

1359

00:56:03,660 --> 00:56:05,280  
that you've really only been able to learn

1360

00:56:05,280 --> 00:56:07,680  
because of working at this intersection?

1361

00:56:07,680 --> 00:56:08,850  
- There's no such thing as failure.

1362

00:56:08,850 --> 00:56:11,160  
The good thing when  
everything is uncertain

1363

00:56:11,160 --> 00:56:15,385  
is that there's no real  
failure because failure itself,

1364

00:56:15,385 --> 00:56:17,850  
either it means you've  
discovered something new

1365

00:56:17,850 --> 00:56:21,870  
because something old has  
failed, or you've discovered

1366

00:56:21,870 --> 00:56:24,600  
that there's no one thing that is success,

1367

00:56:24,600 --> 00:56:27,210  
so either you have to try to go around

1368  
00:56:27,210 --> 00:56:28,680  
whatever is a barrier, because yeah,

1369  
00:56:28,680 --> 00:56:31,140  
that's a real failure and  
you, it just won't work,

1370  
00:56:31,140 --> 00:56:32,760  
but that means you have to adapt,

1371  
00:56:32,760 --> 00:56:34,950  
or it means that maybe  
there's just not one answer.

1372  
00:56:34,950 --> 00:56:36,030  
There's more than one.

1373  
00:56:36,030 --> 00:56:39,060  
So to me, that's been  
also another great lesson,

1374  
00:56:39,060 --> 00:56:41,598  
as in failure just rolls off now,

1375  
00:56:41,598 --> 00:56:44,848  
so another failure,  
yay, I'll celebrate it.

1376  
00:56:44,848 --> 00:56:47,190  
As you said, we should  
have that as a slide

1377  
00:56:47,190 --> 00:56:48,660  
in all of our presentations,

1378  
00:56:48,660 --> 00:56:51,510

or I'll start showing the failure movie or something.

1379

00:56:51,510 --> 00:56:53,027  
- Makes the success more exciting.

1380

00:56:53,027 --> 00:56:54,783  
- Celebrate the failure, I say.

1381

00:56:55,620 --> 00:56:57,690  
- You also do a lot of this kind of thing,

1382

00:56:57,690 --> 00:56:59,970  
where you talk about science to audiences

1383

00:56:59,970 --> 00:57:01,320  
that are not scientists.

1384

00:57:01,320 --> 00:57:03,600  
Why do you do so much of that?

1385

00:57:03,600 --> 00:57:04,433  
- Couple of reasons.

1386

00:57:04,433 --> 00:57:06,420  
Firstly, I feel like there's so many exciting things

1387

00:57:06,420 --> 00:57:08,820  
in physics that I've learned myself

1388

00:57:08,820 --> 00:57:11,250  
that feels like a big secret if I don't talk about it,

1389

00:57:11,250 --> 00:57:14,370  
right, so it's almost like I can't stop talking about it,

1390  
00:57:14,370 --> 00:57:16,728  
which is probably not a good  
thing in some situations.

1391  
00:57:16,728 --> 00:57:17,657  
- It's perfect for this situation.

1392  
00:57:17,657 --> 00:57:21,150  
- You're a captive  
audience, but often you say,

1393  
00:57:21,150 --> 00:57:23,520  
hi, I'm so and so,  
whatever, you're at a bar

1394  
00:57:23,520 --> 00:57:24,900  
and say hi, and I'm doing physics,

1395  
00:57:24,900 --> 00:57:26,760  
and people will turn around and run away,

1396  
00:57:26,760 --> 00:57:29,280  
so it's not always that I talk about it,

1397  
00:57:29,280 --> 00:57:32,370  
but I think it is important to not just

1398  
00:57:32,370 --> 00:57:34,050  
talk to fellow physicists, of course,

1399  
00:57:34,050 --> 00:57:35,310  
because yeah, we all get it.

1400  
00:57:35,310 --> 00:57:37,890  
We start from the assumption  
that I'm not the only one

1401  
00:57:37,890 --> 00:57:39,870

who gets this excited  
and giddy about physics.

1402

00:57:39,870 --> 00:57:42,050

In fact, everybody in  
physics is kind of like that.

1403

00:57:42,050 --> 00:57:44,010

We just don't show it, because  
when we give our talks,

1404

00:57:44,010 --> 00:57:46,230

we're very objective,  
and I don't know why,

1405

00:57:46,230 --> 00:57:49,170

because I know I'd prefer to  
be just excited all the time.

1406

00:57:49,170 --> 00:57:51,260

But this is where we start from,

1407

00:57:51,260 --> 00:57:55,497

already that assumption  
that we're all super into it

1408

00:57:55,497 --> 00:57:58,650

and we really want to learn  
more about the universe,

1409

00:57:58,650 --> 00:58:01,320

but perhaps somebody outside  
physics doesn't get it,

1410

00:58:01,320 --> 00:58:03,458

as in why are these dry equations

1411

00:58:03,458 --> 00:58:05,667

so important or interesting,



1412  
00:58:05,667 --> 00:58:09,270  
and that's why I think it's  
important to tell the story

1413  
00:58:09,270 --> 00:58:12,450  
behind those equations and  
the story of who we are,

1414  
00:58:12,450 --> 00:58:14,880  
why do we do physics and  
how do we do it in ways

1415  
00:58:14,880 --> 00:58:17,130  
that are about its relevance

1416  
00:58:17,130 --> 00:58:20,971  
and how it connects to  
our everyday lives too,

1417  
00:58:20,971 --> 00:58:24,840  
'cause it is one of the  
really unifying things.

1418  
00:58:24,840 --> 00:58:28,710  
We are all part of the same  
universe, so the more we know,

1419  
00:58:28,710 --> 00:58:32,970  
the more it helps us know ourselves too,

1420  
00:58:32,970 --> 00:58:34,530  
so I feel like that's the reason

1421  
00:58:34,530 --> 00:58:37,290  
that it's important to  
get everybody engaged.

1422  
00:58:37,290 --> 00:58:39,872  
Not to mention, we've just

seen throughout the pandemic

1423

00:58:39,872 --> 00:58:42,390  
the importance of really  
understanding science

1424

00:58:42,390 --> 00:58:43,950  
and making decisions

1425

00:58:43,950 --> 00:58:46,980  
and also knowing how to be  
critically thinking about it.

1426

00:58:46,980 --> 00:58:47,940  
What's the good science?

1427

00:58:47,940 --> 00:58:48,840  
What's the bad science?

1428

00:58:48,840 --> 00:58:50,460  
All of that can only happen

1429

00:58:50,460 --> 00:58:52,740  
if we reach outside of  
our own communities.

1430

00:58:52,740 --> 00:58:55,530  
To me that's a, it's a critical piece.

1431

00:58:55,530 --> 00:58:56,363  
- Well, Shohini,

1432

00:58:56,363 --> 00:58:58,350  
thank you so much for  
sitting down with us today.

1433

00:58:58,350 --> 00:59:00,240  
This has been an amazing conversation.

1434

00:59:00,240 --> 00:59:02,460

Thank you so much for  
sharing your time with us.

1435

00:59:02,460 --> 00:59:04,060

- Thank you, I had a lot of fun.

1436

00:59:06,660 --> 00:59:08,092

- Thanks so much for listening.

1437

00:59:08,092 --> 00:59:10,500

Perimeter Institute is a not for profit

1438

00:59:10,500 --> 00:59:12,030

charitable organization

1439

00:59:12,030 --> 00:59:14,460

that shares cutting edge  
ideas with the world,

1440

00:59:14,460 --> 00:59:16,770

thanks to the ongoing  
support of the governments

1441

00:59:16,770 --> 00:59:20,052

of Ontario and Canada, and  
thanks to donors like you.

1442

00:59:20,052 --> 00:59:21,991

Thanks for being part of the equation.

1443

00:59:21,991 --> 00:59:25,241

(bright ambient music)