1
00:00:00,273 --> 00:00:02,856
(gentle music)

2
00:00:08,920 --> 00:00:10,700
- Hello, everyone, and welcome back

3
00:00:10,700 --> 00:00:12,640
to Conversations at the Perimeter.

4
00:00:12,640 --> 00:00:15,540
I'm Colin and I'm with Lauren
and we are just thrilled

5
00:00:15,540 --> 00:00:18,240
to introduce you to our guests this time.

6
00:00:18,240 --> 00:00:21,410
They are Ghazal Geshnizjani
and Niayesh Afshordi.

7
00:00:21,410 --> 00:00:24,060
They are both researchers
here at Perimeter Institute.

8
00:00:24,060 --> 00:00:26,900
They work in astrophysics and cosmology,

9
00:00:26,900 --> 00:00:28,550
the Big Bang and black holes,

10
00:00:28,550 --> 00:00:31,150
and they also happen to
be married to one another.

11
00:00:31,150 --> 00:00:34,050
- We talk about a little bit
of everything in this episode.

12

00:00:34,050 --> 00:00:36,820
Niayesh also shares with us
that he's recently applied

13
00:00:36,820 --> 00:00:39,720
some of his knowledge and skills
from astrophysical modeling

14
00:00:39,720 --> 00:00:42,670
to studying the spread of COVID 19.

15
00:00:42,670 --> 00:00:45,560
And Ghazal tells us about
her recent children's book

16
00:00:45,560 --> 00:00:47,350
called "Bella, the Black Hole"

17
00:00:47,350 --> 00:00:49,950
and they also tell us a lot
about their work in equity,

18
00:00:49,950 --> 00:00:52,190
diversity and inclusion in academia.

19
00:00:52,190 --> 00:00:54,500
- And what's really fun about
interviewing them both at once

20
00:00:54,500 --> 00:00:57,150
is they just have this
fantastic rapport between them.

21
00:00:57,150 --> 00:00:58,840
They finish one another's sentences

22
00:00:58,840 --> 00:01:01,280
and start one another's
sentences and just have

23
00:01:01,280 --> 00:01:03,677
a great sort of fun
relationship with science

24
00:01:03,677 --> 00:01:06,430
and the family and with us,
so it was so fun to hear.

25
00:01:06,430 --> 00:01:08,150
- It really was a lot of fun.

26
00:01:08,150 --> 00:01:09,963
Let's step inside the Perimeter.

27
00:01:13,283 --> 00:01:15,730
Ghazal and Niayesh, thank you so much

28
00:01:15,730 --> 00:01:17,670
for sitting down with us today.

29
00:01:17,670 --> 00:01:20,610
So in preparing for
the conversation today,

30
00:01:20,610 --> 00:01:22,750
I was looking at both of your websites

31
00:01:22,750 --> 00:01:25,510
and I saw that Ghazal, you
describe yourself there

32
00:01:25,510 --> 00:01:27,500
as a cosmologist, while, Niayesh,

33
00:01:27,500 --> 00:01:29,250
you describe yourself on your website

34
00:01:29,250 --> 00:01:31,180

primarily as an astrophysicist.

35
00:01:31,180 --> 00:01:33,830
Are you able to tell us what
each of those words mean

36
00:01:33,830 --> 00:01:35,500
and maybe what the difference is?

37
00:01:35,500 --> 00:01:36,870
- Yeah, how do you possibly get along

38
00:01:36,870 --> 00:01:38,678
when you have such different careers?

39
00:01:38,678 --> 00:01:40,420
(all laughing)

40
00:01:40,420 --> 00:01:42,740
- It just reminded me like yesterday,

41
00:01:42,740 --> 00:01:45,310
one of our friends, our
colleagues on Twitter

42
00:01:45,310 --> 00:01:48,950
posted, "Does your Sunday
morning starts with arguing

43
00:01:48,950 --> 00:01:50,750
about the scattering amplitude?"

44
00:01:50,750 --> 00:01:53,026
And I'm like, "Only Sunday morning?"

45
00:01:53,026 --> 00:01:54,330
(all laughing)

46

00:01:54,330 --> 00:01:55,587
- Why wait till Sunday?

47
00:01:56,830 --> 00:02:00,800
- So I'm cosmologist, I guess
traditionally cosmologist,

48
00:02:00,800 --> 00:02:05,500
but it's hard to say these
things what each field is really

49
00:02:05,500 --> 00:02:07,840
because all the different disciplines

50
00:02:07,840 --> 00:02:11,360
have so many common interests
and it's always good.

51
00:02:11,360 --> 00:02:14,110
I tell my students right away, you know,

52
00:02:14,110 --> 00:02:16,970
don't just put yourself in one box.

53
00:02:16,970 --> 00:02:20,170
All the amazing things that
happen in science and physics

54
00:02:20,170 --> 00:02:23,570
is when people try to
reach over to other fields

55
00:02:23,570 --> 00:02:26,680
and we work with other ones
and see what they're doing.

56
00:02:26,680 --> 00:02:30,430
A lot of technical things,
a lot of methodology

57
00:02:30,430 --> 00:02:32,410
and other things that
come in other fields,

58
00:02:32,410 --> 00:02:35,450
really all of them are
related to nature and nature

59
00:02:35,450 --> 00:02:38,540
has same way of doing things,
so you learn from them

60
00:02:38,540 --> 00:02:40,250
what they have learned and right,

61
00:02:40,250 --> 00:02:43,450
so cosmology, I guess
technically is universe

62
00:02:43,450 --> 00:02:46,980
at really, really larger
scales beyond galaxies

63
00:02:46,980 --> 00:02:48,840
and the evolution of the universe,

64
00:02:48,840 --> 00:02:52,240
historically how it started
like and how it began,

65
00:02:52,240 --> 00:02:55,040
or as far as we can go
back in time to today

66
00:02:55,040 --> 00:02:58,960
how it's evolving and
what's gonna be its fate.

67
00:02:58,960 --> 00:03:01,500

Obviously the little things that we see,

68
00:03:01,500 --> 00:03:04,660
even as small as a planet in these scales

69
00:03:04,660 --> 00:03:08,620
came out of the universe so
everything we do in cosmology

70
00:03:08,620 --> 00:03:11,440
will have implication for understanding

71
00:03:11,440 --> 00:03:14,380
the rest of the science in the cosmos,

72
00:03:14,380 --> 00:03:19,320
like how the initial conditions
were set back in time

73
00:03:19,320 --> 00:03:23,230
which gave rise or planted
the seed or everything else

74
00:03:23,230 --> 00:03:24,530
that grew out of it.

75
00:03:24,530 --> 00:03:27,830
Okay, I leave the astro to Niayesh to go.

76
00:03:27,830 --> 00:03:30,310
- That's the excellent question
and I don't really know.

77
00:03:30,310 --> 00:03:32,480
I guess it's our historical differences,

78
00:03:32,480 --> 00:03:35,540
but as Ghazal mentioned,
cosmology is a study

79
00:03:35,540 --> 00:03:38,760
of universe as a whole and
in including its formation

80
00:03:38,760 --> 00:03:42,440
and its history, but
astrophysics can be that,

81
00:03:42,440 --> 00:03:45,830
but also can be just looking at things

82
00:03:45,830 --> 00:03:47,860
in more detail right now.

83
00:03:47,860 --> 00:03:51,330
I would say that astrophysics
has a broader purview

84
00:03:51,330 --> 00:03:55,017
in the sense that you could
get very deep in understanding

85
00:03:55,017 --> 00:03:58,380
the stars or molecular
clouds in our galaxy,

86
00:03:58,380 --> 00:04:01,950
or you could get deep in
understanding the early times

87
00:04:01,950 --> 00:04:04,270
at the Big Bang, so I would say, I mean,

88
00:04:04,270 --> 00:04:07,410
being an astrophysicist is
like being a generalist.

89
00:04:07,410 --> 00:04:10,136

My own background, when I was a teenager,

90
00:04:10,136 --> 00:04:12,430
I was an amateur astronomer.

91
00:04:12,430 --> 00:04:16,040
When we were taught what that
means, the meaning is lover,

92
00:04:16,040 --> 00:04:19,090
so someone who loves to do
something and that's using

93
00:04:19,090 --> 00:04:20,447
contrast to I guess
professional astronomers

94
00:04:20,447 --> 00:04:25,262
who do this just to make
money like I am now,

95
00:04:25,262 --> 00:04:29,880
but the amateurs do it for
the love of doing things

96
00:04:29,880 --> 00:04:31,520
or doing astronomy.

97
00:04:31,520 --> 00:04:32,830
- Did you have your own
telescope as a teenager?

98
00:04:32,830 --> 00:04:34,860
- I did have my own telescope.

99
00:04:34,860 --> 00:04:36,790
So I started from there.

100
00:04:36,790 --> 00:04:38,400

I mean, I wanted to do astronomy,

101
00:04:38,400 --> 00:04:41,290
study the stars and whatever
out there in the heavens

102
00:04:41,290 --> 00:04:42,880
just for the love of it.

103
00:04:42,880 --> 00:04:46,124
The question is when you
start at face, hard to stop,

104
00:04:46,124 --> 00:04:48,930
and if you wanna understand the stars,

105
00:04:48,930 --> 00:04:51,880
then you try to because you love it

106
00:04:51,880 --> 00:04:55,100
and if you understand galaxies
and if you wanna understand

107
00:04:55,100 --> 00:04:58,050
the Big Bang and it's
hard to stop at any point

108
00:04:58,050 --> 00:05:01,260
and that's where you become
an astrophysicist, right,

109
00:05:01,260 --> 00:05:04,440
so you just, yeah,
universe is your playground

110
00:05:04,440 --> 00:05:08,290
and you just cannot limit
yourself to studying one thing

111

00:05:08,290 --> 00:05:10,986
so you study everything.

112
00:05:10,986 --> 00:05:12,440
- The universe is your
playground, I like that.

113
00:05:12,440 --> 00:05:14,970
That should go on your business card.

114
00:05:14,970 --> 00:05:15,803
- Let me see.

115
00:05:17,160 --> 00:05:19,960
- I notice when I look through
the work that both of you do,

116
00:05:19,960 --> 00:05:22,010
there's a couple of recurring themes.

117
00:05:22,010 --> 00:05:24,690
One is black holes and
the other is the Big Bang

118
00:05:24,690 --> 00:05:26,820
or the very, very early universe.

119
00:05:26,820 --> 00:05:29,220
Are they related, black
holes and the Big Bang,

120
00:05:29,220 --> 00:05:30,970
and if so, can you tell us how?

121
00:05:30,970 --> 00:05:32,820
- Yeah, in a way they're very related.

122
00:05:32,820 --> 00:05:36,710
It has to do I guess with

Einstein theory of gravity.

123
00:05:36,710 --> 00:05:39,637
I sometimes when I'm
writing grants proposals,

124
00:05:39,637 --> 00:05:43,860
I would say when Einstein wrote
his own theory of gravity,

125
00:05:43,860 --> 00:05:47,410
he didn't think it would
bring also the breakdown

126
00:05:47,410 --> 00:05:49,950
of the theory, and I think in a way,

127
00:05:49,950 --> 00:05:54,270
both Big Bang and black
holes are what we call

128
00:05:54,270 --> 00:05:57,540
singularity points of Einstein gravity

129
00:05:57,540 --> 00:05:59,480
of general relativity,
which is like the points

130
00:05:59,480 --> 00:06:01,750
that general relativity is breaking down.

131
00:06:01,750 --> 00:06:05,970
- By singularity, that
means that this tiny point.

132
00:06:05,970 --> 00:06:07,720
- Doesn't have to be tiny,

133
00:06:07,720 --> 00:06:10,640

but it's a regime when
things are not working

134
00:06:10,640 --> 00:06:14,600
within the theory anymore,
so I guess technically

135
00:06:14,600 --> 00:06:17,410
there's different mathematical
ways to understanding

136
00:06:17,410 --> 00:06:19,900
and it's not clear cut at
all because when something

137
00:06:19,900 --> 00:06:22,547
is breaking down, how do you describe it

138
00:06:22,547 --> 00:06:23,500
with your theory because it's already,

139
00:06:23,500 --> 00:06:24,800
like your tools are breaking,

140
00:06:24,800 --> 00:06:26,330
so you cannot even characterize it,

141
00:06:26,330 --> 00:06:29,080
but the people that do
it in different ways,

142
00:06:29,080 --> 00:06:32,640
and one way to say this,
for example, a spacetime,

143
00:06:32,640 --> 00:06:36,108
this whole fabric is getting
so curved up that the curvature

144

00:06:36,108 --> 00:06:41,108
is getting infinite and we
know infinity is summary.

145
00:06:41,690 --> 00:06:45,210
It's not anymore mathematical-like.

146
00:06:45,210 --> 00:06:48,120
Or like geophysics, it's
trajectories that we follow

147
00:06:48,120 --> 00:06:51,630
the math on, then all of a
sudden they have end points

148
00:06:51,630 --> 00:06:53,590
and then we cannot go beyond that,

149
00:06:53,590 --> 00:06:56,700
so in a way so they
both are the same story.

150
00:06:56,700 --> 00:06:59,750
One is happening in time
as we go past in time

151
00:06:59,750 --> 00:07:03,480
in our history and the
other one is in space.

152
00:07:03,480 --> 00:07:06,640
In certain points in a
space, we see, we predict it,

153
00:07:06,640 --> 00:07:09,307
but at the same time we predict
that things are not working,

154
00:07:09,307 --> 00:07:10,240
are breaking up.

155
00:07:10,240 --> 00:07:13,240
- So you're using both
of those types of study

156
00:07:13,240 --> 00:07:16,150
to figure out the places
where Einstein's theory

157
00:07:16,150 --> 00:07:17,710
needs some improvement.

158
00:07:17,710 --> 00:07:18,613
- Yes, exactly.

159
00:07:19,550 --> 00:07:20,470
- Interesting.

160
00:07:20,470 --> 00:07:23,350
- This is probably a
gross oversimplification,

161
00:07:23,350 --> 00:07:27,550
but the way I understand it
is a black hole is this mass

162
00:07:27,550 --> 00:07:28,950
that things sort of fall into it,

163
00:07:28,950 --> 00:07:30,807
attracts into a singularity,

164
00:07:30,807 --> 00:07:32,810
and the Big Bang seems to be a singularity

165
00:07:32,810 --> 00:07:35,350
that does the opposite, bursts outward.

166

00:07:35,350 --> 00:07:39,110
Is that a gross oversimplification
of the similarities?

167
00:07:39,110 --> 00:07:40,650
You can say yes.

168
00:07:40,650 --> 00:07:41,483
- I would say no.

169
00:07:41,483 --> 00:07:44,383
I mean, we wrote a paper saying that.

170
00:07:45,320 --> 00:07:46,153
- You're saying it is true.

171
00:07:46,153 --> 00:07:48,157
- Yeah, I mean, I don't know
if it was worth a paper,

172
00:07:48,157 --> 00:07:49,890
but we actually published a paper

173
00:07:49,890 --> 00:07:52,123
and it wasn't Scientific America.

174
00:07:53,890 --> 00:07:54,723
No, I mean that.

175
00:07:54,723 --> 00:07:56,340
Actually, literally this is true.

176
00:07:56,340 --> 00:07:59,240
I mean the Big Bang is,
if you just turn the clock

177
00:07:59,240 --> 00:08:00,370
or the time backwards,

178
00:08:00,370 --> 00:08:02,310
then black hole looks like a Big Bang.

179
00:08:02,310 --> 00:08:04,410
If you hear of a black hole
that collapse of a star

180
00:08:04,410 --> 00:08:07,993
into point, but if you imagine
you just take that movie

181
00:08:07,993 --> 00:08:10,770
and run it backwards, it just is something

182
00:08:10,770 --> 00:08:12,640
came out of, well, nothing.

183
00:08:12,640 --> 00:08:16,130
There is the one cast that the
Big Bang happened everywhere

184
00:08:16,130 --> 00:08:18,440
and black hole is in one place.

185
00:08:18,440 --> 00:08:22,132
There lies the up basic,
had to make that work.

186
00:08:22,132 --> 00:08:25,200
That's I guess a billion
dollar question, if you will.

187
00:08:25,200 --> 00:08:28,820
So to make that work and make
Big Bang look the way we do

188
00:08:28,820 --> 00:08:31,800
see it and black holes the
way we do see them to be,

189
00:08:31,800 --> 00:08:33,445
you have to change something

190
00:08:33,445 --> 00:08:36,400
because black holes in one
place, Big Bang everywhere.

191
00:08:36,400 --> 00:08:39,750
- Can studying black
holes give you insight

192
00:08:39,750 --> 00:08:42,380
into the Big Bang or vice versa?

193
00:08:42,380 --> 00:08:43,990
- Yeah, I mean, I think so, yeah.

194
00:08:43,990 --> 00:08:46,610
I think there's a lot of
similarity in the things

195
00:08:46,610 --> 00:08:47,910
that could be happening.

196
00:08:47,910 --> 00:08:50,800
For example, if there is
a improvement of gravity

197
00:08:50,800 --> 00:08:54,140
or quantum gravity, learning
from one could shed light

198
00:08:54,140 --> 00:08:55,510
on the other one as well,

199
00:08:55,510 --> 00:08:57,820
but they also have their own differences.

200
00:08:57,820 --> 00:08:59,320
I would never say it's a burst.

201
00:08:59,320 --> 00:09:02,280
I would say it's like
Big Bang is in our back

202
00:09:02,280 --> 00:09:04,960
like a wall or something,
we come out of it.

203
00:09:04,960 --> 00:09:07,570
We don't know what's happening beyond it,

204
00:09:07,570 --> 00:09:10,147
but doesn't have to be like,
the reason I'm bringing up,

205
00:09:10,147 --> 00:09:12,250
but there is sometimes this misconception

206
00:09:12,250 --> 00:09:15,680
of its explosion and things
like that and I don't know,

207
00:09:15,680 --> 00:09:18,783
I feel like I don't
connect to that metaphor

208
00:09:18,783 --> 00:09:20,780
that it's explosion necessarily.

209
00:09:20,780 --> 00:09:24,580
It's something that, yeah,
it's kind of going in the past

210
00:09:24,580 --> 00:09:26,490
and all of a sudden we are cut back.

211
00:09:26,490 --> 00:09:28,620
We don't know what's happening beyond it.

212
00:09:28,620 --> 00:09:31,810
- Is Big Bang maybe unfortunate term

213
00:09:31,810 --> 00:09:34,020
because bang implies an explosion?

214
00:09:34,020 --> 00:09:36,750
- Yeah, so I often, like when
I'm teaching my students,

215
00:09:36,750 --> 00:09:39,500
I keep saying, "Call it a
Big Bang era, at least,"

216
00:09:39,500 --> 00:09:41,993
because we know things got
hotter and hotter and hotter,

217
00:09:41,993 --> 00:09:45,470
but I wouldn't say there
was one big explosion,

218
00:09:45,470 --> 00:09:47,610
at least that's my way
of thinking about it.

219
00:09:47,610 --> 00:09:50,720
- So yeah, the question
is it a point in a space

220
00:09:50,720 --> 00:09:52,560
or is it the point in time?

221
00:09:52,560 --> 00:09:56,430
This actually applies to both
Big Bang and black holes.

222
00:09:56,430 --> 00:10:00,200
There is this misconception
that the singularity or Big Bang

223
00:10:00,200 --> 00:10:01,440
is a point in a space.

224
00:10:01,440 --> 00:10:02,880
If you're far away from it,

225
00:10:02,880 --> 00:10:05,880
the Big Bang happened in one
point in space or, I mean,

226
00:10:05,880 --> 00:10:08,600
there's a singularity, the
percent of the black hole,

227
00:10:08,600 --> 00:10:09,433
that's not true.

228
00:10:09,433 --> 00:10:12,480
So in fact, both of
these are points in time,

229
00:10:12,480 --> 00:10:14,180
or as Ghazal said, is an era.

230
00:10:14,180 --> 00:10:16,480
So Big Bang is a point in time

231
00:10:16,480 --> 00:10:19,033
at which basically physics
breaks as we know it.

232
00:10:19,033 --> 00:10:21,170
Doesn't matter where you are.

233
00:10:21,170 --> 00:10:23,250
If you are happening or
you happen to be where

234
00:10:23,250 --> 00:10:25,947
Big Bang is happening, then
physics breaks down, basically,

235
00:10:25,947 --> 00:10:28,320
'cause it's an era or a point in time.

236
00:10:28,320 --> 00:10:30,620
The same is true at the
center of the black hole.

237
00:10:30,620 --> 00:10:33,810
It's not the point, but
rather anyone who happens

238
00:10:33,810 --> 00:10:37,180
to wander across the event
horizon of a black hole,

239
00:10:37,180 --> 00:10:39,590
they have one eventuality.

240
00:10:39,590 --> 00:10:41,910
There's an era at which
they will be crushed

241
00:10:41,910 --> 00:10:45,250
with this singularity and that's
a point in time, basically.

242
00:10:45,250 --> 00:10:47,370
That's an era in their future.

243
00:10:47,370 --> 00:10:49,283
It's like saying everybody dies.

244
00:10:50,570 --> 00:10:52,860
- It just happens faster if
you walk into a black hole.

245
00:10:52,860 --> 00:10:55,670
- It depends on how big
the black hole is, yes.

246
00:10:55,670 --> 00:10:59,461
But yes, indeed, and yeah, this
is not the point in a space.

247
00:10:59,461 --> 00:11:02,268
If you wander in anywhere
you are in there,

248
00:11:02,268 --> 00:11:04,304
then it's gonna happen to you.

249
00:11:04,304 --> 00:11:05,940
- And what are some of the ways
that you both think gravity

250
00:11:07,270 --> 00:11:10,660
might be modified to help improve the way

251
00:11:10,660 --> 00:11:12,350
we describe these things?

252
00:11:12,350 --> 00:11:14,790
- So the big elephant in the room,

253
00:11:14,790 --> 00:11:17,910
in fundamental physics and
especially in this building,

254
00:11:17,910 --> 00:11:19,810
is the quantum gravity, right?

255
00:11:19,810 --> 00:11:22,920
So we know physics has this regime

256
00:11:22,920 --> 00:11:27,230
that things become quantized
and all of our other forces

257
00:11:27,230 --> 00:11:30,550
of nature can be described in quantum way

258
00:11:30,550 --> 00:11:32,970
and there is this other force, gravity,

259
00:11:32,970 --> 00:11:36,070
that we have not been able
and we think it should also

260
00:11:36,070 --> 00:11:39,630
to merge all of this
together has to be also have

261
00:11:39,630 --> 00:11:41,300
a quantum description.

262
00:11:41,300 --> 00:11:44,010
A lot of people like, I don't
know, more than half of people

263
00:11:44,010 --> 00:11:45,510
in this building are working on that

264
00:11:45,510 --> 00:11:48,350
in different approaches,
so that could be one thing,

265
00:11:48,350 --> 00:11:52,261
I think, that eventual,
but there is also this idea

266
00:11:52,261 --> 00:11:55,490
and it's not new, I think,
it's has always been

267
00:11:55,490 --> 00:11:57,960
like since even Newton to
Einstein and other things

268
00:11:57,960 --> 00:12:02,030
that there is always a regime
when we describe things.

269
00:12:02,030 --> 00:12:03,700
You don't have to go all the way

270
00:12:03,700 --> 00:12:07,660
to very microscopic quantum
regime to understand physics.

271
00:12:07,660 --> 00:12:11,170
There may be some middle
ground coming from cosmology.

272
00:12:11,170 --> 00:12:13,340
I feel like this method
has a always worked,

273
00:12:13,340 --> 00:12:15,570
so maybe we don't have to,

274
00:12:15,570 --> 00:12:18,150
I don't have to start
from completely scratch

275
00:12:18,150 --> 00:12:19,630
to build up everything.

276
00:12:19,630 --> 00:12:22,710

Maybe start from things that
we know like Einstein gravity,

277
00:12:22,710 --> 00:12:23,950
we know works.

278
00:12:23,950 --> 00:12:27,320
Can we start modifying that
as slightly one by one?

279
00:12:27,320 --> 00:12:29,060
And maybe on the other side it's gonna be,

280
00:12:29,060 --> 00:12:31,170
eventually gonna reach to quantum gravity,

281
00:12:31,170 --> 00:12:34,600
but there's a middle way
that you better understand

282
00:12:34,600 --> 00:12:36,550
you are still connected
to GR and the things

283
00:12:36,550 --> 00:12:39,920
that you understand, but
slightly move away from that.

284
00:12:39,920 --> 00:12:44,557
These approaches in cosmology
are called modified gravities.

285
00:12:45,530 --> 00:12:48,560
And there is one that
Niayesh and I, for example,

286
00:12:48,560 --> 00:12:52,170
have been fond of and
worked on and thought of,

287
00:12:52,170 --> 00:12:54,590
which is the Cuscutan gravity.

288
00:12:54,590 --> 00:12:58,460
We have been working on that
because one thing interesting

289
00:12:58,460 --> 00:13:00,060
about it is that we noticed

290
00:13:00,060 --> 00:13:03,840
this is the minimal
modification of gravity.

291
00:13:03,840 --> 00:13:08,770
You don't add any additional
player to the game, as you say.

292
00:13:08,770 --> 00:13:10,290
- What would a player be?

293
00:13:10,290 --> 00:13:12,730
- A player, technically we call them

294
00:13:12,730 --> 00:13:15,410
dynamical degrees of freedom,

295
00:13:15,410 --> 00:13:20,410
things that can generate
additional dynamics in your field,

296
00:13:20,500 --> 00:13:25,270
like additional car or something
that moves things around,

297
00:13:25,270 --> 00:13:29,230
right, and gravity by itself doesn't have,

298

00:13:29,230 --> 00:13:33,320
has two, actually, two, which
are the gravitational waves,

299
00:13:33,320 --> 00:13:34,610
what people call.

300
00:13:34,610 --> 00:13:38,690
Other things that we have,
like every other thing,

301
00:13:38,690 --> 00:13:41,610
like varions or electrons,
things like that,

302
00:13:41,610 --> 00:13:42,630
you add to theories,

303
00:13:42,630 --> 00:13:45,350
they all have this
additional degree of freedom.

304
00:13:45,350 --> 00:13:46,880
You add them to your theory.

305
00:13:46,880 --> 00:13:48,660
These are the matter field

306
00:13:48,660 --> 00:13:50,400
and then there is general relativity,

307
00:13:50,400 --> 00:13:53,410
so usually the story is that
you add the matter fields

308
00:13:53,410 --> 00:13:56,660
and general relativity has
this own gravitational ways

309

00:13:56,660 --> 00:13:59,400
which really didn't play much for the,

310
00:13:59,400 --> 00:14:02,050
and we didn't detect them
until six years ago, right.

311
00:14:02,050 --> 00:14:05,680
Everything else we saw was this
matter force as generators.

312
00:14:05,680 --> 00:14:08,850
This Cuscutan is somewhere in the middle.

313
00:14:08,850 --> 00:14:12,007
It's a slightly modification
of general relativity

314
00:14:12,007 --> 00:14:15,860
and it doesn't add additional
generator, but modifies it,

315
00:14:15,860 --> 00:14:18,270
and we assume everything
else is the matter fields

316
00:14:18,270 --> 00:14:19,960
that we had as before.

317
00:14:19,960 --> 00:14:23,442
- Could you explain
the name again of that?

318
00:14:23,442 --> 00:14:27,470
- Cuscutan, Cuscutan is a field

319
00:14:27,470 --> 00:14:30,850
which modifies gravity,
but as I mentioned,

320
00:14:30,850 --> 00:14:33,870
because it doesn't have its
own dynamics or generator,

321
00:14:33,870 --> 00:14:38,210
I thought of something that's
the same thing on Earth,

322
00:14:38,210 --> 00:14:41,980
or like in everyday life,
and I thought of a plant,

323
00:14:41,980 --> 00:14:45,310
the parasite plant, which
can feed off other things

324
00:14:45,310 --> 00:14:47,210
and even modify their behavior,

325
00:14:47,210 --> 00:14:48,860
but doesn't have its own root.

326
00:14:48,860 --> 00:14:50,920
- So it winds around another plant

327
00:14:50,920 --> 00:14:53,640
and takes advantage of its root system.

328
00:14:53,640 --> 00:14:56,378
- It's called dodder, I guess it is.

329
00:14:56,378 --> 00:14:59,060
- I guess dodder is one, yeah.

330
00:14:59,060 --> 00:15:01,487
And then I thought of what's
the technical term for it

331

00:15:01,487 --> 00:15:05,190
and apparently in plant biology is called-

332
00:15:05,190 --> 00:15:06,611
- Botany.

333
00:15:06,611 --> 00:15:07,444
- Botany.

334
00:15:07,444 --> 00:15:08,883
- That's called Cuscuta.

335
00:15:10,780 --> 00:15:14,307
So therefore we draw, 'cause
I suggested the name Cuscutan

336
00:15:14,307 --> 00:15:16,819
and my collaborator accepted.

337
00:15:16,819 --> 00:15:17,760
- Yeah.

338
00:15:17,760 --> 00:15:21,160
As a metaphor of this idea
that it attaches to an existing

339
00:15:21,160 --> 00:15:24,740
theory without requiring
its own sort of roots.

340
00:15:24,740 --> 00:15:27,170
- Right, but it slightly modifies it

341
00:15:27,170 --> 00:15:31,800
in a way that might have
cosmological implications,

342
00:15:31,800 --> 00:15:35,270
but doesn't mess up other

things that we don't wanna miss.

343
00:15:35,270 --> 00:15:37,730
- And Ghazal, I know you
said that you and Niayesh

344
00:15:37,730 --> 00:15:40,040
worked on some aspects
of this theory together

345
00:15:40,040 --> 00:15:42,760
and now you've been doing
some further explorations.

346
00:15:42,760 --> 00:15:45,750
Can you tell us about some of
the things you both explored

347
00:15:45,750 --> 00:15:47,180
together and maybe some of the things

348
00:15:47,180 --> 00:15:48,830
you've continued to work on?

349
00:15:48,830 --> 00:15:50,797
- It's a long and winding road.

350
00:15:50,797 --> 00:15:55,797
It starts far, far, far away,
in fact, Madison, Wisconsin,

351
00:15:57,010 --> 00:15:58,620
when Ghazal was a postdoc

352
00:15:58,620 --> 00:16:00,900
with the Cosmologist, Daniel Chung,

353
00:16:00,900 --> 00:16:05,100
and I used to visit a lot,

but their story was really,

354
00:16:05,100 --> 00:16:07,840
what is the fastest that
something can travel

355
00:16:07,840 --> 00:16:10,610
and not violate the laws of relativity?

356
00:16:10,610 --> 00:16:12,740
And you would think that
nothing can travel faster

357
00:16:12,740 --> 00:16:14,800
than the speed of light,
but it turned out,

358
00:16:14,800 --> 00:16:18,190
in fact, Einstein's relativity
does allow for things that,

359
00:16:18,190 --> 00:16:21,590
on paper have things that
propagate infinitely fast

360
00:16:21,590 --> 00:16:23,700
and it's just very counterintuitive,

361
00:16:23,700 --> 00:16:25,980
so we try to make sense out of it

362
00:16:25,980 --> 00:16:28,480
and at the time we
realize that even though

363
00:16:28,480 --> 00:16:30,950
Einstein relativity seems to allow for it,

364
00:16:30,950 --> 00:16:33,950

you cannot actually send
information with it.

365
00:16:33,950 --> 00:16:36,960
And basically we started
exploring that and then ended up

366
00:16:36,960 --> 00:16:40,550
with this theory of a field,
which seemed to be doing this,

367
00:16:40,550 --> 00:16:43,700
that on paper it seemed
that it has basically waves,

368
00:16:43,700 --> 00:16:46,550
sound waves in it that
propagate infinitely fast,

369
00:16:46,550 --> 00:16:50,070
but in practice, you couldn't
actually send signals with it,

370
00:16:50,070 --> 00:16:51,420
but what could you do with it?

371
00:16:51,420 --> 00:16:53,240
It turns out, as Ghazal mentioned,

372
00:16:53,240 --> 00:16:56,670
it could modify the gravitational dynamics

373
00:16:56,670 --> 00:16:59,430
beyond Einstein's theory of relativity.

374
00:16:59,430 --> 00:17:00,840
And what was hot back then,

375
00:17:00,840 --> 00:17:03,680

I guess it's still hot
somewhat now, is dark energy.

376
00:17:03,680 --> 00:17:06,431
It was just discovered so I guess when we,

377
00:17:06,431 --> 00:17:10,353
they got the Nobel Prize,
I think it was 2011,

378
00:17:10,353 --> 00:17:12,020
I don't remember exactly, yeah,

379
00:17:12,020 --> 00:17:13,940
but it was discovered around 2000,

380
00:17:13,940 --> 00:17:15,410
around the turn of the century,

381
00:17:15,410 --> 00:17:19,670
so we kind of were halfway
between those at that point.

382
00:17:19,670 --> 00:17:22,400
- Could you just briefly
explain dark energy

383
00:17:22,400 --> 00:17:26,850
and what changed when it
was discovered in the 1990s?

384
00:17:26,850 --> 00:17:29,440
- Absolutely, so there is this big,

385
00:17:29,440 --> 00:17:30,780
there's been this big puzzle

386
00:17:30,780 --> 00:17:32,719
in Einstein's theory of relativity,

387
00:17:32,719 --> 00:17:35,170
in Einstein's gravity, for over a century

388
00:17:35,170 --> 00:17:36,003
since this was discovered.

389
00:17:36,003 --> 00:17:38,960
So in fact, Einstein,
when he first wrote down

390
00:17:38,960 --> 00:17:41,960
his equations, he added this constant

391
00:17:41,960 --> 00:17:44,600
called the cosmological
constant and he needed them

392
00:17:44,600 --> 00:17:47,880
to keep the universe
ecstatic because otherwise

393
00:17:47,880 --> 00:17:50,480
he wanted to either blow up or crash

394
00:17:50,480 --> 00:17:52,082
and he wanted to tame it,

395
00:17:52,082 --> 00:17:53,440
so he just basically added this thing

396
00:17:53,440 --> 00:17:55,100
as just as keep it there.

397
00:17:55,100 --> 00:17:57,740
It turned out that that
wasn't a very effective way

398

00:17:57,740 --> 00:17:59,870
of doing it and he later confessed

399
00:17:59,870 --> 00:18:02,600
that it was his biggest blunder
to actually add that there.

400
00:18:02,600 --> 00:18:04,990
If he hadn't, he actually
would've predicted universe

401
00:18:04,990 --> 00:18:07,570
cannot be a static and
Hubble later discovered

402
00:18:07,570 --> 00:18:08,980
the universe was not static.

403
00:18:08,980 --> 00:18:11,000
However that the cat was out of the bag,

404
00:18:11,000 --> 00:18:13,110
so this cosmology constant
that Einstein introduced

405
00:18:13,110 --> 00:18:15,430
never really disappeared,
so it was always there.

406
00:18:15,430 --> 00:18:18,590
People always knew about it
and it took another 100 years

407
00:18:18,590 --> 00:18:21,070
for people to actually
discover a sign of that

408
00:18:21,070 --> 00:18:22,450
or something like that.

409
00:18:22,450 --> 00:18:25,160
The problem is it's just such
a big surprise because it

410
00:18:25,160 --> 00:18:28,060
doesn't fit anything else that it has.

411
00:18:28,060 --> 00:18:30,810
So there is this thing
that looks like a constant.

412
00:18:30,810 --> 00:18:33,810
It has energy, it has pressure,
it has negative pressure,

413
00:18:33,810 --> 00:18:34,963
so the only thing that we know

414
00:18:34,963 --> 00:18:36,920
that does have negative pressure

415
00:18:36,920 --> 00:18:39,830
and it's a scale that is smaller
that by orders of magnitude

416
00:18:39,830 --> 00:18:43,590
than anything else we see around
us in the standard physics.

417
00:18:43,590 --> 00:18:46,810
So it's such a bizarre thing
that we kind of physicists

418
00:18:46,810 --> 00:18:48,226
had the field day with it.

419
00:18:48,226 --> 00:18:49,180
I guess they're still having.

420
00:18:49,180 --> 00:18:51,230
They invented all sorts of things

421
00:18:51,230 --> 00:18:54,530
with all sorts of funny
names to kind of model it.

422
00:18:54,530 --> 00:18:57,650
Unfortunately so far,
the evidence doesn't show

423
00:18:57,650 --> 00:18:59,740
that necessarily it's anything

424
00:18:59,740 --> 00:19:03,420
more than a cosmology
constant, but it could be.

425
00:19:03,420 --> 00:19:05,990
And at that time, basically
one of the possibilities

426
00:19:05,990 --> 00:19:08,025
we saw that, okay, so I mean,

427
00:19:08,025 --> 00:19:09,780
Einstein theory has been so successful,

428
00:19:09,780 --> 00:19:10,907
maybe it's a cosmology constant,

429
00:19:10,907 --> 00:19:13,720
but then what is the next simplest thing

430
00:19:13,720 --> 00:19:15,330
that we could come up with?

431
00:19:15,330 --> 00:19:17,680

And this Cuscutan was an idea,

432
00:19:17,680 --> 00:19:19,450
and it's the next
simplest things in a sense

433
00:19:19,450 --> 00:19:21,060
that you're not adding anything

434
00:19:21,060 --> 00:19:23,060
to Einstein's theory of
gravity and every other

435
00:19:23,060 --> 00:19:25,110
possibilities that people have studied,

436
00:19:25,110 --> 00:19:27,350
you're adding additional
degrees of freedom,

437
00:19:27,350 --> 00:19:30,170
additional kind of beasts into the theory

438
00:19:30,170 --> 00:19:32,800
and this one was not just the same beast,

439
00:19:32,800 --> 00:19:35,320
but just a slightly modified behavior.

440
00:19:35,320 --> 00:19:37,940
That was the beginning and we had,

441
00:19:37,940 --> 00:19:40,287
we kind of explored the
possibility, which is still there.

442
00:19:40,287 --> 00:19:43,580
The dark energy could be type of Cuscutan.

443
00:19:43,580 --> 00:19:46,150
We haven't confirmed or ruled it out yet.

444
00:19:46,150 --> 00:19:48,340
- And dark energy,
correct me if I'm wrong,

445
00:19:48,340 --> 00:19:51,270
it's what's making the universe expand

446
00:19:51,270 --> 00:19:52,710
in an accelerating rate.

447
00:19:52,710 --> 00:19:54,850
- That's right.
- Yes, exactly.

448
00:19:54,850 --> 00:19:59,357
Basically, cosmologists love
the term dark, whatever.

449
00:20:00,280 --> 00:20:01,700
You put that dark in front of it.

450
00:20:01,700 --> 00:20:04,328
- I noticed that, regarding dark matter.

451
00:20:04,328 --> 00:20:09,091
- We have now dark radiation, dark sirens.

452
00:20:09,091 --> 00:20:11,960
- Does it essentially mean unknown,

453
00:20:11,960 --> 00:20:13,740
it's an unknown quantity?

454
00:20:13,740 --> 00:20:15,568
We don't know what to call it aside from-

455
00:20:15,568 --> 00:20:16,401
- Most of the time.

456
00:20:16,401 --> 00:20:18,200
The dark sirens are slightly different,

457
00:20:18,200 --> 00:20:20,240
but most of the time.

458
00:20:20,240 --> 00:20:22,570
- Different times means different things,

459
00:20:22,570 --> 00:20:24,120
but for dark energy,

460
00:20:24,120 --> 00:20:25,903
it's probably as dark as it gets.

461
00:20:28,400 --> 00:20:30,530
It doesn't seem to be
interacting with anything,

462
00:20:30,530 --> 00:20:34,040
we don't see it, so that's
a term that, I don't know.

463
00:20:34,040 --> 00:20:37,200
I think Mike Turner
first invented that term,

464
00:20:37,200 --> 00:20:40,080
but I mean, people,
indeed, what was discovered

465
00:20:40,080 --> 00:20:43,350
with cosmic acceleration,
which was very surprising.

466
00:20:43,350 --> 00:20:45,550
You would think gravity is attractive,

467
00:20:45,550 --> 00:20:47,310
so if universe is expanding,

468
00:20:47,310 --> 00:20:49,870
it should be slowing
down because of gravity

469
00:20:49,870 --> 00:20:52,150
and low and behold when they measured it,

470
00:20:52,150 --> 00:20:54,040
they realize it's speeding up,

471
00:20:54,040 --> 00:20:56,570
but it turns out they
already had a model waiting

472
00:20:56,570 --> 00:20:59,450
like for 100 years to
explain it as Einstein's.

473
00:20:59,450 --> 00:21:01,870
- We are not sure yet,
like they're still like,

474
00:21:01,870 --> 00:21:03,700
we talk to a string theorist.

475
00:21:03,700 --> 00:21:08,380
First, I think when the
astrophysicists started noticing it,

476
00:21:08,380 --> 00:21:10,230
they were still in the camp that no,

477

00:21:10,230 --> 00:21:12,540
in the string theory,
there's no such thing

478
00:21:12,540 --> 00:21:14,860
cosmological constant, it cannot be.

479
00:21:14,860 --> 00:21:18,410
Then like once they observe
it and then all of a sudden

480
00:21:18,410 --> 00:21:20,100
they started, oh, actually we have.

481
00:21:20,100 --> 00:21:21,613
- 10 to the 500.

482
00:21:21,613 --> 00:21:24,490
- 500 of them in our
theory and they're like,

483
00:21:24,490 --> 00:21:25,882
now what do we do?

484
00:21:25,882 --> 00:21:27,326
Get rid of all of them.

485
00:21:27,326 --> 00:21:30,940
- Cannot quite decide is
zero or 10 to the 500.

486
00:21:32,644 --> 00:21:33,670
- Ballpark.

487
00:21:33,670 --> 00:21:35,600
- Yeah, so now there are a
couple of camps, apparently.

488
00:21:35,600 --> 00:21:37,130

Some are like, there are a lot of it

489
00:21:37,130 --> 00:21:39,280
and some are like, "No,
we cannot have it."

490
00:21:40,691 --> 00:21:43,860
But what is for sure certain
is that it's observed,

491
00:21:43,860 --> 00:21:45,040
something is there.

492
00:21:45,040 --> 00:21:45,873
- Yeah.

493
00:21:46,877 --> 00:21:49,193
Is one of the goals to try to explain it

494
00:21:49,193 --> 00:21:51,680
with as few new variables,

495
00:21:51,680 --> 00:21:54,410
as few complications as
possible and then add them?

496
00:21:54,410 --> 00:21:57,330
- For us, it is, yeah,
from our point of view.

497
00:21:57,330 --> 00:22:00,520
I guess our approach is
sometimes called bottom up.

498
00:22:00,520 --> 00:22:03,880
Their approach, starting from
very fundamental theories,

499
00:22:03,880 --> 00:22:06,980

top down approach, so they're
going working our way,

500
00:22:06,980 --> 00:22:07,863
it's going up.

501
00:22:09,048 --> 00:22:11,440
- Hoping to meet at some point some.

502
00:22:11,440 --> 00:22:13,650
- I wanted to ask, you've both studied

503
00:22:13,650 --> 00:22:18,102
the early, early universe
shortly after the Big Bang,

504
00:22:18,102 --> 00:22:21,390
is that research related to dark energy?

505
00:22:21,390 --> 00:22:24,130
Can we learn anything from
the origins of the universe

506
00:22:24,130 --> 00:22:26,710
about what it's doing now, it's
expansion and acceleration?

507
00:22:26,710 --> 00:22:29,580
- I think because a lot of
it is really mathmat, right,

508
00:22:29,580 --> 00:22:32,880
at the heart of it and the
mathematics that is describing

509
00:22:32,880 --> 00:22:37,150
the same theory, gravity,
so what applies back then

510

00:22:37,150 --> 00:22:39,240
should be applicable today as well.

511
00:22:39,240 --> 00:22:41,570
Some things may be more relevant back then

512
00:22:41,570 --> 00:22:44,270
than they are today because
energy is where universe

513
00:22:44,270 --> 00:22:46,920
was much hotter so than
today, it's much cold,

514
00:22:46,920 --> 00:22:49,900
but at the same time, yeah,
the rules be the same.

515
00:22:49,900 --> 00:22:53,260
That's why it's very easy
and it happens so very often.

516
00:22:53,260 --> 00:22:56,270
We learn something that can
be done in early universe

517
00:22:56,270 --> 00:22:59,370
and then few years after we
try to apply the same thing

518
00:22:59,370 --> 00:23:01,850
in late universe, oh, this
technique worked there,

519
00:23:01,850 --> 00:23:04,460
like in that context can
we do the same thing now

520
00:23:04,460 --> 00:23:08,057
in late universe and there's

so many examples of that.

521
00:23:08,057 --> 00:23:10,020
- I guess just to follow up on that,

522
00:23:10,020 --> 00:23:11,870
the most popular theory for the universe

523
00:23:11,870 --> 00:23:16,510
is called inflation, which in
fact is like a dark energy,

524
00:23:16,510 --> 00:23:20,630
but at like souped up or
on steroids, much higher,

525
00:23:20,630 --> 00:23:24,430
much higher energy, so
we see it happening now,

526
00:23:24,430 --> 00:23:26,750
but it's proposed that something like that

527
00:23:26,750 --> 00:23:29,860
with much, much higher rates
was happening early on.

528
00:23:29,860 --> 00:23:32,590
That's to one possibility that
could be a similar scenario,

529
00:23:32,590 --> 00:23:34,427
of course, on very different
scales of happening

530
00:23:34,427 --> 00:23:36,970
at acceleration of cosmic expansion.

531
00:23:36,970 --> 00:23:38,710

But beyond that, there
could be other possibility

532
00:23:38,710 --> 00:23:41,470
if you have like a cyclic
scenario of the universe,

533
00:23:41,470 --> 00:23:43,890
then in fact our future
is our past, so yeah,

534
00:23:43,890 --> 00:23:47,580
what's happening now like
the cosmic acceleration

535
00:23:47,580 --> 00:23:49,400
could be setting up the initial conditions

536
00:23:49,400 --> 00:23:52,270
for the next generation of the universe.

537
00:23:52,270 --> 00:23:53,690
So depending on the scenario,

538
00:23:53,690 --> 00:23:56,560
there could be even more cross-connections

539
00:23:56,560 --> 00:23:58,510
between early and late universe.

540
00:23:58,510 --> 00:24:01,162
- Could there be future Big Bangs?

541
00:24:01,162 --> 00:24:03,270
- There could be, yeah,
in a cyclic scenario.

542
00:24:03,270 --> 00:24:05,890
I mean, Roger Penrose

is a big fan of that,

543
00:24:05,890 --> 00:24:09,920
as our previous director, Neil
Turok and Paul Steinhardt.

544
00:24:09,920 --> 00:24:12,730
They had their different
models of cyclic universes

545
00:24:12,730 --> 00:24:15,340
and yeah, so that's
certainly one possibility

546
00:24:15,340 --> 00:24:17,150
that people have studied.

547
00:24:17,150 --> 00:24:19,900
- And is it possible
that this Cuscutan model

548
00:24:19,900 --> 00:24:21,983
would support some of those scenarios?

549
00:24:22,952 --> 00:24:26,410
- To be honest, I have
not considered that,

550
00:24:26,410 --> 00:24:29,500
but because it has, it's
kind of a like a puzzle.

551
00:24:29,500 --> 00:24:32,460
I have been focusing on
a particular piece of it

552
00:24:32,460 --> 00:24:37,460
just going from one contraction
to expansion, it seems,

553
00:24:38,760 --> 00:24:41,430
so let me back up a little bit.

554
00:24:41,430 --> 00:24:44,420
So if you wanna have, right
now the universe is expanding

555
00:24:44,420 --> 00:24:48,720
and accelerating so if I wanna
go back into the beginning,

556
00:24:48,720 --> 00:24:51,500
what scenarios could I imagine?

557
00:24:51,500 --> 00:24:56,500
One is that maybe then
expansion enters contraction

558
00:24:56,760 --> 00:24:59,800
and then again, expand,
that's one possibility,

559
00:24:59,800 --> 00:25:02,100
but there could be other
things like expands

560
00:25:02,100 --> 00:25:05,240
and then out of it something
bubbles out or tunnels out,

561
00:25:05,240 --> 00:25:07,440
and then again, so depending on this,

562
00:25:07,440 --> 00:25:09,390
then you have to work
on a different scenario

563
00:25:09,390 --> 00:25:11,970
for that transition to happen.

564
00:25:11,970 --> 00:25:15,560
But one thing I am
working on it, maybe this,

565
00:25:15,560 --> 00:25:18,920
at least we can figure out how
you can go from a contracting

566
00:25:18,920 --> 00:25:22,990
universe into expanding universe,
which is not an easy task,

567
00:25:22,990 --> 00:25:26,760
like general relativity doesn't
allow it because you violate

568
00:25:26,760 --> 00:25:30,210
center and energy condition,
which if you do that,

569
00:25:30,210 --> 00:25:34,500
then the things break loose,
a lot of instabilities,

570
00:25:34,500 --> 00:25:37,670
and here it again goes
through violent behaviors,

571
00:25:37,670 --> 00:25:41,027
but that's where right
now my focus, in fact,

572
00:25:41,027 --> 00:25:42,510
one of my program is.

573
00:25:42,510 --> 00:25:45,370
It looks like Cuscutan
can make that possible,

574
00:25:45,370 --> 00:25:48,810
so you could make universe
go through a contraction

575
00:25:48,810 --> 00:25:52,500
and then we call it a
bounce off into a expansion,

576
00:25:52,500 --> 00:25:55,370
so in that context, it could
fall into a bigger picture

577
00:25:55,370 --> 00:25:57,380
of cyclic universe.

578
00:25:57,380 --> 00:25:59,520
We haven't expanded too far.

579
00:25:59,520 --> 00:26:02,960
We are now focused on that
particular phase of bouncing,

580
00:26:02,960 --> 00:26:05,020
but yeah, certainly could be applicable

581
00:26:05,020 --> 00:26:07,020
to that bigger picture.

582
00:26:07,020 --> 00:26:09,540
- Yeah and I think answer leads
to maybe a bigger question

583
00:26:09,540 --> 00:26:11,420
that when you're trying to,

584
00:26:11,420 --> 00:26:14,040
I guess in the end of the
day, approach quantum gravity,

585
00:26:14,040 --> 00:26:16,480
there's so many different
ways to approach that

586
00:26:16,480 --> 00:26:18,907
and you're talking more
about modified gravity

587
00:26:18,907 --> 00:26:20,770
and there's so many ways within that,

588
00:26:20,770 --> 00:26:23,270
so we have a really good
question that was sent in

589
00:26:23,270 --> 00:26:25,260
by a master student, Anna Canura,

590
00:26:25,260 --> 00:26:26,780
here at the Perimeter Institute,

591
00:26:26,780 --> 00:26:28,940
so let's play that question.

592
00:26:28,940 --> 00:26:30,900
- How would you describe
each other's approach

593
00:26:30,900 --> 00:26:32,390
to doing physics?

594
00:26:32,390 --> 00:26:35,243
Would you say you have
different styles of research?

595
00:26:37,470 --> 00:26:40,293
- Long pause as they consider
their answers carefully.

596
00:26:40,293 --> 00:26:42,560
- I go first or do you wanna go?

597
00:26:42,560 --> 00:26:44,632
- My answer is yes.

598
00:26:44,632 --> 00:26:47,896
(all laughing)

599
00:26:47,896 --> 00:26:48,860
That's it.

600
00:26:48,860 --> 00:26:50,943
- We request a more elaborate answer.

601
00:26:52,890 --> 00:26:54,956
- Maybe I, yeah, I can.

602
00:26:54,956 --> 00:26:59,060
- Is that correct term cynical
or someone who is like,

603
00:26:59,060 --> 00:27:01,610
I have this approach that I question

604
00:27:01,610 --> 00:27:03,040
the validity of everything.

605
00:27:03,040 --> 00:27:06,240
Niayesh has this approach
that no, of course,

606
00:27:06,240 --> 00:27:07,697
that's the way it is, and I'm like,

607
00:27:07,697 --> 00:27:10,840
"No, sit down, let's write it."

608
00:27:10,840 --> 00:27:13,000
So it's a lot of back and forth argument.

609
00:27:13,000 --> 00:27:16,217
Like I am like, I don't
know, I always like,

610
00:27:16,217 --> 00:27:18,880
"No, there must be
something wrong with it.

611
00:27:18,880 --> 00:27:20,990
Let's check this aspect,
let's check that aspect."

612
00:27:20,990 --> 00:27:24,120
He is more optimistic
and like taking a leap

613
00:27:24,120 --> 00:27:28,050
to next big thing and, "Yeah,
universe goes from this

614
00:27:28,050 --> 00:27:29,670
and then cycles to that."

615
00:27:29,670 --> 00:27:31,258
And I'm like, "No, no, no.

616
00:27:31,258 --> 00:27:32,760
You know there's a lot
of things can go wrong.

617
00:27:32,760 --> 00:27:33,960
Let's work it out."

618
00:27:34,880 --> 00:27:36,010
- Is that an accurate depiction?

619
00:27:36,010 --> 00:27:38,391
- I think that's very accurate, yes.

620
00:27:38,391 --> 00:27:40,320
(all laughing)

621
00:27:40,320 --> 00:27:42,610
- But is it useful to have
both of those perspectives

622
00:27:42,610 --> 00:27:44,460
when you work together on something?

623
00:27:44,460 --> 00:27:48,070
- I think so, yeah, like
he, I'm trying to, yeah.

624
00:27:48,070 --> 00:27:51,251
- It sounds like two halves of
sort of one brain trying to,

625
00:27:51,251 --> 00:27:53,055
you know, check each other.

626
00:27:53,055 --> 00:27:55,520
- Check and balances, I guess, something.

627
00:27:55,520 --> 00:27:58,610
- Yeah, I think Ghazal is very
good at kind of identifying

628
00:27:58,610 --> 00:28:01,851
the details that are important
and needs to be understood

629
00:28:01,851 --> 00:28:04,480
to kind of for the whole
picture to make sense.

630
00:28:04,480 --> 00:28:06,400
My own approach is that
usually I have some

631
00:28:06,400 --> 00:28:08,413
very big pictures that this
should work and then I say,

632
00:28:08,413 --> 00:28:10,260
"So you need to fill out the detail,"

633
00:28:10,260 --> 00:28:11,820
and then either I ask someone to do it

634
00:28:11,820 --> 00:28:16,090
or just sit down and
count as hours and yeah.

635
00:28:16,090 --> 00:28:17,960
Sometimes the details will be filled out,

636
00:28:17,960 --> 00:28:19,480
more often than not, it doesn't,

637
00:28:19,480 --> 00:28:22,170
and just because the whole
picture was wrong sometimes,

638
00:28:22,170 --> 00:28:24,282
or maybe just takes much more time,

639
00:28:24,282 --> 00:28:28,680
but that's, yeah, that's the
approach, which I don't know,

640
00:28:28,680 --> 00:28:31,870
it's just worked for me,
but I think it's very good

641
00:28:31,870 --> 00:28:34,350
that Ghazal can identify all the places

642
00:28:34,350 --> 00:28:35,583
that it doesn't work.

643
00:28:37,460 --> 00:28:40,313
- Does that apply in life
outside of science too?

644
00:28:42,219 --> 00:28:43,440
- You can imagine.

645
00:28:43,440 --> 00:28:44,903
- Yeah, he is like, oh.

646
00:28:45,952 --> 00:28:48,413
You know, let's have kids do
this. I'm like, "Wait a minute.

647
00:28:49,719 --> 00:28:50,690
It doesn't work that easily.

648
00:28:50,690 --> 00:28:52,160
I have to do this research.

649
00:28:52,160 --> 00:28:53,923
You have to check that, you know."

650
00:28:55,463 --> 00:28:57,910
- Does this apply to the Cuscutan model?

651
00:28:57,910 --> 00:29:00,840
Ghazal, you're still checking
a lot of different aspects

652
00:29:00,840 --> 00:29:03,083
of that and really looking through it.

653
00:29:03,083 --> 00:29:04,773
- Exactly, like I am, yeah, I am that way.

654
00:29:04,773 --> 00:29:08,230
Like it takes me longer to
make sure I feel confident,

655
00:29:08,230 --> 00:29:11,320
you know, even though like I
have, we have I think by now

656
00:29:11,320 --> 00:29:15,050
three papers out, I'm still
like, "Okay, next let's do

657
00:29:15,050 --> 00:29:18,547
one additional step, check
this thing, check that thing."

658
00:29:19,610 --> 00:29:22,020
And I think to his credit,
he does a lot of that too.

659
00:29:22,020 --> 00:29:24,260
Like if he come, he has done it, like,

660
00:29:24,260 --> 00:29:27,611
this is very unique because
most physicists our expert

661
00:29:27,611 --> 00:29:30,150
in one particular field,
but Niayesh does this thing

662
00:29:30,150 --> 00:29:32,250
that he comes up with a theory,

663
00:29:32,250 --> 00:29:35,160

then he checks the data
and they're like, you know,

664
00:29:35,160 --> 00:29:37,863
goes to talk to the statistician

665
00:29:37,863 --> 00:29:40,860
and it's all like simulation
and does these things, but.

666
00:29:40,860 --> 00:29:43,330
- It does seem, Niayesh,
especially going through

667
00:29:43,330 --> 00:29:47,240
your website, the subject areas
that you're interested in,

668
00:29:47,240 --> 00:29:50,090
it gets to be a bit of a long list.

669
00:29:50,090 --> 00:29:52,280
There's all sorts of subject areas that,

670
00:29:52,280 --> 00:29:54,290
can you explain, is that just a,

671
00:29:54,290 --> 00:29:56,600
have you always been
curious about all sorts

672
00:29:56,600 --> 00:29:58,040
of different aspects of physics?

673
00:29:58,040 --> 00:30:01,099
- Yeah, it's kind of
this thing in your head.

674
00:30:01,099 --> 00:30:04,250

I guess you kind of, I start
exploring different things

675
00:30:04,250 --> 00:30:07,360
as a kid and then at some
point there's a switch there.

676
00:30:07,360 --> 00:30:09,950
It says, okay, "That's enough, probably.

677
00:30:09,950 --> 00:30:11,230
You wanna stop somewhere."

678
00:30:11,230 --> 00:30:13,720
And maybe that's missing in my head

679
00:30:13,720 --> 00:30:15,430
that kind of keep exploring.

680
00:30:15,430 --> 00:30:17,900
And the thing is, I mean,
the more tools you have

681
00:30:17,900 --> 00:30:20,600
and the more experience
you have at this thing,

682
00:30:20,600 --> 00:30:22,440
you think you can understand more things,

683
00:30:22,440 --> 00:30:26,100
which doesn't work, to
be honest, but yeah,

684
00:30:26,100 --> 00:30:28,450
somehow that hasn't sunk in.

685
00:30:28,450 --> 00:30:31,110
Your experience doesn't

necessarily lead you to, I mean,

686
00:30:31,110 --> 00:30:32,720
it doesn't help with solve
things better, you just,

687
00:30:32,720 --> 00:30:35,200
there are more and more problems
that needs to be solved.

688
00:30:35,200 --> 00:30:38,630
But nonetheless, I mean, when
I see a puzzle, be it, I mean,

689
00:30:38,630 --> 00:30:40,400
what happens at the
center of the black hole

690
00:30:40,400 --> 00:30:45,400
or the Big Bang, or it could
be, I mean, dark matter halos,

691
00:30:45,640 --> 00:30:49,450
cosmic acceleration, or how
COVID spreads across the globe,

692
00:30:49,450 --> 00:30:52,250
it seems that, I mean, when
I look at what's happening,

693
00:30:52,250 --> 00:30:54,070
I can see all the similarities,

694
00:30:54,070 --> 00:30:56,550
like when we study dark
matter and dark energy,

695
00:30:56,550 --> 00:31:00,020
and then we study the spread
of COVID, neither of them,

696
00:31:00,020 --> 00:31:02,160
we actually see what's happen.

697
00:31:02,160 --> 00:31:04,847
We don't see the viruses
going around like one by one

698
00:31:04,847 --> 00:31:06,670
and we don't see the
dark matter particles,

699
00:31:06,670 --> 00:31:08,880
but what we do see are the consequences.

700
00:31:08,880 --> 00:31:09,920
We see the shutdowns,

701
00:31:09,920 --> 00:31:12,867
we see the hospitals filling
up and things like that,

702
00:31:12,867 --> 00:31:15,250
and we see formation of galaxies

703
00:31:15,250 --> 00:31:17,370
and then that's where
I see the similarities

704
00:31:17,370 --> 00:31:19,773
and it's kind of, it's
hard to ignore those.

705
00:31:20,630 --> 00:31:21,620
That's the problem.

706
00:31:21,620 --> 00:31:24,957
I kind of lie awake at night, says,

707
00:31:24,957 --> 00:31:27,310
"Okay, so this is very similar to that,"

708
00:31:27,310 --> 00:31:30,380
and I cannot just fall asleep
without kind of pursuing that

709
00:31:30,380 --> 00:31:31,940
and that's what happens.

710
00:31:31,940 --> 00:31:36,330
- And are there certain
models or ideas from your work

711
00:31:36,330 --> 00:31:38,770
in astrophysics that
were particularly helpful

712
00:31:38,770 --> 00:31:42,320
when you were studying
this COVID 19 modeling?

713
00:31:42,320 --> 00:31:45,780
- So my PhD is kind of
an interesting story,

714
00:31:45,780 --> 00:31:49,040
which as similar to the
rest of my academic career

715
00:31:49,040 --> 00:31:50,620
had lots of different things,

716
00:31:50,620 --> 00:31:54,310
but one thing in particular
was very similar to COVID

717
00:31:54,310 --> 00:31:57,090
because I was interested,

my supervisor was working

718
00:31:57,090 --> 00:31:59,230
on cosmic molecular background,

719
00:31:59,230 --> 00:32:01,530
but then we also had
galaxy airways out there.

720
00:32:01,530 --> 00:32:03,640
With galaxies, people
see them with telescopes,

721
00:32:03,640 --> 00:32:05,740
optical telescopes,
cosmomicrowave background,

722
00:32:05,740 --> 00:32:07,800
you have the satellite that see microwave,

723
00:32:07,800 --> 00:32:10,180
so different things and for the most part,

724
00:32:10,180 --> 00:32:13,080
they are different things,
they see different things,

725
00:32:13,080 --> 00:32:15,880
but then what I did was I
actually looked at the correlation

726
00:32:15,880 --> 00:32:17,920
of the two signals and
then it turns out there's

727
00:32:17,920 --> 00:32:21,220
a tiny fraction of these
different things that are same.

728

00:32:21,220 --> 00:32:23,807
So there's some is the
effect of the dark energy,

729
00:32:23,807 --> 00:32:24,877
the cosmic expansion,

730
00:32:24,877 --> 00:32:29,350
some was the effect of hot gas
in the microwave background.

731
00:32:29,350 --> 00:32:31,540
And it turns out that these
are the things that you

732
00:32:31,540 --> 00:32:34,980
couldn't see on each of these
surveys on their own easily,

733
00:32:34,980 --> 00:32:36,290
but if you combine them,

734
00:32:36,290 --> 00:32:38,940
you could actually kind of
get these tiny signatures

735
00:32:38,940 --> 00:32:40,270
are through the combination

736
00:32:40,270 --> 00:32:41,950
and that's what I did for my PhD

737
00:32:41,950 --> 00:32:44,980
and it wasn't very much off mainstreams.

738
00:32:44,980 --> 00:32:47,310
I mean, I was like one of the first people

739
00:32:47,310 --> 00:32:49,410

who were doing it, but
now everybody does it.

740
00:32:49,410 --> 00:32:51,220
And if you just think about it,

741
00:32:51,220 --> 00:32:52,780
you can do this everywhere, right?

742
00:32:52,780 --> 00:32:56,740
So we see very different things
for very different reasons,

743
00:32:56,740 --> 00:32:58,270
but if you can combine them,

744
00:32:58,270 --> 00:33:00,470
you can learn something very
different that each of those

745
00:33:00,470 --> 00:33:01,810
datasets cannot teach you.

746
00:33:01,810 --> 00:33:03,870
And I realized that
basically that technique,

747
00:33:03,870 --> 00:33:08,100
which I guess the technical
can for this cross-correlation

748
00:33:08,100 --> 00:33:10,790
that can be used kind
of widely, for example,

749
00:33:10,790 --> 00:33:13,340
in the pandemic that you
could use various measures

750

00:33:13,340 --> 00:33:16,440
of people's activity
and spread of a disease

751
00:33:16,440 --> 00:33:18,380
and then through carefully designing

752
00:33:18,380 --> 00:33:21,410
cross-correlational studies
in a space and time,

753
00:33:21,410 --> 00:33:24,210
which is what similar to what
you do in cosmology, right?

754
00:33:24,210 --> 00:33:28,130
We could learn about the various
properties of the disease.

755
00:33:28,130 --> 00:33:30,840
For example, if people
are getting vaccinated

756
00:33:30,840 --> 00:33:33,561
and at the same time
they're having lockdowns,

757
00:33:33,561 --> 00:33:36,900
and at the same time some
people are getting immunity

758
00:33:36,900 --> 00:33:39,400
from prior disease, how can these three

759
00:33:39,400 --> 00:33:41,790
in track with each other
because they could all have

760
00:33:41,790 --> 00:33:44,530
similar consequences and

this cross-correlation

761
00:33:44,530 --> 00:33:45,560
is the way to do it.

762
00:33:45,560 --> 00:33:48,000
In fact, that's how I did,

763
00:33:48,000 --> 00:33:50,300
I could separate the
effect of dark energy,

764
00:33:50,300 --> 00:33:51,470
the effect of hot gas,

765
00:33:51,470 --> 00:33:53,160
and effect of radio sources

766
00:33:53,160 --> 00:33:55,040
but through this
cross-correlational study.

767
00:33:55,040 --> 00:33:57,400
So if you have a lot of data,
you could do it, basically.

768
00:33:57,400 --> 00:33:59,530
- You mentioned in one interview that data

769
00:33:59,530 --> 00:34:02,307
from the COVID pandemic,
there's a lot more of it

770
00:34:02,307 --> 00:34:04,803
and it comes a lot faster
than from black holes.

771
00:34:06,200 --> 00:34:08,180
Was it sort of a gift of data for you

772
00:34:08,180 --> 00:34:09,969
that you had these huge numbers?

773
00:34:09,969 --> 00:34:11,032
- It's a curse.

774
00:34:11,032 --> 00:34:13,280
(all laughing)

775
00:34:13,280 --> 00:34:15,620
You would think it's
a gift like for a week

776
00:34:17,480 --> 00:34:18,613
and then it's a curse.

777
00:34:19,870 --> 00:34:20,703
- Too much data?

778
00:34:20,703 --> 00:34:22,860
- Too much data, too much too fast,

779
00:34:22,860 --> 00:34:23,900
too many things happening.

780
00:34:23,900 --> 00:34:25,960
- I don't know, it's the
other way around, right?

781
00:34:25,960 --> 00:34:27,430
You're losing the data.

782
00:34:27,430 --> 00:34:29,610
He wasn't quite like that
because you were telling me

783
00:34:29,610 --> 00:34:31,090

and was part of the problem,

784
00:34:31,090 --> 00:34:33,300
like I kept telling him,
"Tell me about Waterloo,

785
00:34:33,300 --> 00:34:34,160
like what's the economy."

786
00:34:34,160 --> 00:34:36,110
And he's like, "No, we
don't have data in Canada.

787
00:34:36,110 --> 00:34:39,090
All I can tell you is
what the count is in US

788
00:34:39,090 --> 00:34:42,290
because the data was I've been and there."

789
00:34:42,290 --> 00:34:44,974
It could like cross correlate
between all different

790
00:34:44,974 --> 00:34:48,096
counties, how many there
were like, I don't know,

791
00:34:48,096 --> 00:34:49,672
30, like more than, 3,000.

792
00:34:49,672 --> 00:34:50,988
- 3,000 counties, yeah.

793
00:34:50,988 --> 00:34:53,880
- Counties where each had their
own dataset you can track.

794
00:34:53,880 --> 00:34:56,580

- And essentially you
made sort of a dashboard

795
00:34:56,580 --> 00:35:00,970
where you input factors say whether or-

796
00:35:00,970 --> 00:35:01,803
- Lockdowns.

797
00:35:01,803 --> 00:35:03,530
- Lockdowns.
- Lockdowns, yeah.

798
00:35:03,530 --> 00:35:05,000
- And vaccination rates.

799
00:35:05,000 --> 00:35:08,249
And then it was sort of a
predictive model of spread.

800
00:35:08,249 --> 00:35:09,129
- Yeah, that's right.

801
00:35:09,129 --> 00:35:12,030
- One conclusion I saw that surprised me

802
00:35:12,030 --> 00:35:15,710
until I heard an explanation
was that the effect of weather,

803
00:35:15,710 --> 00:35:17,530
or at least the indirect
effect of weather,

804
00:35:17,530 --> 00:35:19,180
hot weather and cold weather.

805
00:35:19,180 --> 00:35:21,272
Could you explain what you saw there?

806
00:35:21,272 --> 00:35:22,890
- I mean, these are all the
things that come out of data.

807
00:35:22,890 --> 00:35:25,187
I mean, I wish I had a
better understanding of it,

808
00:35:25,187 --> 00:35:28,210
but it's in fact, somewhat
similar to what as I was talking

809
00:35:28,210 --> 00:35:30,070
about that you don't
necessarily understand

810
00:35:30,070 --> 00:35:31,850
fundamentally what's happening.

811
00:35:31,850 --> 00:35:33,020
Same with quantum gravity,

812
00:35:33,020 --> 00:35:34,820
you don't necessarily
fundamentally understand

813
00:35:34,820 --> 00:35:37,670
what's happening, but if
you have a good enough data,

814
00:35:37,670 --> 00:35:39,610
you could have an effective description

815
00:35:39,610 --> 00:35:42,710
and what we did is we got
this effective description

816
00:35:42,710 --> 00:35:45,410

of what's happening and
basically the conclusion

817
00:35:45,410 --> 00:35:47,980
was that if you look at a spread of COVID

818
00:35:47,980 --> 00:35:51,420
across thousands of counties,
across thousand about,

819
00:35:51,420 --> 00:35:52,740
I guess you have hundreds of days now,

820
00:35:52,740 --> 00:35:55,530
there are these factors that are at play

821
00:35:55,530 --> 00:35:57,710
and one of the significant
ones are weather,

822
00:35:57,710 --> 00:35:59,690
that when things get colder,

823
00:35:59,690 --> 00:36:03,240
where the temperatures dip
below around 15 degrees Celsius,

824
00:36:03,240 --> 00:36:05,400
then COVID spreads faster.

825
00:36:05,400 --> 00:36:07,530
And then this is in addition
to all the other effects.

826
00:36:07,530 --> 00:36:10,260
So if you include effects
of mobility and vaccination

827
00:36:10,260 --> 00:36:12,450

and everything, I guess this is probably

828
00:36:12,450 --> 00:36:13,490
the least surprising one

829
00:36:13,490 --> 00:36:17,640
because we had seen that for
other prior virus like flu.

830
00:36:17,640 --> 00:36:19,270
In winter, they are more severe.

831
00:36:19,270 --> 00:36:20,660
So there are all of these.

832
00:36:20,660 --> 00:36:22,210
The thing is that there is no one factor,

833
00:36:22,210 --> 00:36:24,103
and this is kind of one of the problems

834
00:36:24,103 --> 00:36:26,070
that I kind of keep rolling my eyes

835
00:36:26,070 --> 00:36:28,910
whenever I see an analysis
of COVID anywhere,

836
00:36:28,910 --> 00:36:31,260
which there are so many of
them it's hard to avoid them

837
00:36:31,260 --> 00:36:33,240
because they just kinda
say, "Look, this place,

838
00:36:33,240 --> 00:36:35,560
this country did this, and
then they're doing well,

839
00:36:35,560 --> 00:36:37,813
and then this state did
this or this city did this

840
00:36:37,813 --> 00:36:38,646
and they're doing so well.

841
00:36:38,646 --> 00:36:40,340
Or maybe they did this
and they're doing so bad."

842
00:36:40,340 --> 00:36:42,346
I looked at that and said, I mean,

843
00:36:42,346 --> 00:36:43,350
hundreds of thousands of data points

844
00:36:43,350 --> 00:36:44,710
and there is no one thing.

845
00:36:44,710 --> 00:36:47,860
All of these happen in concert,
there are various things,

846
00:36:47,860 --> 00:36:50,280
and that's the way science
works is that we need to,

847
00:36:50,280 --> 00:36:52,900
I don't really know how, but if this,

848
00:36:52,900 --> 00:36:55,670
if we can teach people this in any way,

849
00:36:55,670 --> 00:36:57,550
either the school or through outreach,

850

00:36:57,550 --> 00:37:01,190
that science is understanding
of various things

851
00:37:01,190 --> 00:37:04,150
that happen at the same time
in face of uncertainties.

852
00:37:04,150 --> 00:37:05,550
That's the way science works.

853
00:37:05,550 --> 00:37:09,800
You cannot say with certainty
that if you do this,

854
00:37:09,800 --> 00:37:11,150
this is gonna happen.

855
00:37:11,150 --> 00:37:12,630
That that never really happens.

856
00:37:12,630 --> 00:37:13,605
- Right.

857
00:37:13,605 --> 00:37:14,470
- And another thing I keep wondering

858
00:37:14,470 --> 00:37:16,920
when I look at this idea of combining

859
00:37:16,920 --> 00:37:18,610
these different kinds of
data, as you were saying,

860
00:37:18,610 --> 00:37:21,430
you have a lot of data, but
you're trying to combine

861
00:37:21,430 --> 00:37:22,760

different aspects, right?

862
00:37:22,760 --> 00:37:25,670
And I guess some of those
aspects might have more data

863
00:37:25,670 --> 00:37:28,800
than others so something that
maybe still could be important

864
00:37:28,800 --> 00:37:30,890
for modeling something
maybe could be harder

865
00:37:30,890 --> 00:37:31,723
to collect data.

866
00:37:31,723 --> 00:37:35,400
So, one in particular, when I
looked at this online portal

867
00:37:35,400 --> 00:37:38,333
that you made is the number
of people wearing face masks.

868
00:37:38,333 --> 00:37:39,900
I would assume this is something

869
00:37:39,900 --> 00:37:42,588
that's probably quite hard to measure.

870
00:37:42,588 --> 00:37:44,284
- We had a way to do it,

871
00:37:44,284 --> 00:37:47,084
which is a number of people
who were Googling face mask,

872
00:37:48,070 --> 00:37:50,950

which was not the best and
one of the challenges, I mean,

873
00:37:50,950 --> 00:37:53,920
actually not the challenge,
part of the scientific method

874
00:37:53,920 --> 00:37:55,290
is not just understand your data,

875
00:37:55,290 --> 00:37:58,150
but understand the
errors or uncertainties,

876
00:37:58,150 --> 00:38:00,830
and that's not just for your
data, but also for your models.

877
00:38:00,830 --> 00:38:02,240
We have to understand our model.

878
00:38:02,240 --> 00:38:04,070
We had to understand our
subject and our model,

879
00:38:04,070 --> 00:38:06,070
and we have to understand our
data and our understanding,

880
00:38:06,070 --> 00:38:07,460
so those were all the challenges

881
00:38:07,460 --> 00:38:10,660
and these are challenges that
we deal with in cosmology

882
00:38:10,660 --> 00:38:12,880
and we deal with in COVID

883

00:38:12,880 --> 00:38:16,290
so I try to kind of
import those techniques

884
00:38:16,290 --> 00:38:19,160
in from cosmology to some extent.

885
00:38:19,160 --> 00:38:21,960
But yeah, the thing is
you can never only focus

886
00:38:21,960 --> 00:38:23,610
on your model or your data.

887
00:38:23,610 --> 00:38:25,590
It's all, uncertainty is all aware.

888
00:38:25,590 --> 00:38:28,713
So uncertainty is the real boss, actually.

889
00:38:29,623 --> 00:38:31,790
- Can I ask us to go a
little bit back in time

890
00:38:31,790 --> 00:38:35,510
'cause I'm so curious to
know how and when you met.

891
00:38:35,510 --> 00:38:38,041
- You said you met me first, right?

892
00:38:38,041 --> 00:38:39,850
(Niayesh laughing)

893
00:38:39,850 --> 00:38:41,596
- No, I think you said,

894
00:38:41,596 --> 00:38:45,840
you heard me say something

and then you could,

895
00:38:45,840 --> 00:38:47,380
you didn't have your
glasses, so you couldn't see.

896
00:38:47,380 --> 00:38:49,720
- No, but I'm talking
about before that, right?

897
00:38:49,720 --> 00:38:50,553
In high school.

898
00:38:50,553 --> 00:38:51,820
- Oh yeah, high school, that's right.

899
00:38:51,820 --> 00:38:53,400
No, that's true, I did, yes.

900
00:38:53,400 --> 00:38:54,630
- Oh, I didn't know
there was a high school.

901
00:38:54,630 --> 00:38:55,892
- There was a high school.

902
00:38:55,892 --> 00:38:59,740
- Vague, I mean vague
meeting as in quotation mark.

903
00:38:59,740 --> 00:39:00,573
- Yes.

904
00:39:00,573 --> 00:39:01,910
- So apparently there was a,

905
00:39:01,910 --> 00:39:05,070
so there was this national
competition for math

906
00:39:05,070 --> 00:39:07,170
and computer science and things.

907
00:39:07,170 --> 00:39:08,003
- In Iran?

908
00:39:08,003 --> 00:39:10,560
- In Iran, each province, for example,

909
00:39:10,560 --> 00:39:13,110
you do the first round and then
you get to the second round

910
00:39:13,110 --> 00:39:16,610
and we both have made it
to the national level.

911
00:39:16,610 --> 00:39:20,630
And then they took us on this
one week competition trip

912
00:39:20,630 --> 00:39:22,580
that now from all provinces people

913
00:39:22,580 --> 00:39:24,110
go to do the second round

914
00:39:24,110 --> 00:39:26,850
so I was competing in
math and computer science.

915
00:39:26,850 --> 00:39:28,790
- Where was that contest?

916
00:39:28,790 --> 00:39:32,550
- The contest, the second round
was in the city of Mashhad.

917
00:39:32,550 --> 00:39:34,720
So there weren't, I guess, many women

918
00:39:34,720 --> 00:39:39,130
who in the second round
got prizes and stuff

919
00:39:39,130 --> 00:39:43,110
and apparently Niayesh says
I remember a couple of girls

920
00:39:43,110 --> 00:39:45,776
went up there and got a trophy.

921
00:39:45,776 --> 00:39:48,771
I'm like, "Oh, that
was me," so you met me.

922
00:39:48,771 --> 00:39:50,672
- Yeah, I didn't get
anything in that prize

923
00:39:50,672 --> 00:39:53,210
and that competition.

924
00:39:53,210 --> 00:39:54,043
- So anyway.

925
00:39:54,043 --> 00:39:55,860
- How many students were
in this competition?

926
00:39:55,860 --> 00:40:00,860
- The second round, I think
maybe 100 in each topic.

927
00:40:00,890 --> 00:40:03,390
- Probably 100, 150, I would think so.

928
00:40:03,390 --> 00:40:05,510
- So you both already
had a strong inclination

929
00:40:05,510 --> 00:40:07,840
towards science and math at that point.

930
00:40:07,840 --> 00:40:09,025
- Math, yeah, so yeah.

931
00:40:09,025 --> 00:40:13,960
I had a good study group in high school,

932
00:40:13,960 --> 00:40:15,420
especially another friend.

933
00:40:15,420 --> 00:40:17,680
We really loved to do math problems.

934
00:40:17,680 --> 00:40:20,420
I didn't think I was good at
computer science so that one,

935
00:40:20,420 --> 00:40:22,200
I just participated for fun.

936
00:40:22,200 --> 00:40:23,480
No, actually, which way it is?

937
00:40:23,480 --> 00:40:25,270
I think I did it the other way.

938
00:40:25,270 --> 00:40:27,640
I wanted to compete in
computer science, the math,

939
00:40:27,640 --> 00:40:30,192
I participated for fun because

now I remember, so they had,

940
00:40:30,192 --> 00:40:32,595
the days of the test were alternating

941
00:40:32,595 --> 00:40:36,020
so the day we had the
computer science test,

942
00:40:36,020 --> 00:40:37,967
the night before that, me
and my friend was like,

943
00:40:37,967 --> 00:40:41,110
"Okay, let's sleep early,
tomorrow we have to be focused."

944
00:40:41,110 --> 00:40:42,487
- Yeah, I don't know a
lot of people who say,

945
00:40:42,487 --> 00:40:43,730
"Do you wanna go out and have fun

946
00:40:43,730 --> 00:40:47,603
by going to a computer
science contest with me?"

947
00:40:47,603 --> 00:40:48,953
It's an interesting definition.

948
00:40:48,953 --> 00:40:52,510
- I don't know, and then
the math one, the math one,

949
00:40:52,510 --> 00:40:54,920
I would go like, "Oh, let's go do it."

950
00:40:54,920 --> 00:40:56,710

- Then the math one was for fun.

951
00:40:56,710 --> 00:40:59,620
- Yeah, honestly like so there was a,

952
00:40:59,620 --> 00:41:01,490
because there is a
funniest story about it.

953
00:41:01,490 --> 00:41:02,460
So at the math one,

954
00:41:02,460 --> 00:41:05,260
you might have heard of Maryam Mirzakhani.

955
00:41:05,260 --> 00:41:08,020
So she was competing from
Tehran and I was competing

956
00:41:08,020 --> 00:41:09,060
from this other city.

957
00:41:09,060 --> 00:41:10,150
I'm like, look at her.

958
00:41:10,150 --> 00:41:13,030
Obviously she had already
won the math gold medal

959
00:41:13,030 --> 00:41:14,880
internationally the year before.

960
00:41:14,880 --> 00:41:16,320
I'm like, "What am I doing here?"

961
00:41:16,320 --> 00:41:18,610
So she was doing and
sitting like in the exam.

962
00:41:18,610 --> 00:41:22,243
I was looking at her and I
was having sipping my snacks.

963
00:41:24,020 --> 00:41:26,133
The little I know I did
very better in math.

964
00:41:26,133 --> 00:41:27,990
I won the silver medal.

965
00:41:27,990 --> 00:41:30,437
I'm like, "Oh, I should have
tried a little bit harder."

966
00:41:33,060 --> 00:41:34,253
But anyway, yeah.

967
00:41:35,230 --> 00:41:37,910
- But that was just a
sort of fleeting meeting.

968
00:41:37,910 --> 00:41:41,047
- And I guess, Ghazal, you
don't remember meeting Niayesh,

969
00:41:41,047 --> 00:41:42,570
but Niayesh, you remember seeing.

970
00:41:42,570 --> 00:41:44,497
- Yeah, I was in like in the auditorium,

971
00:41:44,497 --> 00:41:47,401
but somewhere down there and yeah,

972
00:41:47,401 --> 00:41:50,820
she was on the podium on the scene.

973

00:41:50,820 --> 00:41:53,230
So yeah, so that was that.

974
00:41:53,230 --> 00:41:57,293
I think Ghazal said you heard me.

975
00:41:58,280 --> 00:42:00,183
I was kicked out of the class.

976
00:42:00,183 --> 00:42:03,840
- Yes, so there was a
modern physics course

977
00:42:03,840 --> 00:42:06,560
and then I didn't bring
my glasses that day

978
00:42:06,560 --> 00:42:08,490
so I couldn't see very well the board,

979
00:42:08,490 --> 00:42:10,510
so I sat in the front row.

980
00:42:10,510 --> 00:42:12,910
Apparently some students entered the class

981
00:42:12,910 --> 00:42:14,590
and we had this older professor

982
00:42:14,590 --> 00:42:18,007
who was very much into like
etiquette of the class and pain

983
00:42:18,007 --> 00:42:21,300
and he got really upset,
started, "What are you doing?"

984
00:42:21,300 --> 00:42:24,830
Like started kind of

yelling at you, I think.

985
00:42:24,830 --> 00:42:26,790
- What were you doing wrong?

986
00:42:26,790 --> 00:42:28,853
- Because I was at another class.

987
00:42:30,050 --> 00:42:31,977
I was trying to take so many.

988
00:42:31,977 --> 00:42:36,977
That was like my first semester
at college and I was trying.

989
00:42:37,510 --> 00:42:40,160
Like everything else I do,
I wanted to do everything.

990
00:42:41,930 --> 00:42:44,330
And there were different
classes overlapping and somehow

991
00:42:44,330 --> 00:42:47,850
decided that maybe I could
just miss the first 20 minutes

992
00:42:47,850 --> 00:42:51,930
of my class and yeah, but
then my professor was,

993
00:42:51,930 --> 00:42:54,070
who we turned out to be
great friends afterwards,

994
00:42:54,070 --> 00:42:57,150
but he kicked me out and I think I lost.

995
00:42:57,150 --> 00:42:58,780

- So yeah, I just heard
like there was a boy there

996
00:42:58,780 --> 00:42:59,817
and then some of my friends said,

997
00:42:59,817 --> 00:43:04,341
"Oh, this is the guy who won
the physics context Olympian."

998
00:43:04,341 --> 00:43:06,880
I'm like, "Ooh, like who is that guy?"

999
00:43:06,880 --> 00:43:10,125
- Who's this guy getting
kicked out of the class?

1000
00:43:10,125 --> 00:43:11,020
- And then was it shortly after that

1001
00:43:11,020 --> 00:43:13,108
that you actually started talking?

1002
00:43:13,108 --> 00:43:15,395
- Then you said you came
to my tutorial session.

1003
00:43:15,395 --> 00:43:16,990
- Yeah, she had a tutorial.

1004
00:43:16,990 --> 00:43:19,510
I remember she solved for the students,

1005
00:43:19,510 --> 00:43:21,555
including me there that day.

1006
00:43:21,555 --> 00:43:23,040
What is the shape of a
string if you hang them

1007
00:43:23,040 --> 00:43:24,600
from two points?

1008
00:43:24,600 --> 00:43:26,413
Cosine hyperbolic.

1009
00:43:28,490 --> 00:43:30,222
- And you were teaching that, Ghazal.

1010
00:43:30,222 --> 00:43:32,420
- Yeah, so then I was like a second year

1011
00:43:32,420 --> 00:43:35,200
undergraduate student and
the first year undergraduate

1012
00:43:35,200 --> 00:43:39,240
approached us and say, "Would
your higher year students

1013
00:43:39,240 --> 00:43:42,530
want to do some problem-solving
sessions for us?"

1014
00:43:42,530 --> 00:43:44,290
And I said, "Sure, yeah."

1015
00:43:44,290 --> 00:43:45,760
I volunteered to do that and I thought

1016
00:43:45,760 --> 00:43:47,580
this is a very fun problem to solve.

1017
00:43:47,580 --> 00:43:50,166
The math is very nice and beautiful

1018
00:43:50,166 --> 00:43:53,377

so I was solving that
on the board for them.

1019
00:43:53,377 --> 00:43:55,580
- And you didn't kick
him out of your tutorial?

1020
00:43:55,580 --> 00:43:56,523
- No, I didn't.

1021
00:43:57,570 --> 00:43:59,633
- No, she was a nice.
- Show up on time?

1022
00:44:00,850 --> 00:44:02,600
- That I don't remember.

1023
00:44:03,570 --> 00:44:05,967
- Yeah, I probably thought,
"What is he doing here?"

1024
00:44:07,207 --> 00:44:08,850
- And so this was undergrad, right?

1025
00:44:08,850 --> 00:44:11,090
And then so what happened from there?

1026
00:44:11,090 --> 00:44:16,090
- So then the fourth year, I
think I saw him here and there.

1027
00:44:16,303 --> 00:44:19,513
Niayesh didn't take actually
many undergrad courses anymore.

1028
00:44:19,513 --> 00:44:22,250
I think at some point
after the first semester

1029

00:44:22,250 --> 00:44:24,970
he decided to just go
directly through grad courses

1030
00:44:25,890 --> 00:44:26,910
and gave up.

1031
00:44:26,910 --> 00:44:30,810
And then one of our professor
was planning to organize

1032
00:44:30,810 --> 00:44:35,260
international workshop in one
of the islands in Persian Gulf

1033
00:44:35,260 --> 00:44:39,220
and so therefore in a year
before that in preparation,

1034
00:44:39,220 --> 00:44:43,680
he had started this cosmology
courses and cosmology

1035
00:44:43,680 --> 00:44:45,730
and he was learning, he was a GR person,

1036
00:44:45,730 --> 00:44:48,932
general relativity, his
specialty was general relativity,

1037
00:44:48,932 --> 00:44:50,397
but he wanted to do the
workshop on cosmology and said,

1038
00:44:50,397 --> 00:44:51,700
"I'm learning myself."

1039
00:44:51,700 --> 00:44:54,870
And he recruited some graduate students

1040
00:44:54,870 --> 00:44:59,170
and maybe Niayesh as well and
I think I heard about that.

1041
00:44:59,170 --> 00:45:02,240
So I signed up for the cosmology class.

1042
00:45:02,240 --> 00:45:04,300
Niayesh already became the TA for me.

1043
00:45:04,300 --> 00:45:06,250
That was not the other way around.

1044
00:45:06,250 --> 00:45:08,670
There's another story
about that, which I'm,

1045
00:45:08,670 --> 00:45:10,600
and then meanwhile, another.

1046
00:45:10,600 --> 00:45:12,517
- Which you're good to tell us.

1047
00:45:12,517 --> 00:45:17,319
- Really still very upset
about it, I can see that.

1048
00:45:17,319 --> 00:45:20,240
- I think just the moral
of that story is that

1049
00:45:20,240 --> 00:45:23,663
if you are a TA you
shouldn't date your students.

1050
00:45:27,600 --> 00:45:30,800
- So meanwhile, another
professor suggested

1051
00:45:30,800 --> 00:45:35,350
another interesting like
project based for undergrads

1052
00:45:35,350 --> 00:45:37,650
and he started the cosmology project

1053
00:45:37,650 --> 00:45:38,960
and I think you and I.

1054
00:45:38,960 --> 00:45:40,832
- Anyway, there were lots of different.

1055
00:45:40,832 --> 00:45:42,170
- A lot of things, so we
got to know each other

1056
00:45:42,170 --> 00:45:45,470
and then gradually we started
dating, but then meanwhile,

1057
00:45:45,470 --> 00:45:47,870
he was my TA in this cosmology class.

1058
00:45:47,870 --> 00:45:50,810
So the story that I'm
upset about is because they

1059
00:45:50,810 --> 00:45:54,080
give a midterm, he's proctoring the exam,

1060
00:45:54,080 --> 00:45:56,010
I am a very like a slow writer.

1061
00:45:56,010 --> 00:45:59,020
I can never write in time,

1062
00:45:59,020 --> 00:46:01,730

so right now I know like me being here,

1063
00:46:01,730 --> 00:46:03,340
I know probably had a disability,

1064
00:46:03,340 --> 00:46:05,710
I should have asked for
extension, but anyway,

1065
00:46:05,710 --> 00:46:08,950
the example had ended and halfway through,

1066
00:46:08,950 --> 00:46:11,390
there's a lot of problems
I haven't solve and Niayesh

1067
00:46:11,390 --> 00:46:15,230
is like, "Okay, time's
up," took my paper and went

1068
00:46:15,230 --> 00:46:19,100
and I had another good
friend, same took the course

1069
00:46:19,100 --> 00:46:20,890
and then they, a couple of days later,

1070
00:46:20,890 --> 00:46:25,810
they posted the marks and
I was like the first mark

1071
00:46:25,810 --> 00:46:27,680
or second mark or something

1072
00:46:27,680 --> 00:46:30,407
and then this friend of
my teases me and says,

1073
00:46:30,407 --> 00:46:33,250

"Haha, of course you're dating him."

1074
00:46:33,250 --> 00:46:37,097
Got really upset and then
I talked to him and I said,

1075
00:46:37,097 --> 00:46:38,510
"Oh, did he say to that?"

1076
00:46:38,510 --> 00:46:40,250
Because I gave him extra time.

1077
00:46:40,250 --> 00:46:43,500
I let him take the exam home
and bring it the next day.

1078
00:46:43,500 --> 00:46:46,350
And they're like, "What
are you talking about?"

1079
00:46:48,060 --> 00:46:49,280
Anyway.

1080
00:46:49,280 --> 00:46:51,130
- So you didn't get special
treatment, somebody else did.

1081
00:46:51,130 --> 00:46:54,100
- No, even like the first
and then the other guy.

1082
00:46:54,100 --> 00:46:56,216
I'm like, "Oh, gosh."

1083
00:46:56,216 --> 00:46:57,970
- And yet here you are.

1084
00:46:57,970 --> 00:47:00,780
- Yeah, he should have been

disciplined for that TA.

1085
00:47:00,780 --> 00:47:03,230
- I should have been disciplined, yes.

1086
00:47:03,230 --> 00:47:06,284
I was a very bad TA.
(Niayesh laughing)

1087
00:47:06,284 --> 00:47:07,840
- But I relate to you,
Ghazal, 'cause for me,

1088
00:47:07,840 --> 00:47:11,010
also writing in time was really
hard and I never, I, yeah,

1089
00:47:11,010 --> 00:47:12,900
I maybe also needed to
ask about something,

1090
00:47:12,900 --> 00:47:15,510
but I just can remember after exam season,

1091
00:47:15,510 --> 00:47:18,460
I would carry all the stress
of the exam in my hand,

1092
00:47:18,460 --> 00:47:20,560
I think and then I would
need a couple weeks

1093
00:47:20,560 --> 00:47:21,880
after exams to recover.

1094
00:47:21,880 --> 00:47:25,120
My hand would just be so tense
from all like from trying

1095

00:47:25,120 --> 00:47:28,150
to write everything
that was there so fast.

1096
00:47:28,150 --> 00:47:31,230
And then so it was graduate
school shortly after that?

1097
00:47:31,230 --> 00:47:32,950
- And then they went to this workshop,

1098
00:47:32,950 --> 00:47:36,300
cosmology workshop in Kish
Island, very beautiful island.

1099
00:47:36,300 --> 00:47:38,710
If you ever go to like Coral island,

1100
00:47:38,710 --> 00:47:41,010
is it one of the few
Coral islands in the world

1101
00:47:41,010 --> 00:47:43,640
where like the water is so clear?

1102
00:47:43,640 --> 00:47:46,660
Like it's all the beaches is just corals.

1103
00:47:46,660 --> 00:47:51,660
And my supervisor was there and I guess-

1104
00:47:51,991 --> 00:47:52,824
- Future supervisor.

1105
00:47:52,824 --> 00:47:55,690
- Future supervisor, PhD supervisor.

1106
00:47:55,690 --> 00:47:58,573
Back then, like he was

very willing to go to this

1107
00:47:58,573 --> 00:48:01,760
like to Brazil, to Iran, to other places

1108
00:48:01,760 --> 00:48:04,150
and recruit graduate students.

1109
00:48:04,150 --> 00:48:07,120
I mean, like if he's also
a good graduate student,

1110
00:48:07,120 --> 00:48:08,650
he would support them.

1111
00:48:08,650 --> 00:48:10,970
So we met him there, he
was very impressed with me

1112
00:48:10,970 --> 00:48:13,410
at Niayesh and we said,
"Well, we haven't applied,

1113
00:48:13,410 --> 00:48:16,360
but we know coming, going
to US is extremely hard

1114
00:48:16,360 --> 00:48:17,650
for Iranian student."

1115
00:48:17,650 --> 00:48:19,370
He said, "Okay, you
know, I'm gonna go there

1116
00:48:19,370 --> 00:48:21,250
and you send your application.

1117
00:48:21,250 --> 00:48:23,410
We'll see how things go."

1118
00:48:23,410 --> 00:48:25,380
And we didn't really have much hope

1119
00:48:25,380 --> 00:48:29,250
because not many Iranians
would make it to US.

1120
00:48:29,250 --> 00:48:30,940
And it's a are very hard even to this day,

1121
00:48:30,940 --> 00:48:32,530
like it's a hard decision.

1122
00:48:32,530 --> 00:48:34,630
If you go there, you're
trapped for few years,

1123
00:48:34,630 --> 00:48:35,920
you won't see your families

1124
00:48:35,920 --> 00:48:38,010
and a lot of other complications.

1125
00:48:38,010 --> 00:48:41,580
But anyway, he went there
and then we both applied

1126
00:48:41,580 --> 00:48:43,280
and we got admissions.

1127
00:48:43,280 --> 00:48:45,050
In the middle, had to do a lot of things.

1128
00:48:45,050 --> 00:48:49,330
We had to go to a third
country to do GRS exams.

1129

00:48:49,330 --> 00:48:52,840
We had to apply for visas
couple of times, got rejected,

1130
00:48:52,840 --> 00:48:54,863
then go to another country, apply again.

1131
00:48:55,930 --> 00:48:57,400
So after a lot of hurdles,

1132
00:48:57,400 --> 00:49:00,204
we finally got the visa and admission.

1133
00:49:00,204 --> 00:49:01,037
- And then we got married.

1134
00:49:01,037 --> 00:49:03,683
- And then we said, okay,
yeah, we were, yeah,

1135
00:49:03,683 --> 00:49:07,420
we were dating and everything
for a couple of years then

1136
00:49:07,420 --> 00:49:09,970
but then we said, "Okay, we
are not gonna see our parents

1137
00:49:09,970 --> 00:49:11,630
probably for a long time

1138
00:49:11,630 --> 00:49:13,370
and if we are planning to get married,

1139
00:49:13,370 --> 00:49:16,487
let's do it and celebrate
it with them before moving,"

1140
00:49:17,410 --> 00:49:18,710

which I think was a good thing.

1141
00:49:18,710 --> 00:49:22,396
Like everybody celebrated
and then we moved to US.

1142
00:49:22,396 --> 00:49:24,695
- And then we disappear.

1143
00:49:24,695 --> 00:49:26,623
- Okay, got married, bye.

1144
00:49:28,350 --> 00:49:30,900
- Now you're married, you're
both at Perimeter Institute

1145
00:49:30,900 --> 00:49:31,860
and you have kids.

1146
00:49:31,860 --> 00:49:35,280
I wanted to bring up your kids
partly because of the book

1147
00:49:35,280 --> 00:49:36,770
that you wrote.

1148
00:49:36,770 --> 00:49:39,410
Can you tell us a bit about
the book and why you wrote it?

1149
00:49:39,410 --> 00:49:42,180
- My son was, I mean,

1150
00:49:42,180 --> 00:49:44,190
as it is probably with a lot of children,

1151
00:49:44,190 --> 00:49:47,840
like they get really upset,
obsessed about something

1152
00:49:47,840 --> 00:49:52,640
like one day it's the, what
is it, the Sphinx in Egypt.

1153
00:49:52,640 --> 00:49:54,880
- Sounds like something they
got from their father, maybe.

1154
00:49:54,880 --> 00:49:58,200
- Yeah, maybe, like then
for a couple of months

1155
00:49:58,200 --> 00:50:02,486
we are just looking and
reading about Sphinx and Egypt

1156
00:50:02,486 --> 00:50:04,760
and our whole future is
planned to move to Egypt

1157
00:50:04,760 --> 00:50:07,140
to live next to the pyramids.

1158
00:50:08,080 --> 00:50:11,470
And then there is the like human
body again, like, you know,

1159
00:50:11,470 --> 00:50:13,550
there's a phase of that
and there was a phase

1160
00:50:13,550 --> 00:50:16,857
of the black holes, like he
was obsessed, like what is it?

1161
00:50:16,857 --> 00:50:18,780
And then I'm like, okay.

1162

00:50:18,780 --> 00:50:20,060
- Did he know about them because of what

1163
00:50:20,060 --> 00:50:21,970
you do for a living or
did he see something?

1164
00:50:21,970 --> 00:50:25,260
- No, I think overall space
is one of those things

1165
00:50:25,260 --> 00:50:29,170
that children, maybe it's
the impact of the media

1166
00:50:29,170 --> 00:50:32,214
and outside world, or maybe
it's like kids are maybe-

1167
00:50:32,214 --> 00:50:33,374
- He must have seen it somewhere.

1168
00:50:33,374 --> 00:50:36,324
- But it's not from you two
are arguing over singularities?

1169
00:50:37,930 --> 00:50:40,760
- No, if anything, we
probably have the reverse.

1170
00:50:40,760 --> 00:50:45,467
- We try to keep them
protected from hostile events.

1171
00:50:46,657 --> 00:50:49,770
- Yesterday our younger
son was watching something

1172
00:50:49,770 --> 00:50:52,227
about the space on YouTube

and Niayesh was like,

1173
00:50:52,227 --> 00:50:53,240
"I don't wanna listen.

1174
00:50:53,240 --> 00:50:55,240
There's so many mistakes in that video."

1175
00:50:58,750 --> 00:51:00,510
- And how old was your son when he started

1176
00:51:00,510 --> 00:51:01,690
getting interested in black holes?

1177
00:51:01,690 --> 00:51:04,140
- So he was almost four.

1178
00:51:04,140 --> 00:51:04,973
- Wow.

1179
00:51:04,973 --> 00:51:08,500
- So at that point I'm like,
okay, obviously it's too soon

1180
00:51:08,500 --> 00:51:11,670
to teach him any science,
but still there's like a,

1181
00:51:11,670 --> 00:51:13,290
I maybe I can do a small,

1182
00:51:13,290 --> 00:51:16,900
very short story to not scientific,

1183
00:51:16,900 --> 00:51:20,250
to include not scientifically
wrong things in it,

1184

00:51:20,250 --> 00:51:22,903
but at the same time, be
just a story, you know,

1185
00:51:22,903 --> 00:51:27,360
just like keep his mind
entertained, read it to him.

1186
00:51:27,360 --> 00:51:30,340
- Well it's great too 'cause
you have this guide for parents

1187
00:51:30,340 --> 00:51:33,100
or teachers as well that
goes a little bit deeper

1188
00:51:33,100 --> 00:51:35,450
so you can give the book
to the four-year-old

1189
00:51:35,450 --> 00:51:37,850
and then the parents can
learn a little bit more.

1190
00:51:37,850 --> 00:51:41,690
- I think so, I think it
all, like I learn a lot

1191
00:51:41,690 --> 00:51:44,370
because of my children in other topics

1192
00:51:44,370 --> 00:51:47,210
that are not my specialty
when they become interested

1193
00:51:47,210 --> 00:51:51,140
in something and then he brings
up the book and then I get

1194
00:51:51,140 --> 00:51:54,380

curious, okay, what is the
actual thing that is happening

1195
00:51:54,380 --> 00:51:57,230
is you're learning about
this country or geography

1196
00:51:57,230 --> 00:51:59,870
or this plant or something else.

1197
00:51:59,870 --> 00:52:03,540
So I feel like it's very
good bonding experiments

1198
00:52:03,540 --> 00:52:06,120
and educational experience
for parents and child

1199
00:52:06,120 --> 00:52:08,010
if they read together things

1200
00:52:08,010 --> 00:52:09,550
so that's why I included the guide,

1201
00:52:09,550 --> 00:52:11,000
so if you're reading about it,

1202
00:52:11,000 --> 00:52:14,218
they also learn a little bit
about the science behind it.

1203
00:52:14,218 --> 00:52:16,000
- For the people with, who are watching,

1204
00:52:16,000 --> 00:52:19,350
could you show us, it's called
"Bella, the Black Hole."

1205
00:52:19,350 --> 00:52:21,707

- Yes, "Bella, the Black Hole."

1206
00:52:21,707 --> 00:52:22,990
- Would you mind reading us a little bit?

1207
00:52:22,990 --> 00:52:24,240
- Okay, sure.

1208
00:52:24,240 --> 00:52:26,450
- I wanna say it's also
beautifully illustrated

1209
00:52:26,450 --> 00:52:29,190
and I believe it's illustrated
by a relative, is that right?

1210
00:52:29,190 --> 00:52:33,710
- Yes, Niayesh's cousin,
Nasim Abaeian in Toronto.

1211
00:52:35,558 --> 00:52:36,740
I like her work.

1212
00:52:36,740 --> 00:52:38,724
- She's an illustrator.

1213
00:52:38,724 --> 00:52:39,890
- And it does have a little bit

1214
00:52:39,890 --> 00:52:43,418
of a Middle Eastern teaming
to it, like I feel like.

1215
00:52:43,418 --> 00:52:44,378
- Yeah, it does.

1216
00:52:44,378 --> 00:52:46,790
Like you said, it's
scientifically accurate,

1217
00:52:46,790 --> 00:52:49,340
but it's obviously not
scientifically detailed,

1218
00:52:49,340 --> 00:52:51,870
so that's a challenge
to write for a child,

1219
00:52:51,870 --> 00:52:55,350
to comprehend without getting
the essential truth wrong.

1220
00:52:55,350 --> 00:52:58,060
- Yeah and I'm hoping like
even as they get older,

1221
00:52:58,060 --> 00:52:59,367
they look back at it and like,

1222
00:52:59,367 --> 00:53:01,330
"Oh, what did she mean by that?

1223
00:53:01,330 --> 00:53:04,917
Maybe I have to go read a
little bit more about this."

1224
00:53:04,917 --> 00:53:06,820
"My name is Bella.

1225
00:53:06,820 --> 00:53:10,580
I am a very shiny and hot star.

1226
00:53:10,580 --> 00:53:12,820
Do you know another star?

1227
00:53:12,820 --> 00:53:16,200
Yes, our sun is a star too.

1228
00:53:16,200 --> 00:53:20,320
I'm younger, but much bigger than the sun.

1229
00:53:20,320 --> 00:53:23,207
Gravity wants to squeeze me."

1230
00:53:24,060 --> 00:53:26,250
- I like that that's
just one page in itself.

1231
00:53:26,250 --> 00:53:30,040
Like what a beautiful
condensation of an idea,

1232
00:53:30,040 --> 00:53:31,190
wants to squeeze me.

1233
00:53:31,190 --> 00:53:33,610
- It's not easy to condense
these content things

1234
00:53:33,610 --> 00:53:35,130
into one phrase like that.

1235
00:53:35,130 --> 00:53:36,960
- We all had to meet the actual motions

1236
00:53:36,960 --> 00:53:40,113
that we had to squeeze
the child at that point.

1237
00:53:41,290 --> 00:53:43,380
- Oh, is this a participatory book?

1238
00:53:43,380 --> 00:53:44,770
- Yes.

1239
00:53:44,770 --> 00:53:48,100

I remember that's how it
went, but it's been a while.

1240
00:53:49,097 --> 00:53:53,500
- "But the pressure from
hot gas pushes me back.

1241
00:53:53,500 --> 00:53:57,190
At last I get tired and gravity wins."

1242
00:53:57,190 --> 00:53:59,462
- I think you should maybe not finish it.

1243
00:53:59,462 --> 00:54:00,535
- Leave the rest of it.

1244
00:54:00,535 --> 00:54:01,368
(all laughing)

1245
00:54:01,368 --> 00:54:02,560
- The origin story.

1246
00:54:02,560 --> 00:54:03,400
- A cliffhanger.

1247
00:54:03,400 --> 00:54:04,380
- Yeah, cliffhanger.

1248
00:54:04,380 --> 00:54:07,130
- So I'm not gonna of
spoiled the end of it,

1249
00:54:07,130 --> 00:54:10,870
but I guess from the name
there's a black hole appearing.

1250
00:54:10,870 --> 00:54:11,703
- Somewhere, yeah.

1251
00:54:11,703 --> 00:54:14,370
- And what was your son's
reaction to this book?

1252
00:54:14,370 --> 00:54:16,950
- I think he really loves
like those action motion,

1253
00:54:16,950 --> 00:54:20,650
like the pushing and
gravity and like and then.

1254
00:54:20,650 --> 00:54:22,193
- There's spaghetti in there.

1255
00:54:22,193 --> 00:54:24,840
- Spaghetti.

1256
00:54:24,840 --> 00:54:27,240
- Actually, can you explain
the spaghetti reference

1257
00:54:27,240 --> 00:54:28,660
'cause it does actually,

1258
00:54:28,660 --> 00:54:32,490
spaghetti has a scientific
sort of black hole meaning.

1259
00:54:32,490 --> 00:54:36,040
- Right, so spaghettification,
that's the term, I guess,

1260
00:54:36,040 --> 00:54:38,970
that as we get pulled
into a big black hole,

1261
00:54:38,970 --> 00:54:41,179
stellar black holes, right?

1262
00:54:41,179 --> 00:54:42,012
Is that the.

1263
00:54:42,012 --> 00:54:44,420
- Well, any, depends on how close you get.

1264
00:54:44,420 --> 00:54:47,300
- Yeah and then people have this idea

1265
00:54:47,300 --> 00:54:49,910
that they would just let go inside nicely,

1266
00:54:49,910 --> 00:54:53,160
but that's not how it's
gonna happen, unfortunately.

1267
00:54:53,160 --> 00:54:56,990
They're gonna, does this
interstella have the,

1268
00:54:56,990 --> 00:54:58,590
they don't they go, that movie.

1269
00:54:58,590 --> 00:54:59,423
- The movie.

1270
00:55:01,050 --> 00:55:03,140
They have a very big back hole, so this-

1271
00:55:03,140 --> 00:55:05,020
- Okay, so that's when they just went in,

1272
00:55:05,020 --> 00:55:07,070
like thinking there they went in

1273
00:55:07,070 --> 00:55:08,298
without anything happening to them.

1274
00:55:08,298 --> 00:55:09,131
- I don't think they got spaghettified.

1275
00:55:09,131 --> 00:55:10,050
- No, they didn't, right,

1276
00:55:10,050 --> 00:55:13,460
but in this one she gets
pulled and get the title,

1277
00:55:13,460 --> 00:55:17,410
you start to get stretched and stretched

1278
00:55:17,410 --> 00:55:19,560
and then become like a spaghetti,

1279
00:55:19,560 --> 00:55:21,989
so there is not really much of you

1280
00:55:21,989 --> 00:55:23,270
that's gonna make it inside.

1281
00:55:23,270 --> 00:55:25,500
- It's nice that you could
write about something

1282
00:55:25,500 --> 00:55:27,570
that is kind of, that
idea is kind of scary,

1283
00:55:27,570 --> 00:55:30,810
but in the book, Bella
is this lovable character

1284
00:55:30,810 --> 00:55:32,530
who's explaining her life cycle.

1285

00:55:32,530 --> 00:55:36,450
- And then you can see inside
the mom or parents' mind

1286
00:55:36,450 --> 00:55:38,380
that what they're
struggling at that point,

1287
00:55:38,380 --> 00:55:40,650
like between the different
foods, like, you know,

1288
00:55:40,650 --> 00:55:43,361
eat the broccoli, but no spaghetti.

1289
00:55:43,361 --> 00:55:46,425
(all laughing)

1290
00:55:46,425 --> 00:55:48,300
- And Niayesh, I know you also have a book

1291
00:55:48,300 --> 00:55:50,450
that you're working on and I
know we're not gonna give away

1292
00:55:50,450 --> 00:55:52,270
too many details, but do you wanna say,

1293
00:55:52,270 --> 00:55:54,190
is there anything you
wanna say about that?

1294
00:55:54,190 --> 00:55:57,150
- Yeah, it's gonna be a
slightly more elaborate version,

1295
00:55:59,010 --> 00:56:03,640
but yeah, but more focused on
the Big Bang and various ideas

1296
00:56:03,640 --> 00:56:05,490
and characters that are involved.

1297
00:56:05,490 --> 00:56:06,833
- Just to be clear, not
a kid's book, right?

1298
00:56:06,833 --> 00:56:08,670
This is a popular.

1299
00:56:08,670 --> 00:56:12,630
- Yeah, I think kids'
parents could read it.

1300
00:56:12,630 --> 00:56:17,630
Yeah, so this is going
to be a popular audience.

1301
00:56:17,920 --> 00:56:20,740
I hope teenagers could
enjoy it, but we'll see.

1302
00:56:20,740 --> 00:56:23,753
I don't actually know how
much of it I can give away.

1303
00:56:23,753 --> 00:56:25,820
I feel like I can hardly control myself,

1304
00:56:25,820 --> 00:56:29,100
but it's gonna come out
hopefully within a year or so

1305
00:56:29,100 --> 00:56:32,270
and it's more about the
Big Bang and various people

1306
00:56:32,270 --> 00:56:34,170
and characters involved.

1307
00:56:34,170 --> 00:56:35,003
- Another cliffhanger.

1308
00:56:35,003 --> 00:56:37,090
- Another cliffhanger, yes.

1309
00:56:37,090 --> 00:56:40,313
- First we have to finish
reading "Bella, the Black Hole."

1310
00:56:40,313 --> 00:56:41,146
- Yes.

1311
00:56:41,146 --> 00:56:42,340
- That's a prerequisite, I guess.

1312
00:56:42,340 --> 00:56:44,730
- Exactly, start with that,

1313
00:56:44,730 --> 00:56:47,221
and then we gonna build
up our way to the bigger,

1314
00:56:47,221 --> 00:56:48,460
the other one.

1315
00:56:48,460 --> 00:56:50,040
- Well, another thing I
really wanna make sure

1316
00:56:50,040 --> 00:56:52,800
we ask you both about is that
you're both quite involved

1317
00:56:52,800 --> 00:56:54,990
in outreach and versed in writing books

1318

00:56:54,990 --> 00:56:56,310
and in other forms as well

1319
00:56:56,310 --> 00:56:58,510
and you're also both advocates for equity,

1320
00:56:58,510 --> 00:57:02,240
diversity and inclusion,
EDI, within academia.

1321
00:57:02,240 --> 00:57:03,780
For example, Ghazal,
I know you're involved

1322
00:57:03,780 --> 00:57:06,440
with the Supernova Foundation
and a few other initiatives.

1323
00:57:06,440 --> 00:57:08,900
Can you maybe tell us a
little bit about some of these

1324
00:57:08,900 --> 00:57:10,880
initiatives you're involved in?

1325
00:57:10,880 --> 00:57:15,180
- EDI is quite close to my heart
because I mean the journeys

1326
00:57:15,180 --> 00:57:18,810
I've gone through to make it to today,

1327
00:57:18,810 --> 00:57:21,300
still being able to do research has been,

1328
00:57:21,300 --> 00:57:24,340
as I mentioned, alluded
to, it hasn't been easy.

1329

00:57:24,340 --> 00:57:27,281
- You mentioned you were the
one of two women on stage

1330
00:57:27,281 --> 00:57:28,893
in your high school contest.

1331
00:57:28,893 --> 00:57:33,130
- So there is a pre-immigrant phase,

1332
00:57:33,130 --> 00:57:35,410
which I had to deal with certain things

1333
00:57:35,410 --> 00:57:38,630
being a woman and being in
science and being in math,

1334
00:57:38,630 --> 00:57:40,800
it had its own hardship.

1335
00:57:40,800 --> 00:57:44,490
Then being a Middle Eastern
from a certain country

1336
00:57:44,490 --> 00:57:48,260
in North America, we had
to deal with another set

1337
00:57:48,260 --> 00:57:52,200
of problems and then
having a two-body problem,

1338
00:57:52,200 --> 00:57:56,360
which is often a lot of women
physicists have to deal with.

1339
00:57:56,360 --> 00:57:59,520
I think a good proportion of
them have two-body problems.

1340
00:57:59,520 --> 00:58:01,330
- Can you tell us what that phrase means

1341
00:58:01,330 --> 00:58:02,290
for people who might not know?

1342
00:58:02,290 --> 00:58:03,220
- Oh yes.

1343
00:58:03,220 --> 00:58:06,600
So for some reason,
female physicists also,

1344
00:58:06,600 --> 00:58:08,641
their partners are also academics

1345
00:58:08,641 --> 00:58:12,410
and therefore finding two academic jobs

1346
00:58:12,410 --> 00:58:14,930
in the same location is quite hard,

1347
00:58:14,930 --> 00:58:17,390
so we refer to this as a two-body problem

1348
00:58:17,390 --> 00:58:20,300
where one body finding a second job

1349
00:58:20,300 --> 00:58:22,740
or having two in the same institution

1350
00:58:22,740 --> 00:58:25,300
or at the same city is quite hard.

1351
00:58:25,300 --> 00:58:26,780
- I mean, finding even one is hard,

1352

00:58:26,780 --> 00:58:29,190
so finding two is less possible.

1353
00:58:29,190 --> 00:58:32,063
- Exactly, and we have
been through so many things

1354
00:58:32,063 --> 00:58:35,960
over the years, like I had to,
even pregnant with this guy,

1355
00:58:35,960 --> 00:58:38,420
this little kind of older one,

1356
00:58:38,420 --> 00:58:42,010
the closest job I could
find here was in Buffalo.

1357
00:58:42,010 --> 00:58:45,390
So pregnant, I had to travel
back and forth to work,

1358
00:58:46,310 --> 00:58:49,045
crossover, come back and like.

1359
00:58:49,045 --> 00:58:50,471
- Was it like five days before he was born

1360
00:58:50,471 --> 00:58:52,190
that we crossed the border?

1361
00:58:52,190 --> 00:58:54,280
- Yes, also crossed.

1362
00:58:54,280 --> 00:58:55,590
I'm glad I didn't know this,

1363
00:58:55,590 --> 00:58:57,200
but things could get complicated

1364
00:58:57,200 --> 00:58:59,779
if he didn't come right on time.

1365
00:58:59,779 --> 00:59:01,610
Because I was like, "Oh, it's no big deal.

1366
00:59:01,610 --> 00:59:02,940
If I'm having a delivery,

1367
00:59:02,940 --> 00:59:04,967
I'm just gonna go to the hospital."

1368
00:59:06,051 --> 00:59:07,593
But like apparently not, no.

1369
00:59:07,593 --> 00:59:11,890
That could be risky
driving alone and going.

1370
00:59:11,890 --> 00:59:15,029
But anyway, and I mean, again,

1371
00:59:15,029 --> 00:59:20,029
not adding two-body problem,
having families in academia,

1372
00:59:20,270 --> 00:59:23,030
all of this have a lot of challenges

1373
00:59:23,030 --> 00:59:27,090
so marginalized community
have that on top of everything

1374
00:59:27,090 --> 00:59:30,313
else as well so what
can we do to help out?

1375

00:59:30,313 --> 00:59:34,430
I mean, I feel like I might
not be able to move mountains,

1376
00:59:34,430 --> 00:59:37,730
but even if I can help one
person, that's my goal.

1377
00:59:37,730 --> 00:59:39,160
I have done something, right?

1378
00:59:39,160 --> 00:59:41,060
The little things we can do

1379
00:59:41,060 --> 00:59:44,860
and one thing that we
notice, a lot of places,

1380
00:59:44,860 --> 00:59:47,430
a lot of challenges are easier to tackle

1381
00:59:47,430 --> 00:59:50,080
if you have a network,
if you have a friend

1382
00:59:50,080 --> 00:59:52,680
who is there with you
and can hold your hands.

1383
00:59:52,680 --> 00:59:55,200
And especially if they're a
little bit ahead in your road

1384
00:59:55,200 --> 00:59:57,850
and can tell you like, you
know, "I faced the same thing,

1385
00:59:57,850 --> 01:00:00,213
don't doubt yourself, you
might be able to do that

1386
01:00:00,213 --> 01:00:01,990
or there's a strategy.

1387
01:00:01,990 --> 01:00:04,250
Like why don't you talk to another person

1388
01:00:04,250 --> 01:00:06,190
or put you in contact with someone else?"

1389
01:00:06,190 --> 01:00:10,180
So this Supernova Foundation
came out of this idea.

1390
01:00:10,180 --> 01:00:13,930
The original story was that
another friend in Ames,

1391
01:00:13,930 --> 01:00:16,350
the director of cosmology group there,

1392
01:00:16,350 --> 01:00:20,210
used to organize undergrad
workshops in Moreshas,

1393
01:00:20,210 --> 01:00:23,130
so we went for one of
those, similar to what

1394
01:00:23,130 --> 01:00:25,120
my supervisor did for us, I guess.

1395
01:00:25,120 --> 01:00:26,960
After a couple of years,

1396
01:00:26,960 --> 01:00:31,090
I think we went there
in 2013 and 2015 or '14,

1397
01:00:31,090 --> 01:00:33,240
he contacted me and a few of other women

1398
01:00:33,240 --> 01:00:35,900
who had participated and
said, "What I'm noticing

1399
01:00:35,900 --> 01:00:38,790
in this small scale community
is that the students

1400
01:00:38,790 --> 01:00:43,251
that come to our workshop,
we have seen some of the men

1401
01:00:43,251 --> 01:00:46,340
go to graduate school,
but none of the women,

1402
01:00:46,340 --> 01:00:48,370
is there anything we can do?"

1403
01:00:48,370 --> 01:00:53,070
So seven of us, three from the
people we met in a workshop,

1404
01:00:53,070 --> 01:00:57,350
Michelle Lochner and Valeria Paterness.

1405
01:00:57,350 --> 01:00:59,300
Michelle is in South Africa.

1406
01:00:59,300 --> 01:01:00,760
Valeria is-

1407
01:01:00,760 --> 01:01:01,593
- Katerina.

1408

01:01:01,593 --> 01:01:04,610
- Katerina is now based in Paris, France.

1409
01:01:04,610 --> 01:01:08,100
So we volunteered to start something.

1410
01:01:08,100 --> 01:01:10,580
I came back to my friends at Perimeter.

1411
01:01:10,580 --> 01:01:12,200
- Nasipia Swaney.

1412
01:01:12,200 --> 01:01:16,880
- Nasipia Swaney, Chiamata
Otaley, and Sarah Chanderra.

1413
01:01:16,880 --> 01:01:19,280
I recruited them and Renna Logic

1414
01:01:19,280 --> 01:01:22,360
who is now professor in Toronto.

1415
01:01:22,360 --> 01:01:25,720
Seven of us started with eight mentors.

1416
01:01:25,720 --> 01:01:27,810
We said, "Just do whatever we can do."

1417
01:01:27,810 --> 01:01:30,580
Like every couple of months,
let's talk to this women,

1418
01:01:30,580 --> 01:01:32,920
how they're holding up
and it was not easy.

1419
01:01:32,920 --> 01:01:36,700
We didn't have the experience
of doing this kind of work

1420
01:01:36,700 --> 01:01:39,280
before, but at least one of those women

1421
01:01:39,280 --> 01:01:41,360
made it to graduate school and followed up

1422
01:01:41,360 --> 01:01:45,420
and then on to pursue her
area or dreams in physics.

1423
01:01:45,420 --> 01:01:47,270
And then we thought about, okay,

1424
01:01:47,270 --> 01:01:48,880
if there's only seven of us,

1425
01:01:48,880 --> 01:01:52,710
what if there were more of us
and we could have other women

1426
01:01:52,710 --> 01:01:55,210
who can help and out of
this came this a story

1427
01:01:55,210 --> 01:01:58,360
of Supernova Foundation
with no financial support,

1428
01:01:58,360 --> 01:02:01,560
with no administration
support, no nothing,

1429
01:02:01,560 --> 01:02:06,340
just women physicists volunteering
their time and good heart

1430
01:02:06,340 --> 01:02:11,160
decided to help other women,

undergraduate women in physics

1431
01:02:11,160 --> 01:02:15,210
who are in other places who
need someone else like a mentor.

1432
01:02:15,210 --> 01:02:18,030
Michelle put a lot of
time and work into the,

1433
01:02:18,030 --> 01:02:21,440
a little bit of like website
development on that side of it.

1434
01:02:21,440 --> 01:02:26,440
Mom D. Knight became our
program administrator for free.

1435
01:02:26,990 --> 01:02:31,990
And now I think we have around
300 mentees, 100 mentors.

1436
01:02:32,300 --> 01:02:34,650
We have a long waiting
list because unfortunately

1437
01:02:34,650 --> 01:02:36,250
we cannot accommodate anybody.

1438
01:02:36,250 --> 01:02:39,560
If you will go to our
website, it shows the globe

1439
01:02:39,560 --> 01:02:42,200
and they have like anywhere from Brazil,

1440
01:02:42,200 --> 01:02:46,410
Argentina to India and
other Africa, other places,

1441
01:02:46,410 --> 01:02:48,960
women who taking part and
what we learned through this

1442
01:02:48,960 --> 01:02:50,560
process, first of all, I learned a lot.

1443
01:02:50,560 --> 01:02:52,530
This was a learning curve for me

1444
01:02:52,530 --> 01:02:54,120
like how to be a good mentor.

1445
01:02:54,120 --> 01:02:55,940
What are your role as a mentor?

1446
01:02:55,940 --> 01:02:58,610
You are not supervisor,
you are not a counselor.

1447
01:02:58,610 --> 01:03:00,510
What things can you do to help?

1448
01:03:00,510 --> 01:03:03,070
But also we realize we are
helping each other too,

1449
01:03:03,070 --> 01:03:06,210
like just connecting marginalized
people to each other,

1450
01:03:06,210 --> 01:03:08,690
having a network for them
to talk to each other,

1451
01:03:08,690 --> 01:03:11,170
not to feel helpless
or alone and isolated,

1452
01:03:11,170 --> 01:03:13,320
that by itself is a big step.

1453
01:03:13,320 --> 01:03:16,830
A lot of times it's like
maybe a senior physicist

1454
01:03:16,830 --> 01:03:18,437
asking another senior physicist,

1455
01:03:18,437 --> 01:03:20,450
"What did you do when you had this thing?"

1456
01:03:20,450 --> 01:03:22,830
Like, if you are in part
of this collaboration

1457
01:03:22,830 --> 01:03:25,567
and things like, it's come
up, how do you handle that?

1458
01:03:25,567 --> 01:03:28,170
And so far working, we
are growing quite fast.

1459
01:03:28,170 --> 01:03:31,430
So we don't know, we are
planning to maybe restructure it

1460
01:03:31,430 --> 01:03:34,910
to make it more sustainable
to accommodate the growth,

1461
01:03:34,910 --> 01:03:36,990
but let's see how it goes.

1462
01:03:36,990 --> 01:03:41,010
- And so the mentees are
mostly around graduate level?

1463
01:03:41,010 --> 01:03:43,410
- No, they're mostly undergraduate,

1464
01:03:43,410 --> 01:03:45,520
but sometimes master students.

1465
01:03:45,520 --> 01:03:47,760
So now we are thinking
of restructuring it,

1466
01:03:47,760 --> 01:03:50,670
maybe we can do, so when we started,

1467
01:03:50,670 --> 01:03:52,780
we would even have PhD students

1468
01:03:52,780 --> 01:03:55,720
mentor undergraduate students,

1469
01:03:55,720 --> 01:03:58,230
but now we are thinking,
because as we learn,

1470
01:03:58,230 --> 01:04:01,970
like sometimes a younger
postdoc needs a mentor

1471
01:04:01,970 --> 01:04:04,400
from the faculty or a graduate student

1472
01:04:04,400 --> 01:04:06,860
who learned from a postdoc

1473
01:04:06,860 --> 01:04:09,510
so we might do a little
bit of restructuring,

1474

01:04:09,510 --> 01:04:12,480
but the original plan was graduate student

1475
01:04:12,480 --> 01:04:15,537
and higher mentoring undergraduate.

1476
01:04:15,537 --> 01:04:18,600
And we started having even
taking master's students.

1477
01:04:18,600 --> 01:04:21,990
I have had master students
mentees just recently,

1478
01:04:21,990 --> 01:04:25,080
like one of my mentees,
have to brag about it.

1479
01:04:25,080 --> 01:04:28,360
She's interviewing like
top schools in the world,

1480
01:04:28,360 --> 01:04:31,625
has like admissions, like, oh my God.

1481
01:04:31,625 --> 01:04:32,458
- That's great, sounds
like the kind of thing

1482
01:04:32,458 --> 01:04:34,100
that would've been helpful
if it had been around

1483
01:04:34,100 --> 01:04:35,580
when you were their age.

1484
01:04:35,580 --> 01:04:38,720
- I think so, I mean,
I know so many people

1485
01:04:38,720 --> 01:04:41,461
and broke my heart along
the way that we lost, right,

1486
01:04:41,461 --> 01:04:45,940
because I make this
analogy other places too,

1487
01:04:45,940 --> 01:04:47,540
I'm saying this is like a,

1488
01:04:47,540 --> 01:04:51,080
for marginalized people
climbing the academic ladder

1489
01:04:51,080 --> 01:04:54,752
is like a ladder which
is constantly shaking

1490
01:04:54,752 --> 01:04:57,840
so you keep losing people along the way

1491
01:04:57,840 --> 01:05:01,000
and I've seen it, like I've
seen it in my lifetime,

1492
01:05:01,000 --> 01:05:02,640
like so far in my career

1493
01:05:02,640 --> 01:05:04,707
how many we have lost along the way.

1494
01:05:04,707 --> 01:05:07,080
- And it's hard because
this is such a big problem.

1495
01:05:07,080 --> 01:05:09,440
I think so many people
don't know where to start

1496
01:05:09,440 --> 01:05:12,370
and I just love what you said
a little while back that you

1497
01:05:12,370 --> 01:05:15,270
can start with something that
maybe seems small at the time.

1498
01:05:15,270 --> 01:05:17,630
Now this has grown into something
that's not at all small,

1499
01:05:17,630 --> 01:05:20,420
but you started with something
small that you thought

1500
01:05:20,420 --> 01:05:24,113
would be helpful and that
can take you into something

1501
01:05:24,113 --> 01:05:26,600
that can really make a
big difference later on.

1502
01:05:26,600 --> 01:05:28,470
- Yeah and I feel like it
fills into like, again,

1503
01:05:28,470 --> 01:05:30,420
my personality, like we discussed this.

1504
01:05:30,420 --> 01:05:31,610
Niayesh is big picture.

1505
01:05:31,610 --> 01:05:34,523
I'm gonna change and come
around like, let's just focus.

1506

01:05:36,325 --> 01:05:39,240
Let's see what I can do
here and see how it goes.

1507
01:05:39,240 --> 01:05:40,260
- It takes both types.

1508
01:05:40,260 --> 01:05:42,503
- Yeah, exactly, both are very important.

1509
01:05:42,503 --> 01:05:43,703
- Nice of you to say.

1510
01:05:45,200 --> 01:05:48,070
- Niayesh, do you have
like big picture ideas or?

1511
01:05:48,070 --> 01:05:49,940
- Actually, I mean, Ghazal is the expert.

1512
01:05:49,940 --> 01:05:52,600
Actually I have a feeling, I mean, she's,

1513
01:05:52,600 --> 01:05:55,489
maybe we have a little bit
of a role also because I

1514
01:05:55,489 --> 01:05:59,680
Ghazal is, she's also, am I
saying you're the president

1515
01:05:59,680 --> 01:06:02,341
of the women in math in Waterloo.

1516
01:06:02,341 --> 01:06:03,174
- Chair of the women.

1517
01:06:03,174 --> 01:06:04,670
- The chair of the women in math,

1518
01:06:04,670 --> 01:06:07,380
so she has kind of the
Supernova Foundation,

1519
01:06:07,380 --> 01:06:10,120
I think it's a great, it's
such a big project now,

1520
01:06:10,120 --> 01:06:13,260
even though it started small
and also all this stuff

1521
01:06:13,260 --> 01:06:15,955
she's doing it, the women
in math in Waterloo,

1522
01:06:15,955 --> 01:06:17,061
at the University of Waterloo.

1523
01:06:17,061 --> 01:06:20,980
I'm still at the level of
helping one person at the time

1524
01:06:20,980 --> 01:06:24,330
so I haven't really have
as big of an ambition,

1525
01:06:24,330 --> 01:06:27,170
but I try to do my best in this regard.

1526
01:06:27,170 --> 01:06:28,660
- Well, we have one more question

1527
01:06:28,660 --> 01:06:30,900
that was sent in by another student,

1528
01:06:30,900 --> 01:06:32,770
so maybe we can play that one.

1529
01:06:32,770 --> 01:06:34,959
- I'm Matt Duchen, a PT
student at Perimeter.

1530
01:06:34,959 --> 01:06:36,560
What do you think each
other's most interesting

1531
01:06:36,560 --> 01:06:39,050
and exciting contributions have been?

1532
01:06:39,050 --> 01:06:40,384
- We've talked about-

1533
01:06:40,384 --> 01:06:41,380
- For the listener, they
looked at each other

1534
01:06:41,380 --> 01:06:42,213
and didn't answer this.

1535
01:06:42,213 --> 01:06:44,320
- Well, I'm laughing
because I sometimes do

1536
01:06:44,320 --> 01:06:47,559
these interviews, postdoc interviews,

1537
01:06:47,559 --> 01:06:49,199
and this is what I ask.

1538
01:06:49,199 --> 01:06:51,435
- Really?
- Now I'm on the hot seat.

1539
01:06:51,435 --> 01:06:52,268
(all laughing)

1540
01:06:52,268 --> 01:06:53,730
- Now, but you're supposed
to say that about me, right?

1541
01:06:53,730 --> 01:06:56,740
- I think that's the question, yeah.

1542
01:06:57,900 --> 01:07:00,070
- You brag about his
contributions and vice versa.

1543
01:07:00,070 --> 01:07:00,903
- Or bad.

1544
01:07:01,940 --> 01:07:03,763
Doesn't have to be brag, it's okay.

1545
01:07:05,440 --> 01:07:08,741
- Yeah, I think that
cross-correlation, that was a,

1546
01:07:08,741 --> 01:07:11,680
I think that Niayesh was
a pioneer in this era.

1547
01:07:11,680 --> 01:07:16,500
Now it's, I mean, not that I'm
saying not gonna be as big,

1548
01:07:16,500 --> 01:07:19,720
but I'm saying that one
is now tested and grown

1549
01:07:19,720 --> 01:07:22,410
and it was a big
contribution to the field,

1550
01:07:22,410 --> 01:07:26,760
how we can extract some

actual physics and separate

1551
01:07:26,760 --> 01:07:30,510
these things out of such tiny signals

1552
01:07:30,510 --> 01:07:32,650
in different parts of data

1553
01:07:32,650 --> 01:07:35,620
or completely different datasets, I guess.

1554
01:07:35,620 --> 01:07:37,420
- And I don't even think we
asked you about that, Niayesh,

1555
01:07:37,420 --> 01:07:39,510
about these black hole echoes.

1556
01:07:39,510 --> 01:07:42,170
Do you wanna tell us a
little bit about that?

1557
01:07:42,170 --> 01:07:43,160
- It's entirely not your fault.

1558
01:07:43,160 --> 01:07:44,400
I do so many different things.

1559
01:07:44,400 --> 01:07:46,683
Like each of them is like a black hole.

1560
01:07:48,160 --> 01:07:50,660
I actually did work on
actual black holes as well.

1561
01:07:50,660 --> 01:07:52,730
So the story of echos,

1562

01:07:52,730 --> 01:07:54,390
which I think Ghazal was alleging to,

1563
01:07:54,390 --> 01:07:56,950
as maybe not the most exciting thing I do,

1564
01:07:56,950 --> 01:07:59,972
but you see, maybe time will tell.

1565
01:07:59,972 --> 01:08:02,930
So this is started with seeing
LIGO gravitational waves

1566
01:08:02,930 --> 01:08:04,430
around five or six years ago,

1567
01:08:04,430 --> 01:08:07,230
which they won the Nobel prize for.

1568
01:08:07,230 --> 01:08:10,640
But in fact, it's amazing thing
because it opened this door

1569
01:08:10,640 --> 01:08:13,870
for us for looking deep
into places where gravity

1570
01:08:13,870 --> 01:08:18,090
is very, very strong,
basically as strong as it gets,

1571
01:08:18,090 --> 01:08:21,010
these back holes that we
knew about them before.

1572
01:08:21,010 --> 01:08:24,290
Like for example, from Event
Horizon Telescope picture,

1573

01:08:24,290 --> 01:08:26,440
you knew there is some place
where gravity is as strong,

1574
01:08:26,440 --> 01:08:28,300
but it was very hard to get very deep

1575
01:08:28,300 --> 01:08:31,160
because basically just
light stops at some point.

1576
01:08:31,160 --> 01:08:34,660
And gravitational waves
actually can get deeper

1577
01:08:34,660 --> 01:08:37,430
because gravitational waves
are actually weakly interacting

1578
01:08:37,430 --> 01:08:41,340
with matter, so they can probe
very, very deeply into places

1579
01:08:41,340 --> 01:08:44,750
where we know gravity should
break these singularities

1580
01:08:44,750 --> 01:08:45,800
we were talking about.

1581
01:08:45,800 --> 01:08:47,810
Now, whether they will actually get there

1582
01:08:47,810 --> 01:08:50,520
is a matter of debate since LIGO discovery

1583
01:08:50,520 --> 01:08:52,670
gravitational waves, I've
thought about this problem a lot

1584
01:08:52,670 --> 01:08:55,100
and we've written papers
on this with my students

1585
01:08:55,100 --> 01:08:57,160
in the past five years or so.

1586
01:08:57,160 --> 01:09:00,880
I think it's kind of inevitable
that if quantum mechanics

1587
01:09:00,880 --> 01:09:04,540
is somewhere united with
gravity, at some point,

1588
01:09:04,540 --> 01:09:07,550
then black holes cannot
be these bottomless pits

1589
01:09:07,550 --> 01:09:10,456
that basically general
relativity tells us.

1590
01:09:10,456 --> 01:09:12,600
General relativity tells us that, I mean,

1591
01:09:12,600 --> 01:09:14,870
black holes are, don't have any end.

1592
01:09:14,870 --> 01:09:18,182
Basically things fall in and
keep going in and in and in

1593
01:09:18,182 --> 01:09:20,720
and never really, nobody from
outside will never hear you

1594
01:09:20,720 --> 01:09:22,280
hitting the bottom of a black hole.

1595
01:09:22,280 --> 01:09:24,950
According to Einstein,
that's a one-way street.

1596
01:09:24,950 --> 01:09:27,210
But if you believe in quantum
mechanics, it cannot be,

1597
01:09:27,210 --> 01:09:29,430
there should be a finite
demand of a space there,

1598
01:09:29,430 --> 01:09:31,210
so eventually, you gotta hit the bottom

1599
01:09:31,210 --> 01:09:33,540
and you're gonna hear back
and those are the echoes

1600
01:09:33,540 --> 01:09:36,400
that we've kind of been
exploring for a while.

1601
01:09:36,400 --> 01:09:39,020
I think it's an opportune time

1602
01:09:39,020 --> 01:09:42,370
'cause the first time you
can actually hear back holes,

1603
01:09:42,370 --> 01:09:44,360
but also hear them so deeply basically,

1604
01:09:44,360 --> 01:09:46,907
just when they're forming
and basically you can see

1605
01:09:46,907 --> 01:09:50,170

basically down into the
very bottom of them.

1606
01:09:50,170 --> 01:09:52,540
We think echos is a possible signature

1607
01:09:52,540 --> 01:09:55,377
of what could be sitting at
the bottom of the back hole

1608
01:09:55,377 --> 01:09:58,280
and a very opportunistic time
to basically looking for this.

1609
01:09:58,280 --> 01:10:00,040
I mean there is no guarantee,

1610
01:10:00,040 --> 01:10:02,573
but I think that's what
I'm most excited about.

1611
01:10:03,496 --> 01:10:05,850
Also Ghazal has had a lot of interesting

1612
01:10:05,850 --> 01:10:08,020
and influential works, but
I mean, she talked about

1613
01:10:08,020 --> 01:10:10,950
some of them, for example,
how Cuscutan could help us

1614
01:10:10,950 --> 01:10:13,070
balance the universe,
the contracting universe

1615
01:10:13,070 --> 01:10:16,380
could become expanding, but
probably the most important,

1616
01:10:16,380 --> 01:10:18,690
exciting thing is that she showed,

1617
01:10:18,690 --> 01:10:20,470
I mean the very early universe,

1618
01:10:20,470 --> 01:10:23,250
at least one of the three tenants of,

1619
01:10:23,250 --> 01:10:25,790
I mean physics as we know
it should break down,

1620
01:10:25,790 --> 01:10:28,290
it's either that you need
to have negative pressure,

1621
01:10:28,290 --> 01:10:31,630
that inflationary phase like we do now,

1622
01:10:31,630 --> 01:10:32,720
but if you don't do that,

1623
01:10:32,720 --> 01:10:35,740
you either get propagation
faster than the speed of light

1624
01:10:35,740 --> 01:10:39,170
or you need some quantum
gravity effect basically.

1625
01:10:39,170 --> 01:10:42,363
So she actually proved the theorem

1626
01:10:42,363 --> 01:10:45,930
to that effect, so it's a technical work,

1627
01:10:45,930 --> 01:10:48,210

but it's a solid technical
work in the spirit

1628
01:10:48,210 --> 01:10:49,570
of the kind of thing that she does,

1629
01:10:49,570 --> 01:10:52,820
that they're all, she crosses all the Ts

1630
01:10:52,820 --> 01:10:55,320
and dots all the Is so
that there's no doubt left.

1631
01:10:56,160 --> 01:10:57,620
That's what's happening.

1632
01:10:57,620 --> 01:11:00,580
If you think you know, there
are three possibilities,

1633
01:11:00,580 --> 01:11:02,587
thanks to Ghazal we know
in the early universe

1634
01:11:02,587 --> 01:11:04,530
and everything else
people have thought about

1635
01:11:04,530 --> 01:11:05,730
falls under those three.

1636
01:11:06,998 --> 01:11:09,390
- I guess, to explain that
empirically, we noticed it,

1637
01:11:09,390 --> 01:11:11,710
that people are coming
with these scenarios,

1638

01:11:11,710 --> 01:11:14,650
but I noticed that they either
fall into one of these three

1639
01:11:14,650 --> 01:11:16,510
and again, okay, why is that?

1640
01:11:16,510 --> 01:11:17,810
There should be a reason for that,

1641
01:11:17,810 --> 01:11:20,120
that people are coming up only with these

1642
01:11:20,120 --> 01:11:21,930
three different possibilities.

1643
01:11:21,930 --> 01:11:22,900
- So she proved the theorem

1644
01:11:22,900 --> 01:11:25,230
that these are the only
three possibilities.

1645
01:11:25,230 --> 01:11:26,680
- That's why it is happening.

1646
01:11:27,930 --> 01:11:30,290
- Seems like both of these
contributions you're mentioning

1647
01:11:30,290 --> 01:11:32,750
really speak to each of your strengths

1648
01:11:32,750 --> 01:11:34,890
and your unique approaches to research.

1649
01:11:34,890 --> 01:11:36,100
It's neat to hear.

1650
01:11:36,100 --> 01:11:37,370
- Thank you so much for joining us.

1651
01:11:37,370 --> 01:11:38,203
It's just been-

1652
01:11:38,203 --> 01:11:39,590
- Thank you, thank you for inviting us.

1653
01:11:39,590 --> 01:11:41,003
We enjoyed the conversation.

1654
01:11:41,980 --> 01:11:44,920
- It's a lot of fun, thank
you very much for having us.

1655
01:11:44,920 --> 01:11:48,310
(gentle music)

1656
01:11:48,310 --> 01:11:50,240
- Thanks so much for listening.

1657
01:11:50,240 --> 01:11:52,380
Perimeter Institute is a not-for-profit

1658
01:11:52,380 --> 01:11:55,510
charitable organization that
shares cutting edge ideas

1659
01:11:55,510 --> 01:11:58,070
with the world, thanks
to the ongoing support

1660
01:11:58,070 --> 01:12:00,520
of the governments of Ontario in Canada,

1661
01:12:00,520 --> 01:12:02,770
and also thanks to donors like you.

1662
01:12:02,770 --> 01:12:05,573
Thank you for being part of the equation.

1663
01:12:05,573 --> 01:12:08,156
(gentle music)