
Google+
Mario
y Darnell

1
00:00:06,470 --> 00:00:03,990
where are you tony

2
00:00:08,230 --> 00:00:06,480
uh i am in my home office and we are now

3
00:00:10,870 --> 00:00:08,240
live okay

4
00:00:13,430 --> 00:00:10,880
hello everybody and welcome to a very

5
00:00:15,030 --> 00:00:13,440
special edition of our hubble hangouts

6
00:00:16,470 --> 00:00:15,040
uh my name is tony darnell i'm the

7
00:00:19,349 --> 00:00:16,480
social media manager at the space

8
00:00:21,590 --> 00:00:19,359
telescope science institute and this is

9
00:00:23,429 --> 00:00:21,600
a very special edition because we've got

10
00:00:25,029 --> 00:00:23,439
an opportunity to talk with people like

11
00:00:26,950 --> 00:00:25,039
two guys i have been

12
00:00:29,029 --> 00:00:26,960
very much interested in getting into a

13
00:00:30,790 --> 00:00:29,039

hangout and i finally have them here we

14
00:00:32,389 --> 00:00:30,800
only have a few minutes so we'll uh

15
00:00:35,190 --> 00:00:32,399
we'll make this as quickly as pos we'll

16
00:00:36,549 --> 00:00:35,200
make this as as uh brief as we can

17
00:00:37,910 --> 00:00:36,559
because they have other things they've

18
00:00:40,790 --> 00:00:37,920
got to get back to

19
00:00:42,630 --> 00:00:40,800
with me tonight is dr mario olivio he's

20
00:00:45,750 --> 00:00:42,640
an astronomer from the space telescope

21
00:00:47,910 --> 00:00:45,760
science institute hi mario he is an

22
00:00:50,630 --> 00:00:47,920
artist he is an author and blogger and

23
00:00:52,470 --> 00:00:50,640
his his latest book is on scientific

24
00:00:53,830 --> 00:00:52,480
blunders which we did a hangout on a few

25
00:00:55,270 --> 00:00:53,840
months back actually it was almost a

26
00:00:58,950 --> 00:00:55,280
year ago now

27
00:01:00,470 --> 00:00:58,960
which was a great book and uh i i guess

28
00:01:02,310 --> 00:01:00,480
it's been getting a lot getting a lot of

29
00:01:04,070 --> 00:01:02,320
attention uh out there because i keep

30
00:01:06,870 --> 00:01:04,080
hearing about it from people

31
00:01:09,270 --> 00:01:06,880
and uh also with me is uh dr adam reece

32
00:01:11,590 --> 00:01:09,280
he is the uh he's also an astronomer at

33
00:01:12,950 --> 00:01:11,600
the telescope science institute but he

34
00:01:16,070 --> 00:01:12,960
has um

35
00:01:17,310 --> 00:01:16,080
also won the uh he's a nobel prize

36
00:01:20,550 --> 00:01:17,320
winner he won the

37
00:01:24,469 --> 00:01:20,560
2011 nobel prize in physics for his work

38
00:01:27,190 --> 00:01:24,479

on the discovery that the universe is

39
00:01:30,230 --> 00:01:27,200
accelerating as it expands by doing

40
00:01:33,510 --> 00:01:30,240
observations of type 1a supernovae so

41
00:01:34,950 --> 00:01:33,520
welcome guys uh this week you guys have

42
00:01:37,030 --> 00:01:34,960
been very busy

43
00:01:40,069 --> 00:01:37,040
work uh putting together among other

44
00:01:42,710 --> 00:01:40,079
people a workshop at the institute uh

45
00:01:45,910 --> 00:01:42,720
called the cosmic distance ladder

46
00:01:48,469 --> 00:01:45,920
and you've been uh you've been i guess

47
00:01:50,310 --> 00:01:48,479
it's a series of talks and papers and

48
00:01:52,870 --> 00:01:50,320
presentations on

49
00:01:55,670 --> 00:01:52,880
how well we know

50
00:01:57,429 --> 00:01:55,680
how well our techniques for measuring

51
00:01:58,789 --> 00:01:57,439
the universe and how far away things are

52
00:02:00,469 --> 00:01:58,799
is that correct

53
00:02:02,709 --> 00:02:00,479
who wants to who wants to go how about

54
00:02:04,069 --> 00:02:02,719
you dr dr reese go ahead

55
00:02:07,109 --> 00:02:04,079
um yes

56
00:02:08,550 --> 00:02:07,119
we uh we know how to measure distances

57
00:02:12,229 --> 00:02:08,560
in the universe

58
00:02:13,670 --> 00:02:12,239
uh and in some cases we can measure them

59
00:02:16,070 --> 00:02:13,680
starting from

60
00:02:18,710 --> 00:02:16,080
the beginning the big bang and in other

61
00:02:21,430 --> 00:02:18,720
cases we start from nearby

62
00:02:22,550 --> 00:02:21,440
and this week we're trying to see if our

63
00:02:24,390 --> 00:02:22,560

measurements

64
00:02:26,070 --> 00:02:24,400
meet in the middle sort of like building

65
00:02:28,229 --> 00:02:26,080
a bridge from both ends you want to make

66
00:02:30,790 --> 00:02:28,239
sure they connect

67
00:02:32,070 --> 00:02:30,800
okay so the uh we're getting it i'm

68
00:02:33,430 --> 00:02:32,080
hearing your feedback come back a little

69
00:02:37,030 --> 00:02:33,440
bit hopefully that will get that that'll

70
00:02:38,390 --> 00:02:37,040
get better as we go on so why

71
00:02:40,390 --> 00:02:38,400
why do they do is this something

72
00:02:42,390 --> 00:02:40,400
astronomers periodically too do you just

73
00:02:45,190 --> 00:02:42,400
get together and uh and see how well

74
00:02:45,990 --> 00:02:45,200
you're doing uh mario so

75
00:02:47,430 --> 00:02:46,000
yeah

76
00:02:50,630 --> 00:02:47,440
this is a

77
00:02:53,430 --> 00:02:50,640
measurement of the distances uh ties

78
00:02:56,309 --> 00:02:53,440
into something very important which is

79
00:02:58,070 --> 00:02:56,319
uh the age of the universe

80
00:03:00,949 --> 00:02:58,080
and also

81
00:03:03,670 --> 00:03:00,959
we try to determine all the parameters

82
00:03:04,790 --> 00:03:03,680
that determine what our universe looks

83
00:03:07,270 --> 00:03:04,800
like

84
00:03:08,869 --> 00:03:07,280
and this parameter which is called the

85
00:03:12,790 --> 00:03:08,879
hubble constant

86
00:03:15,990 --> 00:03:12,800
um acts as as an anchor if you like to

87
00:03:18,470 --> 00:03:16,000
many other parameters so by measuring

88
00:03:19,750 --> 00:03:18,480

this to a very high accuracy and

89
00:03:22,390 --> 00:03:19,760
precision

90
00:03:25,190 --> 00:03:22,400
uh i think that we can know much more

91
00:03:26,869 --> 00:03:25,200
about our unity

92
00:03:29,350 --> 00:03:26,879
so this hubble constant tell us a little

93
00:03:30,229 --> 00:03:29,360
bit about what that what is that adam

94
00:03:33,670 --> 00:03:30,239
um

95
00:03:37,030 --> 00:03:33,680
the hubble constant is the relationship

96
00:03:39,910 --> 00:03:37,040
between how fast galaxies move away from

97
00:03:42,869 --> 00:03:39,920
us and how far away they are from us so

98
00:03:44,470 --> 00:03:42,879
if you imagine a loaf of raisin bread

99
00:03:47,350 --> 00:03:44,480
rising in the oven

100
00:03:49,670 --> 00:03:47,360
uh the further away a raisin is from

101
00:03:52,070 --> 00:03:49,680
another raisin the faster it will appear

102
00:03:55,430 --> 00:03:52,080
to move away because there's more dough

103
00:03:57,509 --> 00:03:55,440
between those raisins and so this is one

104
00:03:59,910 --> 00:03:57,519
of the amazing facts about our universe

105
00:04:01,990 --> 00:03:59,920
is that because it's expanding but

106
00:04:03,910 --> 00:04:02,000
maintaining its proportions

107
00:04:06,390 --> 00:04:03,920
when we measure ever more distant

108
00:04:08,309 --> 00:04:06,400
galaxies they will rush away faster and

109
00:04:10,070 --> 00:04:08,319
it's this important number the

110
00:04:12,149 --> 00:04:10,080
proportionality constant known as the

111
00:04:14,149 --> 00:04:12,159
hobo constant that tells us the

112
00:04:16,469 --> 00:04:14,159
relationship and the inverse of the

113
00:04:19,030 --> 00:04:16,479

hubble constant tells us approximately

114
00:04:20,550 --> 00:04:19,040
how old the universe is as mario said

115
00:04:23,350 --> 00:04:20,560
so that's the way in which we sort of

116
00:04:24,790 --> 00:04:23,360
run the clock backwards to see right

117
00:04:26,870 --> 00:04:24,800
yeah what the universe was like at

118
00:04:29,270 --> 00:04:26,880
different times of the in our in our

119
00:04:30,870 --> 00:04:29,280
history so what is the relationship is

120
00:04:32,790 --> 00:04:30,880
it linear is it a straight line is the

121
00:04:35,270 --> 00:04:32,800
farther things are the the faster

122
00:04:38,310 --> 00:04:35,280
they're going uh is it very complicated

123
00:04:42,550 --> 00:04:38,320
yeah yeah no it's actually it is linear

124
00:04:48,070 --> 00:04:45,350
yes there is a direct proportionality

125
00:04:51,030 --> 00:04:48,080
something that is twice as far appears

126
00:04:52,629 --> 00:04:51,040
to recede twice as fast

127
00:04:54,950 --> 00:04:52,639
and you know you know it would have

128
00:04:57,270 --> 00:04:54,960
basically stayed like that had it not

129
00:05:01,189 --> 00:04:57,280
been for this discovery that

130
00:05:03,749 --> 00:05:01,199
adam was involved with uh

131
00:05:06,469 --> 00:05:03,759
our universe is not just expanding but

132
00:05:07,430 --> 00:05:06,479
the expansion is actually speeding up

133
00:05:17,990 --> 00:05:07,440
so

134
00:05:21,990 --> 00:05:19,510
we need to take care of this

135
00:05:24,950 --> 00:05:22,000
acceleration and so on

136
00:05:26,790 --> 00:05:24,960
i remember um i think i

137
00:05:28,870 --> 00:05:26,800
back back in the day this was many many

138
00:05:30,310 --> 00:05:28,880

years ago back before uh like back when

139
00:05:31,990 --> 00:05:30,320
i think you were just embarking on this

140
00:05:33,909 --> 00:05:32,000
work uh adam that

141
00:05:36,150 --> 00:05:33,919
i don't think it was a very obvious in

142
00:05:37,909 --> 00:05:36,160
the beginning that the universe was

143
00:05:39,510 --> 00:05:37,919
accelerating as it was expanding

144
00:05:41,590 --> 00:05:39,520
everybody knew it was expanding we've

145
00:05:43,510 --> 00:05:41,600
known that since hubble's time but but

146
00:05:45,590 --> 00:05:43,520
the idea that it was accelerating caught

147
00:05:48,390 --> 00:05:45,600
everybody by surprise didn't i mean

148
00:05:51,110 --> 00:05:48,400
didn't i see a a paper maybe it was you

149
00:05:53,670 --> 00:05:51,120
guys who said where there was a subtitle

150
00:05:55,430 --> 00:05:53,680
called measuring the deceleration of the

151
00:05:57,189 --> 00:05:55,440
universe you were pretty sure you

152
00:05:59,270 --> 00:05:57,199
weren't going to see an acceleration

153
00:06:01,350 --> 00:05:59,280
weren't you that's right the

154
00:06:03,270 --> 00:06:01,360
expectation was that because the

155
00:06:05,830 --> 00:06:03,280
universe is full of matter

156
00:06:08,070 --> 00:06:05,840
uh the gravity between matter and the

157
00:06:11,189 --> 00:06:08,080
universe is attractive and so it would

158
00:06:13,430 --> 00:06:11,199
act to sort of put a halt or break on

159
00:06:15,270 --> 00:06:13,440
the expansion like if you took a pair of

160
00:06:18,150 --> 00:06:15,280
keys and tossed them in the air you

161
00:06:20,150 --> 00:06:18,160
expect gravity to pull them back down um

162
00:06:23,189 --> 00:06:20,160
the question really was how much matter

163
00:06:25,830 --> 00:06:23,199

is out there and so by

164
00:06:27,510 --> 00:06:25,840
how much your keys decelerate back to

165
00:06:29,110 --> 00:06:27,520
the earth you're essentially weighing

166
00:06:31,590 --> 00:06:29,120
earth we thought we were doing that

167
00:06:46,710 --> 00:06:31,600
experiment and when we looked at the

168
00:06:46,720 --> 00:06:55,510
uh

169
00:07:00,790 --> 00:06:58,469
dark energy that represents an energy

170
00:07:03,189 --> 00:07:00,800
built into the vacuum that would cause

171
00:07:05,189 --> 00:07:03,199
this repulsive gravity and the universe

172
00:07:07,430 --> 00:07:05,199
accelerator

173
00:07:09,589 --> 00:07:07,440
so that that you know that blows me away

174
00:07:11,510 --> 00:07:09,599
i mean you i'm a big fan of the nfl and

175
00:07:13,270 --> 00:07:11,520
they always tell you every sunday well

176
00:07:15,350 --> 00:07:13,280
that's why you play the game because you

177
00:07:17,749 --> 00:07:15,360
can't just say for certain how that's

178
00:07:19,830 --> 00:07:17,759
right that's why you use an experiment

179
00:07:21,589 --> 00:07:19,840
yeah and so here it's like well that's

180
00:07:24,070 --> 00:07:21,599
why we do the observations is because we

181
00:07:25,510 --> 00:07:24,080
got to know for sure uh what's going on

182
00:07:26,790 --> 00:07:25,520
so that's what you guys are doing with

183
00:07:28,309 --> 00:07:26,800
this workshop you're you're sort of

184
00:07:31,110 --> 00:07:28,319
commiserating seeing how well you're

185
00:07:32,870 --> 00:07:31,120
doing how well are we doing how well are

186
00:07:35,110 --> 00:07:32,880
we doing with that well we understand

187
00:07:38,790 --> 00:07:35,120
these cosmic distances you know until

188
00:07:39,589 --> 00:07:38,800

about 20 years ago we didn't solve the

189
00:07:41,670 --> 00:07:39,599
this

190
00:08:10,070 --> 00:07:41,680
expansion

191
00:08:15,350 --> 00:08:12,550
and we reached a situation where we're

192
00:08:16,950 --> 00:08:15,360
discussing you know is that even a

193
00:08:18,550 --> 00:08:16,960
discrepancy

194
00:08:21,270 --> 00:08:18,560
uh or not

195
00:08:24,070 --> 00:08:21,280
does it point to some new physics that

196
00:08:26,150 --> 00:08:24,080
we need to understand or you know is it

197
00:08:28,869 --> 00:08:26,160
just still within the errors of the

198
00:08:31,189 --> 00:08:28,879
method but we've made a huge huge

199
00:08:33,110 --> 00:08:31,199
advantages you know you know

200
00:08:35,750 --> 00:08:33,120
not knowing that number two within a

201
00:08:38,070 --> 00:08:35,760
factor of two to now now

202
00:08:52,389 --> 00:08:38,080
about three percent

203
00:08:52,399 --> 00:09:16,949
maybe

204
00:09:32,949 --> 00:09:19,590
another possibility is more exotic

205
00:09:35,910 --> 00:09:33,750
wow

206
00:09:38,150 --> 00:09:35,920
boy i wish i had like two more hours

207
00:09:40,630 --> 00:09:38,160
with you guys so adam adam brought up

208
00:09:42,230 --> 00:09:40,640
the uh the uh talks that were being done

209
00:09:43,030 --> 00:09:42,240
today and i want you guys to know that i

210
00:09:45,509 --> 00:09:43,040
put

211
00:09:47,269 --> 00:09:45,519
a link down in the description box of

212
00:09:49,269 --> 00:09:47,279
the event is also also put it in the

213
00:09:50,949 --> 00:09:49,279

youtube video where you can go and watch

214
00:09:52,230 --> 00:09:50,959
today's talks

215
00:09:53,350 --> 00:09:52,240
i've been watching them on and off

216
00:09:57,030 --> 00:09:53,360
throughout the day and they've been

217
00:10:00,150 --> 00:09:57,040
really really good so um you guys have a

218
00:10:02,949 --> 00:10:00,160
lot of tools in your tool bag to measure

219
00:10:04,790 --> 00:10:02,959
cosmic distances uh you've got things

220
00:10:07,350 --> 00:10:04,800
like well what what adam study which

221
00:10:10,310 --> 00:10:07,360
were type 1a supernovae we also use

222
00:10:13,030 --> 00:10:10,320
cepheid variables uh to to find out how

223
00:10:15,430 --> 00:10:13,040
far away things are

224
00:10:17,670 --> 00:10:15,440
why so many why do we have why do we

225
00:10:18,949 --> 00:10:17,680
have so many ways and and what other

226
00:10:19,990 --> 00:10:18,959
ones are there that maybe i haven't

227
00:10:20,710 --> 00:10:20,000
mentioned

228
00:10:24,949 --> 00:10:20,720
so

229
00:10:27,030 --> 00:10:24,959
methods and uh you know many of them

230
00:10:30,550 --> 00:10:27,040
will be discussed at this meeting things

231
00:10:41,590 --> 00:10:30,560
like gravitational lensing uh you know

232
00:10:46,470 --> 00:10:42,949
is

233
00:10:48,230 --> 00:10:46,480
every one of those methods first of all

234
00:10:52,069 --> 00:10:48,240
you know there are both

235
00:10:55,590 --> 00:10:54,150
both because of the statistics of the

236
00:10:58,310 --> 00:10:55,600
measurement but

237
00:11:12,790 --> 00:10:58,320
also because of what we call the

238
00:11:16,389 --> 00:11:15,350

systematics are different from different

239
00:11:19,990 --> 00:11:16,399
methods

240
00:11:23,190 --> 00:11:20,000
so only by taking the most precise

241
00:11:26,550 --> 00:11:23,200
methods that you have and combining them

242
00:11:29,110 --> 00:11:26,560
you can actually try to get above these

243
00:11:30,470 --> 00:11:29,120
systematics and see what their values

244
00:11:35,509 --> 00:11:30,480
are

245
00:11:37,750 --> 00:11:35,519
methods work better in like uh type 1a

246
00:11:39,509 --> 00:11:37,760
supernovae may be good for a certain

247
00:11:41,509 --> 00:11:39,519
distance regime i would guess and maybe

248
00:11:43,269 --> 00:11:41,519
supernova i know certainly parallax when

249
00:11:45,430 --> 00:11:43,279
you do parallax measurements and that's

250
00:11:48,310 --> 00:11:45,440
the sort of apparent shift of background

251
00:11:50,470 --> 00:11:48,320
against a foreground uh object uh

252
00:11:52,310 --> 00:11:50,480
those certainly aren't good for really

253
00:11:54,310 --> 00:11:52,320
distant measurements most

254
00:11:57,829 --> 00:11:54,320
indicators we use

255
00:11:59,670 --> 00:11:57,839
um change from being

256
00:12:01,509 --> 00:11:59,680
i would say common

257
00:12:02,630 --> 00:12:01,519
but faint those are the ones we use

258
00:12:05,269 --> 00:12:02,640
nearby

259
00:12:07,190 --> 00:12:05,279
to luminous and rare those are the ones

260
00:12:09,509 --> 00:12:07,200
we use far away so

261
00:12:11,990 --> 00:12:09,519
uh i wish that type 1a supernovae would

262
00:12:14,629 --> 00:12:12,000
all go off uh right around us you know

263
00:12:16,470 --> 00:12:14,639

100 parsecs away because i can measure

264
00:12:19,350 --> 00:12:16,480
the parallax of those although it might

265
00:12:22,150 --> 00:12:19,360
be much more comfortable for us

266
00:12:33,269 --> 00:12:22,160
but the reality is that there's

267
00:12:49,430 --> 00:12:35,990
are common in terms of a given galaxy

268
00:12:55,350 --> 00:12:52,629
so different indicators good at

269
00:12:57,829 --> 00:12:55,360
different ranges so in many cases we

270
00:13:01,030 --> 00:12:57,839
have to connect them together to get out

271
00:13:03,590 --> 00:13:01,040
to a smooth expansion of the universe

272
00:13:06,389 --> 00:13:03,600
right so basically

273
00:13:09,350 --> 00:13:06,399
like a ladder kind of where you know

274
00:13:11,750 --> 00:13:09,360
nearby things provide some of the nearby

275
00:13:14,230 --> 00:13:11,760
ones and then you know you have to go to

276
00:13:15,990 --> 00:13:14,240
the next level to provide some more runs

277
00:13:18,829 --> 00:13:16,000
and then eventually to connect to

278
00:13:23,990 --> 00:13:18,839
connect to the farthest

279
00:13:28,870 --> 00:13:26,710
with uh adam with respect to your

280
00:13:31,509 --> 00:13:28,880
research on type 1a

281
00:13:33,829 --> 00:13:31,519
uh supernova you took some observations

282
00:13:36,629 --> 00:13:33,839
and your your research involved

283
00:13:38,790 --> 00:13:36,639
obviously measuring a whole lot of these

284
00:13:40,470 --> 00:13:38,800
but wasn't that a certain instance or a

285
00:13:42,389 --> 00:13:40,480
certain period in

286
00:13:45,910 --> 00:13:42,399
in the universe's history i mean i guess

287
00:13:48,150 --> 00:13:45,920
my question is how certain are we

288
00:13:50,310 --> 00:13:48,160

that the universe has always been

289
00:13:52,069 --> 00:13:50,320
accelerating at the same rate i mean

290
00:13:53,990 --> 00:13:52,079
could it have been different at

291
00:13:55,990 --> 00:13:54,000
different times in the past and wouldn't

292
00:13:57,910 --> 00:13:56,000
we notice that through these different

293
00:14:00,870 --> 00:13:57,920
measurements that you guys are

294
00:14:03,350 --> 00:14:00,880
looking at well type one supernova use

295
00:14:05,269 --> 00:14:03,360
them to be very far back all the way

296
00:14:08,150 --> 00:14:05,279
back to about

297
00:14:12,150 --> 00:14:08,160
12 billion years out of a universe

298
00:14:14,870 --> 00:14:12,160
that's about 14 billion years old so now

299
00:14:16,949 --> 00:14:14,880
the acceleration only started about 5

300
00:14:18,790 --> 00:14:16,959
billion years ago

301
00:14:21,189 --> 00:14:18,800
before that we could see the universe

302
00:14:23,189 --> 00:14:21,199
was decelerating and what we make of

303
00:14:25,189 --> 00:14:23,199
this is that there's two important

304
00:14:27,990 --> 00:14:25,199
components in the universe dark energy

305
00:14:30,150 --> 00:14:28,000
and dark matter dark matter was dominant

306
00:14:32,310 --> 00:14:30,160
earlier when the universe was denser

307
00:14:34,949 --> 00:14:32,320
dark energy is the thing that's dominant

308
00:14:37,269 --> 00:14:34,959
now and whether that acceleration is

309
00:14:39,110 --> 00:14:37,279
constant or not really gets at what the

310
00:14:41,189 --> 00:14:39,120
nature of the dark energy is which is

311
00:14:43,670 --> 00:14:41,199
something we're trying to measure by

312
00:14:45,350 --> 00:14:43,680
observing many more supernovae wow so

313
00:14:47,829 --> 00:14:45,360

that's so that's the first time i had

314
00:14:49,910 --> 00:14:47,839
heard that five billion years ago yeah

315
00:14:52,389 --> 00:14:49,920
or when you uh the the universe was

316
00:14:54,949 --> 00:14:52,399
actually decelerating right

317
00:14:56,949 --> 00:14:54,959
wow and then dominated primarily by dark

318
00:14:58,949 --> 00:14:56,959
matter and then at some point the

319
00:15:00,949 --> 00:14:58,959
expansion got to a certain area where

320
00:15:02,949 --> 00:15:00,959
dark energy took over and started that's

321
00:15:05,350 --> 00:15:02,959
right dark energy is pretty we think

322
00:15:06,550 --> 00:15:05,360
it's fairly constant in its energy

323
00:15:09,430 --> 00:15:06,560
density but

324
00:15:11,590 --> 00:15:09,440
the density of matter drops as the

325
00:15:13,670 --> 00:15:11,600
universe expands simply because there's

326
00:15:16,550 --> 00:15:13,680
more volume and the same amount of

327
00:15:18,629 --> 00:15:16,560
matter so at some point the density of

328
00:15:20,790 --> 00:15:18,639
matter drops below the density of dark

329
00:15:23,670 --> 00:15:20,800
energy in the universe accelerates oh my

330
00:15:25,670 --> 00:15:23,680
gosh wow so what okay so i i've got to

331
00:15:27,189 --> 00:15:25,680
let you guys go but what is the what's

332
00:15:29,030 --> 00:15:27,199
in store for the rest of the week what

333
00:15:29,829 --> 00:15:29,040
what else do you have going on

334
00:15:31,110 --> 00:15:29,839
so

335
00:15:34,710 --> 00:15:31,120
we just have

336
00:15:37,350 --> 00:15:34,720
more of these different methods

337
00:15:39,910 --> 00:15:37,360
and we try you know to compare notes so

338
00:15:42,069 --> 00:15:39,920

to speak between these very different

339
00:15:45,030 --> 00:15:42,079
methods each one of them with its

340
00:15:48,150 --> 00:15:45,040
strengths and weaknesses some methods

341
00:15:50,150 --> 00:15:48,160
are very accurate but you can only find

342
00:15:53,350 --> 00:15:50,160
very few objects so at the end your

343
00:15:53,749 --> 00:15:53,360
precision is not that

344
00:15:56,470 --> 00:15:53,759
you great

345
00:15:59,749 --> 00:15:56,480
lots of objects but maybe they're not as

346
00:16:01,030 --> 00:15:59,759
accurate as that and we hope that by the

347
00:16:02,470 --> 00:16:01,040
end of the

348
00:16:04,230 --> 00:16:02,480
end of wednesday

349
00:16:07,189 --> 00:16:04,240
uh you know we will

350
00:16:10,310 --> 00:16:07,199
have scanned all these methods that we

351
00:16:12,710 --> 00:16:10,320
think can provide us with an accuracy

352
00:16:15,110 --> 00:16:12,720
and precision of a few percent

353
00:16:16,870 --> 00:16:15,120
uh and then look towards the future

354
00:16:18,629 --> 00:16:16,880
because our goal

355
00:16:20,310 --> 00:16:18,639
is to reach a value of the hubble

356
00:16:22,790 --> 00:16:20,320
constant that is

357
00:16:24,550 --> 00:16:22,800
we have an error no larger than about

358
00:16:27,910 --> 00:16:24,560
the percent or so

359
00:16:29,829 --> 00:16:27,920
wow that's that's amazing okay well guys

360
00:16:31,430 --> 00:16:29,839
i i want to i want to thank you both for

361
00:16:33,829 --> 00:16:31,440
taking time out to just give me a few

362
00:16:35,350 --> 00:16:33,839
minutes uh adam am i going to get you

363
00:16:36,870 --> 00:16:35,360

again in a hangout in the future maybe

364
00:16:38,949 --> 00:16:36,880
for a little more time

365
00:16:40,710 --> 00:16:38,959
yeah let's hang out

366
00:16:43,030 --> 00:16:40,720
good i'm glad that you say that you'll

367
00:16:44,550 --> 00:16:43,040
be hearing from me mario as always it is

368
00:16:46,629 --> 00:16:44,560
a lot of fun to talk to you thank you

369
00:16:49,509 --> 00:16:46,639
for taking time out to talk to me as

370
00:16:50,870 --> 00:16:49,519
well um i wish i had more time guys but

371
00:16:52,069 --> 00:16:50,880
i'm gonna have to let let them go

372
00:16:54,069 --> 00:16:52,079
they've got to get back to what they're