



HUBBLE

hangouts

Hubble Finds Extremely Distant Galaxy in Gravitational Lens

Thursday November 20, 2014 3pm EDT, 8pm UT, 9pm CET

1
00:00:09,799 --> 00:00:07,309
hello everybody and welcome to this

2
00:00:11,660 --> 00:00:09,809
week's Hubbell hangout my name is Tony

3
00:00:13,459 --> 00:00:11,670
Darnell I work at the Space Telescope

4
00:00:16,039 --> 00:00:13,469
Science Center and this week we've got a

5
00:00:17,540 --> 00:00:16,049
really interesting hangout plan we're

6
00:00:20,269 --> 00:00:17,550
going to be talking about frontier

7
00:00:23,599 --> 00:00:20,279
fields data gravitational lensing and

8
00:00:25,400 --> 00:00:23,609
distant galaxies and so we're gonna be

9
00:00:26,839 --> 00:00:25,410
when we've got some scientists here with

10
00:00:28,609 --> 00:00:26,849
us who are some astronomers who've been

11
00:00:31,189 --> 00:00:28,619
using this Hubble data and have made an

12
00:00:33,950 --> 00:00:31,199
interesting discovery which we will talk

13
00:00:36,950 --> 00:00:33,960

about at length in just a bit but before

14

00:00:39,400 --> 00:00:36,960

I get started I'm gonna let Scott Lewis

15

00:00:42,920 --> 00:00:39,410

my cohort here he's driving the internet

16

00:00:44,209 --> 00:00:42,930

easily Archie we would we hope that

17

00:00:45,319 --> 00:00:44,219

during the course of this hangout you

18

00:00:47,600 --> 00:00:45,329

will give us your comments and questions

19

00:00:50,540 --> 00:00:47,610

and Scott please tell them how they may

20

00:00:53,420 --> 00:00:50,550

do that all over the place first of all

21

00:00:57,279 --> 00:00:53,430

Tony you work at the Space Telescope

22

00:01:00,709 --> 00:00:57,289

Science Institute not Science Center Oh

23

00:01:03,009 --> 00:01:00,719

yesterday but if you just clarifying

24

00:01:05,149 --> 00:01:03,019

that for you all right

25

00:01:07,250 --> 00:01:05,159

most likely you're watching this on

26

00:01:09,590 --> 00:01:07,260

youtube right now so in the bottom left

27

00:01:12,320 --> 00:01:09,600

you'll see in some yellow text there

28

00:01:15,050 --> 00:01:12,330

that allow you to open up a Q&A app you

29

00:01:16,640 --> 00:01:15,060

can actually ask those questions live so

30

00:01:19,160 --> 00:01:16,650

we'll be able to select them as we go in

31

00:01:20,320 --> 00:01:19,170

and Carols here which are there even

32

00:01:24,499 --> 00:01:20,330

better

33

00:01:26,300 --> 00:01:24,509

it also uses on Google s and you can

34

00:01:28,210 --> 00:01:26,310

leave us comments and questions on the

35

00:01:30,920 --> 00:01:28,220

event page and the regular YouTube and

36

00:01:34,580 --> 00:01:30,930

on top of it all if you were on Twitter

37

00:01:36,050 --> 00:01:34,590

use the Hubble hangout hashtag I'll be

38

00:01:38,300 --> 00:01:36,060

monitoring that and tweeting things up

39

00:01:40,609 --> 00:01:38,310

as Hubble telescope with some of the

40

00:01:43,460 --> 00:01:40,619

awesome pictures and updates as we're

41

00:01:46,639 --> 00:01:43,470

going along that is known as a plethora

42

00:01:49,429 --> 00:01:46,649

of ways to interact in us throw so

43

00:01:52,490 --> 00:01:49,439

believable cornucopia of information was

44

00:01:55,580 --> 00:01:52,500

just convinced it was all over the place

45

00:01:58,190 --> 00:01:55,590

oh and just joining us is also a regular

46

00:01:59,450 --> 00:01:58,200

with is dr. Carol Christian she's the

47

00:02:01,639 --> 00:01:59,460

outreach scientist for the Hubble Space

48

00:02:05,719 --> 00:02:01,649

Telescope almost we were worried about

49

00:02:07,910 --> 00:02:05,729

you Carol welcome thanks just I'm not in

50

00:02:09,830 --> 00:02:07,920

charge of the internet Scott is so yeah

51
00:02:11,780 --> 00:02:09,840
I know he drives that he drives that

52
00:02:15,089 --> 00:02:11,790
thing so I don't know what what he was

53
00:02:20,619 --> 00:02:17,110
okay before we get started I want to

54
00:02:23,259 --> 00:02:20,629
give a quick shout out to a staff member

55
00:02:26,589 --> 00:02:23,269
a colleague at the Institute not the

56
00:02:28,660 --> 00:02:26,599
center dr. Jason Calorie who has made an

57
00:02:31,180 --> 00:02:28,670
academic minute back in July that was

58
00:02:33,550 --> 00:02:31,190
all about exoplanets and it turns out

59
00:02:35,410 --> 00:02:33,560
his it's an audio it's an audio podcast

60
00:02:37,660 --> 00:02:35,420
little thingy and it was on it's on

61
00:02:40,780 --> 00:02:37,670
academic minute org and there is a link

62
00:02:42,550 --> 00:02:40,790
in the event description box which will

63
00:02:44,140 --> 00:02:42,560

which if you click on it you can show

64

00:02:45,789 --> 00:02:44,150

your support because he's up for a

65

00:02:47,530 --> 00:02:45,799

listeners Choice Award so we're like

66

00:02:49,809 --> 00:02:47,540

we'd like you to show your support if

67

00:02:52,569 --> 00:02:49,819

you would think it is a good enough

68

00:02:56,080 --> 00:02:52,579

podcast and vote for dr. Jason calorie

69

00:02:57,910 --> 00:02:56,090

so I would appreciate that okay so let's

70

00:03:00,850 --> 00:02:57,920

get started with today's hangout distant

71

00:03:03,009 --> 00:03:00,860

galaxies and frontier fields and

72

00:03:06,580 --> 00:03:03,019

gravitational lensing with me to talk

73

00:03:09,580 --> 00:03:06,590

about these is IDs it Rijn he's a NASA

74

00:03:13,330 --> 00:03:09,590

Hubble fellow at Caltech a high iodine

75

00:03:15,550 --> 00:03:13,340

welcome also is John Moustakas he's the

76

00:03:18,000 --> 00:03:15,560

he's an astronomer and a faculty member

77

00:03:20,500 --> 00:03:18,010

at Siena College where is that John

78

00:03:22,740 --> 00:03:20,510

Siena College is a small liberal arts

79

00:03:25,809 --> 00:03:22,750

school and upstate New York near Albany

80

00:03:29,170 --> 00:03:25,819

awesome and so we welcome to both of you

81

00:03:31,080 --> 00:03:29,180

guys and we'll let's let's let's go

82

00:03:35,170 --> 00:03:31,090

ahead and let's talk a little bit about

83

00:03:37,210 --> 00:03:35,180

what you are working on and and what you

84

00:03:40,000 --> 00:03:37,220

have found so there's a link also guys

85

00:03:41,680 --> 00:03:40,010

in the description box of the event to a

86

00:03:43,420 --> 00:03:41,690

press release that came out last month

87

00:03:46,629 --> 00:03:43,430

and addy why don't you describe to us

88

00:03:52,449 --> 00:03:46,639

what that press release was about okay

89

00:03:54,309 --> 00:03:52,459

first of all hi so let's start with a

90

00:03:56,440 --> 00:03:54,319

little bit of background we want to know

91

00:03:58,270 --> 00:03:56,450

how the universe evolves how galaxies

92

00:04:00,159 --> 00:03:58,280

form and how they evolve into the

93

00:04:02,620 --> 00:04:00,169

galaxies that we see today so one of the

94

00:04:05,860 --> 00:04:02,630

goals basically is looking for the most

95

00:04:09,400 --> 00:04:05,870

distant galaxies the very young in the

96

00:04:10,839 --> 00:04:09,410

early universe galaxies so we're trying

97

00:04:14,650 --> 00:04:10,849

to do to exploit the lens magnification

98

00:04:17,050 --> 00:04:14,660

of galaxy clusters which have a lot very

99

00:04:19,060 --> 00:04:17,060

high density and a lot of gravity so the

100

00:04:21,610 --> 00:04:19,070

form gravitational lenses in the sky

101
00:04:23,409 --> 00:04:21,620
they help us magnify the background we

102
00:04:25,930 --> 00:04:23,419
look at them in order to find a very

103
00:04:27,190 --> 00:04:25,940
high redshift galaxy so in this paper we

104
00:04:30,550 --> 00:04:27,200
found one of the most

105
00:04:32,110 --> 00:04:30,560
hyah stretch of the galaxy is known and

106
00:04:34,270 --> 00:04:32,120
the interesting thing about this galaxy

107
00:04:36,580 --> 00:04:34,280
is not only that it's one of the

108
00:04:38,650 --> 00:04:36,590
highest-rated ones it's also being a

109
00:04:42,100 --> 00:04:38,660
multiply image by the cluster so we see

110
00:04:43,630 --> 00:04:42,110
it several times oh I can yeah I can't

111
00:04:45,160 --> 00:04:43,640
wait to show we're gonna we're gonna go

112
00:04:47,140 --> 00:04:45,170
back to that in just a minute and well

113
00:04:49,660 --> 00:04:47,150

actually let's go ahead Scott it's got

114

00:04:50,950 --> 00:04:49,670

an image up now and why don't you why

115

00:04:56,350 --> 00:04:50,960

don't you describe what we're looking at

116

00:04:58,860 --> 00:04:56,360

there okay so in the image the squares

117

00:05:01,690 --> 00:04:58,870

that show a B and C are the three

118

00:05:03,490 --> 00:05:01,700

appearances of the same galaxies that

119

00:05:05,590 --> 00:05:03,500

are being lens and magnified by this

120

00:05:07,600 --> 00:05:05,600

cluster so remember that the

121

00:05:09,280 --> 00:05:07,610

magnification by by the cluster is what

122

00:05:12,370 --> 00:05:09,290

helps us see that far to the edge of

123

00:05:14,230 --> 00:05:12,380

edge of the universe basically and it

124

00:05:16,540 --> 00:05:14,240

also multiplies the image so we see

125

00:05:18,100 --> 00:05:16,550

several times now the interesting thing

126

00:05:20,250 --> 00:05:18,110

about these data see is that the

127

00:05:23,290 --> 00:05:20,260

distances between a B and C

128

00:05:25,540 --> 00:05:23,300

independently tell us what distance of

129

00:05:28,150 --> 00:05:25,550

these galaxies so we don't just guess

130

00:05:30,520 --> 00:05:28,160

according to its colors or dimness how

131

00:05:32,890 --> 00:05:30,530

far away it is but also the distances

132

00:05:35,190 --> 00:05:32,900

between a B and C tell us independently

133

00:05:37,060 --> 00:05:35,200

that it is really in the early universe

134

00:05:38,560 --> 00:05:37,070

awesome okay well I'm gonna get to how

135

00:05:40,630 --> 00:05:38,570

you know that in just a minute also how

136

00:05:43,750 --> 00:05:40,640

you know that that little smudge is the

137

00:05:45,280 --> 00:05:43,760

same exact galaxy but we wish you'd

138

00:05:47,320 --> 00:05:45,290

probably take a step back and talk a

139

00:05:49,330 --> 00:05:47,330

little so that's the punchline they

140

00:05:53,050 --> 00:05:49,340

found them one of the most distant

141

00:05:55,210 --> 00:05:53,060

galaxies in the universe and but they

142

00:05:57,090 --> 00:05:55,220

did it with kind of a little bit of a

143

00:05:59,650 --> 00:05:57,100

cheat now you're using something called

144

00:06:02,170 --> 00:05:59,660

frontier fields data and frontier fields

145

00:06:04,300 --> 00:06:02,180

is a project that we've talked about

146

00:06:06,100 --> 00:06:04,310

many times on these hangouts where there

147

00:06:08,110 --> 00:06:06,110

are imaging galaxy clusters and they're

148

00:06:10,480 --> 00:06:08,120

hoping to boost the but we're not hoping

149

00:06:12,220 --> 00:06:10,490

they're using the power of gravitational

150

00:06:14,620 --> 00:06:12,230

lenses to sort of boost the power of

151

00:06:18,040 --> 00:06:14,630

Hubble and see things that Hubble

152

00:06:19,420 --> 00:06:18,050

ordinarily wouldn't be able to see if

153

00:06:23,380 --> 00:06:19,430

they were just trying to look at it

154

00:06:25,180 --> 00:06:23,390

without the gravitational lens so maybe

155

00:06:26,800 --> 00:06:25,190

this would be some a good a good thing

156

00:06:28,510 --> 00:06:26,810

for Carroll to give us a little

157

00:06:31,120 --> 00:06:28,520

introduction into can you talk a little

158

00:06:32,730 --> 00:06:31,130

bit about what frontier fields is doing

159

00:06:36,820 --> 00:06:32,740

and what they're hoping to accomplish

160

00:06:38,800 --> 00:06:36,830

sure so in the history of the Hubble

161

00:06:40,990 --> 00:06:38,810

Space Telescope we've had a number of

162

00:06:43,750 --> 00:06:41,000

initiatives that were taken on by the

163

00:06:45,120 --> 00:06:43,760

Observatory itself as we've talked about

164

00:06:48,310 --> 00:06:45,130

before

165

00:06:50,620 --> 00:06:48,320

astronomers throughout the world

166

00:06:53,080 --> 00:06:50,630

actually apply for time to use the

167

00:06:56,560 --> 00:06:53,090

telescope for specific research purposes

168

00:06:58,330 --> 00:06:56,570

the observatory also under the auspices

169

00:07:02,230 --> 00:06:58,340

of the director sometimes takes on

170

00:07:04,540 --> 00:07:02,240

projects that will need a lot of

171

00:07:07,120 --> 00:07:04,550

observing time and also will serve a big

172

00:07:09,280 --> 00:07:07,130

community and in the past some of those

173

00:07:10,810 --> 00:07:09,290

have been the Hubble Deep Field so there

174

00:07:12,550 --> 00:07:10,820

have been several Hubble Deep fields

175

00:07:14,530 --> 00:07:12,560

where the telescope is used for many

176
00:07:16,930 --> 00:07:14,540
many days just to stare at a small

177
00:07:19,180 --> 00:07:16,940
portion of the sky so the newest

178
00:07:22,690 --> 00:07:19,190
initiative is called frontier fields and

179
00:07:25,480 --> 00:07:22,700
the idea with frontier fields is we've

180
00:07:28,659 --> 00:07:25,490
tried to look back very far just by

181
00:07:30,580 --> 00:07:28,669
staring at part of the sky for a very

182
00:07:32,920 --> 00:07:30,590
long time to go fainter and fainter and

183
00:07:37,540 --> 00:07:32,930
fainter the idea behind frontier fields

184
00:07:39,909 --> 00:07:37,550
is to use a cosmic effect called a

185
00:07:41,860 --> 00:07:39,919
gravitational lens and so we use an

186
00:07:45,640 --> 00:07:41,870
additional lens which is caused by

187
00:07:48,010 --> 00:07:45,650
gravity to magnify objects that are

188
00:07:50,200 --> 00:07:48,020

behind the lens well what is this lens

189

00:07:53,110 --> 00:07:50,210

the lens is actually a cluster of

190

00:07:55,570 --> 00:07:53,120

galaxies that has a lot of mass and the

191

00:07:58,390 --> 00:07:55,580

mass itself distorts the light and

192

00:08:02,460 --> 00:07:58,400

magnifies it so it creates multiple

193

00:08:06,190 --> 00:08:02,470

images and also magnified images of

194

00:08:09,820 --> 00:08:06,200

galaxies further away so in this way we

195

00:08:13,150 --> 00:08:09,830

can reach much further away than we can

196

00:08:15,280 --> 00:08:13,160

if we just stare at the sky without one

197

00:08:18,700 --> 00:08:15,290

of these lenses in place the idea is to

198

00:08:21,280 --> 00:08:18,710

use this cosmic trick to see even deeper

199

00:08:23,440 --> 00:08:21,290

into space and now there's an

200

00:08:27,850 --> 00:08:23,450

illustration of that a little movie of

201
00:08:29,620 --> 00:08:27,860
how a distant object the light comes

202
00:08:34,450 --> 00:08:29,630
from it ordinarily would come straight

203
00:08:37,270 --> 00:08:34,460
to us would be too faint is is acted

204
00:08:40,959 --> 00:08:37,280
upon by this cosmic lens it sometimes is

205
00:08:43,990 --> 00:08:40,969
shredded into arcs and and distorted but

206
00:08:46,600 --> 00:08:44,000
nonetheless it is a way of reaching very

207
00:08:49,270 --> 00:08:46,610
deep deeper than we ever have before and

208
00:08:51,100 --> 00:08:49,280
it also gives us a little teaser on what

209
00:08:54,759 --> 00:08:51,110
mean we might see with the James Webb

210
00:08:56,949 --> 00:08:54,769
telescope after 2018 right

211
00:08:58,569 --> 00:08:56,959
so Scott's showing one of the neatest

212
00:09:00,429 --> 00:08:58,579
little illustrations of what you were

213
00:09:04,329 --> 00:09:00,439

just talking about Carol and as you can

214

00:09:06,220 --> 00:09:04,339

see this lens this galaxy cluster the

215

00:09:09,040 --> 00:09:06,230

mass from that is what is causing the

216

00:09:10,799 --> 00:09:09,050

the lens itself and so we're able to see

217

00:09:14,169 --> 00:09:10,809

things or Hubble is able to see things

218

00:09:18,309 --> 00:09:14,179

other than then otherwise wouldn't so

219

00:09:20,499 --> 00:09:18,319

right six clusters and we have now on

220

00:09:22,780 --> 00:09:20,509

behalf of the community observed three

221

00:09:24,460 --> 00:09:22,790

of them the team at space telescope

222

00:09:27,189 --> 00:09:24,470

works very hard to calibrate that data

223

00:09:29,109 --> 00:09:27,199

very carefully and then it's put out to

224

00:09:31,660 --> 00:09:29,119

the community so the entire community

225

00:09:34,449 --> 00:09:31,670

can yeah and that's something that's

226

00:09:36,609 --> 00:09:34,459

worth mentioning most Hubble data sort

227

00:09:38,590 --> 00:09:36,619

of have a little bit of a an embargo

228

00:09:40,660 --> 00:09:38,600

period so the scientists that asked for

229

00:09:42,039 --> 00:09:40,670

Hubble time can take some time to you

230

00:09:44,439 --> 00:09:42,049

know analyze their data before that's

231

00:09:45,910 --> 00:09:44,449

made public this isn't it's not true for

232

00:09:47,859 --> 00:09:45,920

frontier fields data it's been made

233

00:09:50,019 --> 00:09:47,869

available right away to the community

234

00:09:51,129 --> 00:09:50,029

the science community and in fact we're

235

00:09:52,269 --> 00:09:51,139

gonna talk about this in a little bit

236

00:09:54,699 --> 00:09:52,279

there was you know there was a workshop

237

00:09:56,319 --> 00:09:54,709

just last week that highlighted all of

238

00:09:58,600 --> 00:09:56,329

the science that's being done with this

239

00:10:01,359 --> 00:09:58,610

data as the community get it right away

240

00:10:04,840 --> 00:10:01,369

so John Moustakas let me let me ask you

241

00:10:07,359 --> 00:10:04,850

a question the the the galaxy that you

242

00:10:10,720 --> 00:10:07,369

found ahead of as Adi said was a very

243

00:10:13,329 --> 00:10:10,730

high redshift galaxy can you give us a

244

00:10:15,129 --> 00:10:13,339

brief description of what is meant by

245

00:10:17,230 --> 00:10:15,139

redshift right now I think this

246

00:10:20,949 --> 00:10:17,240

particular galaxy was a redshift of

247

00:10:23,710 --> 00:10:20,959

about ten correct that's right yeah I

248

00:10:26,019 --> 00:10:23,720

actually I just learned a really nice

249

00:10:29,230 --> 00:10:26,029

analogy that describes this so that the

250

00:10:30,819 --> 00:10:29,240

first important point is that and one of

251

00:10:33,669 --> 00:10:30,829

the most important discoveries of at

252

00:10:36,579 --> 00:10:33,679

least the last century is the fact that

253

00:10:42,249 --> 00:10:36,589

the universe isn't static it doesn't I

254

00:10:44,230 --> 00:10:42,259

it's not it changes in other words the

255

00:10:47,049 --> 00:10:44,240

universe is expanding so when we look at

256

00:10:52,419 --> 00:10:47,059

galaxies around us we see that they're

257

00:10:54,400 --> 00:10:52,429

moving all moving away from us and the

258

00:10:55,929 --> 00:10:54,410

way that movement away from us that

259

00:10:58,659 --> 00:10:55,939

expansion of the universe is using this

260

00:10:59,949 --> 00:10:58,669

concept called red jet and so the way to

261

00:11:01,509 --> 00:10:59,959

think about it is imagine you're

262

00:11:06,100 --> 00:11:01,519

standing at the front of an auditorium

263

00:11:08,400 --> 00:11:06,110

and you have a seat full of odd members

264

00:11:10,630 --> 00:11:08,410

what you would see is that

265

00:11:12,700 --> 00:11:10,640

it would be like looking out at the

266

00:11:15,010 --> 00:11:12,710

auditorium and seeing that the people

267

00:11:17,110 --> 00:11:15,020

sitting in front were the oldest people

268

00:11:19,900 --> 00:11:17,120

and then as you looked at further and

269

00:11:21,790 --> 00:11:19,910

further people further and back towards

270

00:11:23,200 --> 00:11:21,800

the back of the auditorium they looked

271

00:11:25,990 --> 00:11:23,210

like they were getting younger and

272

00:11:27,340 --> 00:11:26,000

younger and younger oh I want to be in

273

00:11:28,870 --> 00:11:27,350

the backseat then I want to be in the

274

00:11:32,440 --> 00:11:28,880

background yeah right

275

00:11:34,000 --> 00:11:32,450

and and then at the same time what you

276

00:11:35,800 --> 00:11:34,010

would see if you were just looking at

277

00:11:37,780 --> 00:11:35,810

these people is that the people in the

278

00:11:41,830 --> 00:11:37,790

front would be you know slightly pink

279

00:11:43,300 --> 00:11:41,840

and then as you look at people product

280

00:11:45,910 --> 00:11:43,310

they would get redder and redder and

281

00:11:50,070 --> 00:11:45,920

redder and grosser and rosy and rosier

282

00:11:52,290 --> 00:11:50,080

and the those two ideas there are

283

00:11:55,540 --> 00:11:52,300

essentially what we're trying to do with

284

00:11:57,970 --> 00:11:55,550

with with trying to find the youngest

285

00:12:00,850 --> 00:11:57,980

galaxies or the first galaxies to have

286

00:12:03,250 --> 00:12:00,860

formed so people are getting redder

287

00:12:05,230 --> 00:12:03,260

because as the universe expands it

288

00:12:08,290 --> 00:12:05,240

actually stretches the wavelength of

289

00:12:10,120 --> 00:12:08,300

light and pushes it towards redder

290

00:12:13,120 --> 00:12:10,130

wavelengths so that's why we call this a

291

00:12:17,290 --> 00:12:13,130

redshift and the amount that the light

292

00:12:18,940 --> 00:12:17,300

gets redshift is based on how far away

293

00:12:22,570 --> 00:12:18,950

it is so the further something is the

294

00:12:24,850 --> 00:12:22,580

more it's like it's red shifted and the

295

00:12:27,940 --> 00:12:24,860

reason your audience members in your

296

00:12:30,670 --> 00:12:27,950

hypothetical lecture here are getting

297

00:12:33,280 --> 00:12:30,680

younger is because it takes a finite

298

00:12:35,650 --> 00:12:33,290

amount of time for light to reach our

299

00:12:38,950 --> 00:12:35,660

eyes so but if you look at someone

300

00:12:40,570 --> 00:12:38,960

across the room there it takes about a

301
00:12:43,060 --> 00:12:40,580
billionth of a second for the light

302
00:12:45,070 --> 00:12:43,070
coming off of them to reach your eyes we

303
00:12:46,960 --> 00:12:45,080
will look at the Sun the sun's about 8

304
00:12:48,850 --> 00:12:46,970
light minutes away so you're actually

305
00:12:52,120 --> 00:12:48,860
looking at the Sun the way it appeared

306
00:12:54,190 --> 00:12:52,130
eight minutes ago and so as you look at

307
00:12:58,210 --> 00:12:54,200
more and more distant objects you've

308
00:13:01,270 --> 00:12:58,220
seen the way they looked a long time ago

309
00:13:04,260 --> 00:13:01,280
and so so that's that's the other effect

310
00:13:07,060 --> 00:13:04,270
that we were able to use to try to probe

311
00:13:09,160 --> 00:13:07,070
and understand how galaxies looked like

312
00:13:10,990 --> 00:13:09,170
in the past that is a good analogy I'd

313
00:13:12,760 --> 00:13:11,000

never heard that before now - you need

314

00:13:15,910 --> 00:13:12,770

to continue with that analogy one other

315

00:13:19,510 --> 00:13:15,920

component to it is that the auditorium

316

00:13:22,300 --> 00:13:19,520

itself is also getting larger right so

317

00:13:23,890 --> 00:13:22,310

so while that's going on

318

00:13:25,180 --> 00:13:23,900

the auditorium is getting bigger so

319

00:13:26,920 --> 00:13:25,190

there's another component to that

320

00:13:29,050 --> 00:13:26,930

there's a lots of different distances

321

00:13:30,960 --> 00:13:29,060

that people use and one of the things

322

00:13:34,570 --> 00:13:30,970

that I read was a Ned Wright a

323

00:13:38,470 --> 00:13:34,580

cosmologists had a great has a great web

324

00:13:41,410 --> 00:13:38,480

page on how to count distances in the

325

00:13:42,750 --> 00:13:41,420

universe using redshift and thinking

326

00:13:45,610 --> 00:13:42,760

wrote was that it's probably a bad idea

327

00:13:47,950 --> 00:13:45,620

for the press to start reporting these

328

00:13:50,769 --> 00:13:47,960

distances in light travel time because

329

00:13:52,990 --> 00:13:50,779

there's so much more involved over yes

330

00:13:56,710 --> 00:13:53,000

we may be looking at a galaxy when the

331

00:14:00,160 --> 00:13:56,720

universe was a billion years old but you

332

00:14:02,710 --> 00:14:00,170

know in the twelve or so billion ye here

333

00:14:04,690 --> 00:14:02,720

I'm the universe is also expanded and so

334

00:14:06,610 --> 00:14:04,700

the actual distance to that galaxy is

335

00:14:08,920 --> 00:14:06,620

best expressed in that in that redshift

336

00:14:12,250 --> 00:14:08,930

number you were talking about more so

337

00:14:13,510 --> 00:14:12,260

than in light travel time so it's a it's

338

00:14:14,640 --> 00:14:13,520

an interesting idea different an

339

00:14:17,470 --> 00:14:14,650

interesting concept

340

00:14:21,310 --> 00:14:17,480

so I D let me ask you with the we know a

341

00:14:23,680 --> 00:14:21,320

redshift is now this particular galaxy

342

00:14:26,920 --> 00:14:23,690

is redshift about equal 10 the universe

343

00:14:29,230 --> 00:14:26,930

was roughly how old when when when this

344

00:14:32,980 --> 00:14:29,240

galaxy when the light left this galaxy

345

00:14:36,400 --> 00:14:32,990

so did the galaxy sorry the universe was

346

00:14:39,730 --> 00:14:36,410

about 450 million years which is only

347

00:14:43,420 --> 00:14:39,740

about 3 to 4% of its current age so in

348

00:14:44,680 --> 00:14:43,430

size that's really soon yeah so the

349

00:14:46,329 --> 00:14:44,690

reason I asked you that was because I

350

00:14:48,820 --> 00:14:46,339

have a comment here on YouTube that I

351

00:14:50,560 --> 00:14:48,830

want to get to right away it says for

352

00:14:52,510 --> 00:14:50,570

this is from tangent creative on YouTube

353

00:14:55,030 --> 00:14:52,520

he goes does this mean galaxies formed

354

00:14:58,420 --> 00:14:55,040

very quickly after the Big Bang I mean

355

00:14:59,650 --> 00:14:58,430

real fast I mean 400,000 what is a 400

356

00:15:02,620 --> 00:14:59,660

million years or so that's pretty quick

357

00:15:04,990 --> 00:15:02,630

that's pretty quick that's pretty quick

358

00:15:06,430 --> 00:15:05,000

and actually we at least miracle

359

00:15:08,980 --> 00:15:06,440

simulations we don't observe these

360

00:15:10,810 --> 00:15:08,990

galaxies yet but predicted they have

361

00:15:14,110 --> 00:15:10,820

started forming even a bit earlier so

362

00:15:16,000 --> 00:15:14,120

they started forming at about probably

363

00:15:17,920 --> 00:15:16,010

the guess is a hundred million years

364

00:15:19,060 --> 00:15:17,930

after the Big Bang and this is really

365

00:15:20,949 --> 00:15:19,070

fast yes that's

366

00:15:23,860 --> 00:15:20,959

Wow that that that quickly that that's

367

00:15:26,590 --> 00:15:23,870

pretty that's pretty pretty fast so John

368

00:15:28,980 --> 00:15:26,600

this particular galaxy what does that

369

00:15:31,870 --> 00:15:28,990

red smudge that we looked at earlier

370

00:15:33,640 --> 00:15:31,880

tell you what what what what do you know

371

00:15:36,130 --> 00:15:33,650

about this galaxy based on that little

372

00:15:41,470 --> 00:15:36,140

red dot yeah it's a great question I

373

00:15:43,420 --> 00:15:41,480

wish we could infer more we we can say a

374

00:15:45,610 --> 00:15:43,430

few things about the object what's

375

00:15:50,350 --> 00:15:45,620

really amazing is that as Carol

376
00:15:51,730 --> 00:15:50,360
described an object this faint would not

377
00:15:54,760 --> 00:15:51,740
have been found

378
00:15:56,590 --> 00:15:54,770
in just a blank part of the sky so if

379
00:15:59,920 --> 00:15:56,600
you had just taken Hubble and just

380
00:16:03,850 --> 00:15:59,930
pointed it at a same part of the sky and

381
00:16:06,460 --> 00:16:03,860
just collect difficult and just collected

382
00:16:09,220 --> 00:16:06,470
photons the way has been done in past

383
00:16:11,350 --> 00:16:09,230
efforts with the Hubble Deep fields for

384
00:16:14,440 --> 00:16:11,360
example you would not have found this

385
00:16:18,940 --> 00:16:14,450
galaxy so just thinking about how faint

386
00:16:20,770 --> 00:16:18,950
it is this is about other thing it's a

387
00:16:22,810 --> 00:16:20,780
very much at the limits of what the

388
00:16:24,430 --> 00:16:22,820

Hubble Space Telescope can do and the

389

00:16:27,579 --> 00:16:24,440

only way we can really do better is by

390

00:16:30,790 --> 00:16:27,589

putting a bigger telescope in space but

391

00:16:32,890 --> 00:16:30,800

what we know about it is that when we

392

00:16:34,990 --> 00:16:32,900

look at galaxies like our own galaxy

393

00:16:38,110 --> 00:16:35,000

we're in the Milky Way galaxy which is a

394

00:16:40,630 --> 00:16:38,120

spiral galaxy has spiral arms and the

395

00:16:44,440 --> 00:16:40,640

Sun is one Sun among roughly a hundred

396

00:16:47,199 --> 00:16:44,450

billion stars in our galaxy this galaxy

397

00:16:51,010 --> 00:16:47,209

is really you should think about it as a

398

00:16:53,650 --> 00:16:51,020

fragment it's at least one one-hundredth

399

00:16:57,790 --> 00:16:53,660

the size or the mass of the Milky Way

400

00:16:59,530 --> 00:16:57,800

galaxy and maybe even 1,000 so in that

401
00:17:01,540 --> 00:16:59,540
range between a hundredth and one

402
00:17:05,559 --> 00:17:01,550
thousandth of math mass of our own

403
00:17:08,590 --> 00:17:05,569
galaxy and so what we think happened is

404
00:17:09,660 --> 00:17:08,600
that these galaxies like the one we

405
00:17:12,910 --> 00:17:09,670
discovered

406
00:17:15,189 --> 00:17:12,920
came together through gravity to over

407
00:17:20,290 --> 00:17:15,199
time build up the big galaxies that we

408
00:17:23,370 --> 00:17:20,300
see today and so real to young its

409
00:17:27,030 --> 00:17:23,380
forming stars at a very fast clip

410
00:17:29,830 --> 00:17:27,040
because it has a lot of cold gaps and

411
00:17:32,260 --> 00:17:29,840
we're catching it when it was just it

412
00:17:35,770 --> 00:17:32,270
when there was just a fragment of the

413
00:17:38,350 --> 00:17:35,780

big galaxies that we see today Wow

414

00:17:39,520 --> 00:17:38,360

so I'm gonna there's that there's what

415

00:17:43,980 --> 00:17:39,530

we're talking about folks cuz I just

416

00:17:47,510 --> 00:17:43,990

wanted to put this up real fast so so

417

00:17:50,660 --> 00:17:47,520

Idid you said that the this

418

00:17:53,660 --> 00:17:50,670

been this had appeared in the lens to

419

00:17:56,360 --> 00:17:53,670

galaxy several times or in the galaxy in

420

00:17:57,620 --> 00:17:56,370

the galaxy cluster image several times

421

00:18:01,070 --> 00:17:57,630

how do you know that how do you know

422

00:18:03,620 --> 00:18:01,080

that little dot is exactly the same

423

00:18:06,770 --> 00:18:03,630

galaxy and in just in different spots of

424

00:18:10,010 --> 00:18:06,780

the image that's a good question so the

425

00:18:11,750 --> 00:18:10,020

answer divides into first of all we see

426

00:18:14,090 --> 00:18:11,760

many galaxies which are multiplied in

427

00:18:15,830 --> 00:18:14,100

the cluster this is not the only one

428

00:18:19,040 --> 00:18:15,840

and usually the galaxies that we see

429

00:18:22,760 --> 00:18:19,050

multiplied in the cluster if they can be

430

00:18:25,760 --> 00:18:22,770

giant spirals with very distinct colors

431

00:18:27,380 --> 00:18:25,770

or not so there is no doubt that these

432

00:18:29,600 --> 00:18:27,390

are the same background galaxies being

433

00:18:32,450 --> 00:18:29,610

multiplied imaged we can also verify it

434

00:18:35,690 --> 00:18:32,460

by very accurately measuring their

435

00:18:37,370 --> 00:18:35,700

colors so once we establish the

436

00:18:39,530 --> 00:18:37,380

gravitational lensing predicted

437

00:18:42,850 --> 00:18:39,540

according to Einstein general relativity

438

00:18:46,070 --> 00:18:42,860

is a real phenomenon we see galaxies

439

00:18:49,030 --> 00:18:46,080

multiple times in the same by multiply

440

00:18:51,350 --> 00:18:49,040

multiply lens by the same cluster lens

441

00:18:54,650 --> 00:18:51,360

now it's just a question of how do we

442

00:18:57,650 --> 00:18:54,660

know that this exact galaxy the red blob

443

00:19:00,200 --> 00:18:57,660

is really the same galaxy and here we

444

00:19:01,700 --> 00:19:00,210

used basically a lens model so we

445

00:19:04,310 --> 00:19:01,710

construct the mass of the cluster

446

00:19:06,260 --> 00:19:04,320

according to all these other giant

447

00:19:08,360 --> 00:19:06,270

spirals that are being multiplied

448

00:19:09,950 --> 00:19:08,370

lengths that I told you about and then

449

00:19:12,620 --> 00:19:09,960

we can extrapolate to higher redshift

450

00:19:15,800 --> 00:19:12,630

and predict where would we expect to see

451
00:19:18,470 --> 00:19:15,810
such blobs where we to high-redshift

452
00:19:20,620 --> 00:19:18,480
galaxies okay so you mentioned these

453
00:19:24,860 --> 00:19:20,630
lens models and these are mathematical

454
00:19:26,840 --> 00:19:24,870
descriptions of the way in which this

455
00:19:28,940 --> 00:19:26,850
galaxy cluster will bend light and if

456
00:19:32,450 --> 00:19:28,950
specific to this particular galaxy

457
00:19:34,130 --> 00:19:32,460
cluster right so if you if you model

458
00:19:37,010 --> 00:19:34,140
that if you shine light through this

459
00:19:39,290 --> 00:19:37,020
this lens model you're talking about you

460
00:19:43,040 --> 00:19:39,300
should be able to see certain galaxies

461
00:19:45,080 --> 00:19:43,050
behind it in certain locations in the

462
00:19:47,630 --> 00:19:45,090
galaxy cluster right that's exactly

463
00:19:49,550 --> 00:19:47,640

correct okay good so let me interject

464

00:19:51,920 --> 00:19:49,560

there's there's actually a really great

465

00:19:54,980 --> 00:19:51,930

you can do this yourself I do this in my

466

00:19:58,220 --> 00:19:54,990

classroom as Carol described and we've

467

00:20:01,010 --> 00:19:58,230

been talking about lenses make multiple

468

00:20:05,150 --> 00:20:01,020

images so if you take a wineglass

469

00:20:07,640 --> 00:20:05,160

yes promoting alcohol or any famous wine

470

00:20:09,560 --> 00:20:07,650

glass yeah but if you just take a wine

471

00:20:11,750 --> 00:20:09,570

glass and you and you tip it and cut it

472

00:20:13,940 --> 00:20:11,760

sort of look off the end and take a

473

00:20:16,880 --> 00:20:13,950

candle or a match or something like that

474

00:20:19,880 --> 00:20:16,890

and hold it on the backside of the stem

475

00:20:22,730 --> 00:20:19,890

and if you just took the angle you can

476
00:20:24,710 --> 00:20:22,740
actually create multiple images making

477
00:20:27,470 --> 00:20:24,720
twos pretty easy if you're really good

478
00:20:29,210 --> 00:20:27,480
you can make three if it's perfectly

479
00:20:33,560 --> 00:20:29,220
lined up you get what's called an

480
00:20:35,690 --> 00:20:33,570
Einstein ring and really if you know how

481
00:20:38,060 --> 00:20:35,700
the glass is distributed that's really

482
00:20:40,850 --> 00:20:38,070
when we say Allen's model then you can

483
00:20:43,790 --> 00:20:40,860
predict where the candle light will

484
00:20:45,950 --> 00:20:43,800
appear on your eyes right it's great

485
00:20:47,450 --> 00:20:45,960
it's a great demonstration up for those

486
00:20:48,890 --> 00:20:47,460
of you who haven't seen it yet

487
00:20:51,890 --> 00:20:48,900
if you look at one of our very first

488
00:20:53,450 --> 00:20:51,900

frontier fields hangouts Dan Coe what he

489

00:20:55,580 --> 00:20:53,460

did was he had a little galaxy had an

490

00:20:57,560 --> 00:20:55,590

image of one of his galaxies and an

491

00:20:59,590 --> 00:20:57,570

iPhone and then he put that in front of

492

00:21:02,090 --> 00:20:59,600

the glass that he had and he lens that

493

00:21:04,610 --> 00:21:02,100

that image of a galaxy from his iPhone

494

00:21:06,470 --> 00:21:04,620

and you can see for me well how how that

495

00:21:08,390 --> 00:21:06,480

that that works it's a really good

496

00:21:10,070 --> 00:21:08,400

demonstration so if you want to see that

497

00:21:12,170 --> 00:21:10,080

I would check out one of our past our

498

00:21:15,200 --> 00:21:12,180

frontier fields hangouts you'll be able

499

00:21:17,000 --> 00:21:15,210

to see that so Scott would you mind

500

00:21:19,460 --> 00:21:17,010

putting that image up you had with with

501
00:21:23,080 --> 00:21:19,470
the galaxy cluster in the foreground and

502
00:21:27,260 --> 00:21:23,090
the three little in sets again this

503
00:21:29,810 --> 00:21:27,270
cluster is called a bell 27:44 and it's

504
00:21:31,310 --> 00:21:29,820
one of the clusters that frontier fields

505
00:21:34,070 --> 00:21:31,320
is there's one of the six that it's

506
00:21:37,810 --> 00:21:34,080
picked to a show I mean as soon as God

507
00:21:40,790 --> 00:21:37,820
gets it up I want to here come so these

508
00:21:42,770 --> 00:21:40,800
galaxies on the cluster itself are all

509
00:21:45,010 --> 00:21:42,780
very familiar looking they look you know

510
00:21:47,360 --> 00:21:45,020
it looked like a galaxy ah to look and

511
00:21:49,430 --> 00:21:47,370
these are galaxies that are relatively

512
00:21:51,320 --> 00:21:49,440
close by compared to what you've been

513
00:21:53,420 --> 00:21:51,330

observing how are and maybe John this

514

00:21:56,810 --> 00:21:53,430

will be a question for you how are these

515

00:21:58,430 --> 00:21:56,820

early galaxies different from the

516

00:22:01,580 --> 00:21:58,440

galaxies we see today because they're

517

00:22:04,970 --> 00:22:01,590

not the same at all are they that's

518

00:22:08,740 --> 00:22:04,980

right the typically the galaxies that

519

00:22:12,290 --> 00:22:08,750

make up a galaxy cluster like a Bell

520

00:22:14,259 --> 00:22:12,300

2744 are what we call spheroidal

521

00:22:17,889 --> 00:22:14,269

galaxies so if you look in

522

00:22:23,829 --> 00:22:17,899

as image Scott has up basically be the

523

00:22:26,320 --> 00:22:23,839

orangish bright blobs that are that

524

00:22:29,079 --> 00:22:26,330

dominate this image these are all in the

525

00:22:30,579 --> 00:22:29,089

foreground and their brights for auto

526
00:22:32,709 --> 00:22:30,589
galaxies in other words picture them as

527
00:22:34,810 --> 00:22:32,719
beehives essentially they have no

528
00:22:37,359 --> 00:22:34,820
they're not flat in one direction

529
00:22:41,409 --> 00:22:37,369
they're like beehives or footballs in

530
00:22:43,839 --> 00:22:41,419
the sky and so first of all they're

531
00:22:46,029 --> 00:22:43,849
they're very massive as I've described

532
00:22:48,249 --> 00:22:46,039
the object we found which is in the

533
00:22:54,399 --> 00:22:48,259
background that's far far behind this

534
00:22:58,749 --> 00:22:54,409
cluster is is really a fragment of a

535
00:23:01,389 --> 00:22:58,759
galaxy today much less massive and the

536
00:23:02,919 --> 00:23:01,399
galaxies in a cluster for the most part

537
00:23:04,719 --> 00:23:02,929
most of the galaxies have stopped

538
00:23:07,209 --> 00:23:04,729

forming stars in other words they don't

539

00:23:10,449 --> 00:23:07,219

have the fuel for star formation which

540

00:23:14,229 --> 00:23:10,459

is cold gas whereas this distant object

541

00:23:16,479 --> 00:23:14,239

we've discovered has is forming stars at

542

00:23:19,149 --> 00:23:16,489

a significant rate compared to how

543

00:23:23,529 --> 00:23:19,159

massive it is which means it must have a

544

00:23:26,229 --> 00:23:23,539

cold gas reservoir and so there are very

545

00:23:29,589 --> 00:23:26,239

different parts of their life these

546

00:23:30,759 --> 00:23:29,599

these ferrata galaxies in the cluster a

547

00:23:33,519 --> 00:23:30,769

comment called

548

00:23:35,319 --> 00:23:33,529

red and dead galaxies because they have

549

00:23:38,379 --> 00:23:35,329

just stopped for me it's new stars

550

00:23:42,279 --> 00:23:38,389

whereas this distant object is really in

551
00:23:44,339 --> 00:23:42,289
its youth it's a toddler and it's you

552
00:23:47,169 --> 00:23:44,349
know its heyday is yet to come

553
00:23:48,789 --> 00:23:47,179
so indeed to follow up on what he do it

554
00:23:52,149 --> 00:23:48,799
with John was just saying these this

555
00:23:55,319 --> 00:23:52,159
distant galaxies he said has a cold gas

556
00:23:59,019 --> 00:23:55,329
reservoir would this be just the

557
00:24:01,629 --> 00:23:59,029
hydrogen and helium from the from from

558
00:24:03,549 --> 00:24:01,639
the early universe is that what they is

559
00:24:06,399 --> 00:24:03,559
how he's talking about or what well why

560
00:24:09,909 --> 00:24:06,409
would these galaxies be giving so many

561
00:24:10,269 --> 00:24:09,919
are high rates of star birth yes that's

562
00:24:12,310 --> 00:24:10,279
correct

563
00:24:13,959 --> 00:24:12,320

that's the reservoirs of hydrogen and

564

00:24:16,479 --> 00:24:13,969

also some helium from the early universe

565

00:24:18,940 --> 00:24:16,489

I just want to mention before that John

566

00:24:20,199 --> 00:24:18,950

mentioned that the cluster going back to

567

00:24:23,169 --> 00:24:20,209

the redshift John mentioned that the

568

00:24:24,399 --> 00:24:23,179

cluster galaxies are red and dead now we

569

00:24:26,259 --> 00:24:24,409

actually see that the background

570

00:24:28,090 --> 00:24:26,269

galaxies which is supposed to be young

571

00:24:30,220 --> 00:24:28,100

in blue is much redder

572

00:24:33,100 --> 00:24:30,230

now this is exactly the redshift this

573

00:24:35,800 --> 00:24:33,110

very blue galaxy is seen

574

00:24:37,810 --> 00:24:35,810

extremely red to us because it's in the

575

00:24:39,940 --> 00:24:37,820

end of in the edge of the universe so

576

00:24:42,460 --> 00:24:39,950

it's very highly redshifted

577

00:24:46,530 --> 00:24:42,470

but it's physical color is and isn't red

578

00:24:49,720 --> 00:24:46,540

it's actually who's providing it or

579

00:24:51,100 --> 00:24:49,730

because of the star birth the rapid

580

00:24:53,650 --> 00:24:51,110

amount of star birth and the young stars

581

00:24:55,390 --> 00:24:53,660

in there correct exactly okay so we got

582

00:24:58,360 --> 00:24:55,400

this we got this galaxy that's really

583

00:25:01,360 --> 00:24:58,370

ultra violet or blue if we were to be

584

00:25:04,720 --> 00:25:01,370

right next to it although you know 13

585

00:25:07,690 --> 00:25:04,730

billion years ago but it appears red to

586

00:25:10,780 --> 00:25:07,700

us what are the stars like in this

587

00:25:14,920 --> 00:25:10,790

galaxy what do they like John why don't

588

00:25:17,740 --> 00:25:14,930

you take okay John I sure obviously we

589

00:25:20,380 --> 00:25:17,750

we can't say anything about individual

590

00:25:23,290 --> 00:25:20,390

stars so what we're looking at if the

591

00:25:26,920 --> 00:25:23,300

combined light of all the stars in this

592

00:25:29,770 --> 00:25:26,930

galaxy and that's true of almost any

593

00:25:32,050 --> 00:25:29,780

galaxy in the skies galaxies even nearby

594

00:25:34,450 --> 00:25:32,060

ones relatively nearby ones are so

595

00:25:36,070 --> 00:25:34,460

distant that we never see individual

596

00:25:38,560 --> 00:25:36,080

stars so when you look at this cluster

597

00:25:40,900 --> 00:25:38,570

image pick the biggest thing on here

598

00:25:43,150 --> 00:25:40,910

what you're seeing is the faint that

599

00:25:46,120 --> 00:25:43,160

added the light that's added up from all

600

00:25:49,390 --> 00:25:46,130

four many billions of stars that are in

601
00:25:51,940 --> 00:25:49,400
here but the fact that we can say

602
00:25:57,280 --> 00:25:51,950
something about how fast stars are

603
00:26:00,070 --> 00:25:57,290
forming on average and this galaxy as

604
00:26:03,490 --> 00:26:00,080
forming stars at a rate of about three

605
00:26:06,970 --> 00:26:03,500
suns every year which might not seem

606
00:26:09,010 --> 00:26:06,980
like a really big number but you have to

607
00:26:11,260 --> 00:26:09,020
compare it to how big it is because it's

608
00:26:13,540 --> 00:26:11,270
so small the fact that it's forming

609
00:26:16,750 --> 00:26:13,550
three suns of a year what that means is

610
00:26:19,570 --> 00:26:16,760
that in about 200 million years it's

611
00:26:21,340 --> 00:26:19,580
going to get double its size and then if

612
00:26:22,840 --> 00:26:21,350
you continue form stars at that same

613
00:26:25,650 --> 00:26:22,850

rate that means in another two hundred

614

00:26:27,940 --> 00:26:25,660

years it's going to double again and so

615

00:26:31,330 --> 00:26:27,950

even though it doesn't have a large

616

00:26:33,520 --> 00:26:31,340

absolute star formation rate it's a rate

617

00:26:35,770 --> 00:26:33,530

at which it's forming new stars this

618

00:26:37,890 --> 00:26:35,780

thing is is growing up really really

619

00:26:40,740 --> 00:26:37,900

quickly

620

00:26:42,990 --> 00:26:40,750

I see this on a growth spurt huh that's

621

00:26:46,650 --> 00:26:43,000

right okay well while we're on the topic

622

00:26:49,080 --> 00:26:46,660

of these early galaxies versus the ones

623

00:26:51,810 --> 00:26:49,090

that are more closer to us in the in the

624

00:26:55,170 --> 00:26:51,820

present day Lucas a Midori from YouTube

625

00:26:56,670 --> 00:26:55,180

has asked if there were galaxies at

626

00:26:58,770 --> 00:26:56,680

thirteen billion years ago then there

627

00:27:01,770 --> 00:26:58,780

must have also have been super massive

628

00:27:03,930 --> 00:27:01,780

black holes already hanging around to

629

00:27:05,940 --> 00:27:03,940

organize those galaxies together any

630

00:27:07,770 --> 00:27:05,950

ideas on those supermassive black holes

631

00:27:10,080 --> 00:27:07,780

on how those supermassive black holes

632

00:27:12,930 --> 00:27:10,090

might have become so enmeshed in such a

633

00:27:15,480 --> 00:27:12,940

relatively short time after the bang now

634

00:27:17,420 --> 00:27:15,490

that's assuming of course that you

635

00:27:20,070 --> 00:27:17,430

Depthi

636

00:27:24,030 --> 00:27:20,080

that there are these are formed by

637

00:27:28,770 --> 00:27:24,040

supermassive black holes correct so how

638

00:27:33,330 --> 00:27:28,780

do you respond to that are there either

639

00:27:34,950 --> 00:27:33,340

one ID or John anybody I can try if I

640

00:27:36,540 --> 00:27:34,960

got the question correctly first of all

641

00:27:39,510 --> 00:27:36,550

just let me say I'm far from being an

642

00:27:41,640 --> 00:27:39,520

expert on black holes but one of the

643

00:27:44,670 --> 00:27:41,650

theories for forming the the you know

644

00:27:47,400 --> 00:27:44,680

the very messy or at least some of the

645

00:27:50,070 --> 00:27:47,410

the black holes the early ones as we

646

00:27:52,290 --> 00:27:50,080

know it this is to my knowledge is that

647

00:27:54,510 --> 00:27:52,300

massive stars explode and then collapse

648

00:27:54,860 --> 00:27:54,520

to form some sort of sort of a black

649

00:27:58,080 --> 00:27:54,870

hole

650

00:28:00,930 --> 00:27:58,090

now the first stars are expected

651
00:28:02,520 --> 00:28:00,940
expected to be much more massive than

652
00:28:04,470 --> 00:28:02,530
the stars that we see today so this

653
00:28:06,390 --> 00:28:04,480
could be one explanation but I think

654
00:28:07,980 --> 00:28:06,400
that there is some flowing the question

655
00:28:10,520 --> 00:28:07,990
in the same in the the question in the

656
00:28:12,960 --> 00:28:10,530
sense that these galaxies are not

657
00:28:14,580 --> 00:28:12,970
similar in shape to the galaxies that we

658
00:28:17,100 --> 00:28:14,590
see today which have a black hole in

659
00:28:19,530 --> 00:28:17,110
their center these galaxies are fuzzy or

660
00:28:21,690 --> 00:28:19,540
very clumpy objects which are not well

661
00:28:23,460 --> 00:28:21,700
organized so we are not even sure if

662
00:28:24,960 --> 00:28:23,470
there are black holes in their centers

663
00:28:26,550 --> 00:28:24,970

that's what I was hoping you'd address

664

00:28:29,400 --> 00:28:26,560

because it's not necessarily the case

665

00:28:34,320 --> 00:28:29,410

that black holes are responsible for

666

00:28:36,330 --> 00:28:34,330

their formation at all their question so

667

00:28:39,990 --> 00:28:36,340

when I said the flow it was not against

668

00:28:41,190 --> 00:28:40,000

of course that somebody asking the

669

00:28:44,040 --> 00:28:41,200

question that was a very good question

670

00:28:47,340 --> 00:28:44,050

is just that well what about the second

671

00:28:49,860 --> 00:28:47,350

part of it idea so let's just would

672

00:28:51,150 --> 00:28:49,870

would black holes form relatively soon

673

00:28:53,460 --> 00:28:51,160

after the Big Bang

674

00:28:56,370 --> 00:28:53,470

when they you said these stars are very

675

00:28:58,770 --> 00:28:56,380

massive they shine very brightly they

676

00:29:01,530 --> 00:28:58,780

die after a relatively short period of

677

00:29:04,140 --> 00:29:01,540

time presumably in soup in us I believe

678

00:29:06,930 --> 00:29:04,150

it's in a specific kind of supernova and

679

00:29:10,320 --> 00:29:06,940

so would black holes be forming that

680

00:29:12,390 --> 00:29:10,330

during this time yeah I mean I'll pick

681

00:29:15,540 --> 00:29:12,400

this up I would say this is a wide open

682

00:29:17,930 --> 00:29:15,550

question and an important one and a

683

00:29:21,330 --> 00:29:17,940

really exciting one but one that our

684

00:29:24,270 --> 00:29:21,340

discovery at least can't speak to but

685

00:29:28,590 --> 00:29:24,280

it's something that it's an open problem

686

00:29:31,470 --> 00:29:28,600

open question in in really in how the

687

00:29:33,150 --> 00:29:31,480

early universe evolved so when when you

688

00:29:35,610 --> 00:29:33,160

say supermassive black holes what we're

689

00:29:39,240 --> 00:29:35,620

talking about here are black holes at

690

00:29:42,030 --> 00:29:39,250

our millions or even billions times more

691

00:29:46,890 --> 00:29:42,040

massive than our Sun right so for

692

00:29:50,280 --> 00:29:46,900

example like you galaxy is is a about a

693

00:29:53,070 --> 00:29:50,290

four million solar mass black hole but

694

00:29:55,350 --> 00:29:53,080

in but Jesus supermassive black holes

695

00:29:58,080 --> 00:29:55,360

can be even a billion or ten billion

696

00:30:00,480 --> 00:29:58,090

times a massive Sun we do see

697

00:30:03,330 --> 00:30:00,490

supermassive black holes at high

698

00:30:07,350 --> 00:30:03,340

redshift so at redshifts of say six to

699

00:30:10,710 --> 00:30:07,360

seven which is not quite a billion years

700

00:30:14,630 --> 00:30:10,720

after where the object we've discovered

701
00:30:17,850 --> 00:30:14,640
so at some point between the end of the

702
00:30:20,250 --> 00:30:17,860
when galaxy formation began roughly

703
00:30:24,780 --> 00:30:20,260
billion years or so we do know that

704
00:30:26,400 --> 00:30:24,790
super moon now seen but there's no

705
00:30:29,280 --> 00:30:26,410
evidence that there's a supermassive

706
00:30:31,830 --> 00:30:29,290
black hole or that there's any kind of

707
00:30:33,600 --> 00:30:31,840
black hole in the the types of objects

708
00:30:34,920 --> 00:30:33,610
that we've discovered you know this

709
00:30:37,860 --> 00:30:34,930
discovery we were talking about today

710
00:30:41,150 --> 00:30:37,870
and and others like it so what I meant

711
00:30:44,340 --> 00:30:41,160
by it being an open problem is we

712
00:30:46,350 --> 00:30:44,350
there's a missing link we we know that

713
00:30:48,240 --> 00:30:46,360

supermassive black holes appear at some

714

00:30:50,910 --> 00:30:48,250

point later we don't see them where

715

00:30:56,340 --> 00:30:50,920

we're finding them and so it's a

716

00:30:57,990 --> 00:30:56,350

discovery phase and when and how these

717

00:31:00,210 --> 00:30:58,000

supermassive black holes came on the

718

00:31:01,860 --> 00:31:00,220

scene all right thank you very good

719

00:31:05,040 --> 00:31:01,870

question Lucas thank you very much we

720

00:31:06,920 --> 00:31:05,050

appreciate that all right so

721

00:31:10,230 --> 00:31:06,930

we're talking about a period in time

722

00:31:11,730 --> 00:31:10,240

with you know obviously really really

723

00:31:14,700 --> 00:31:11,740

early in the universe we would not have

724

00:31:18,830 --> 00:31:14,710

seen this galaxy had it not been for the

725

00:31:23,280 --> 00:31:18,840

frontier fields there are a lot of

726

00:31:24,420 --> 00:31:23,290

people using this data got you know

727

00:31:26,160 --> 00:31:24,430

right away like we had mentioned earlier

728

00:31:28,170 --> 00:31:26,170

in fact this is just one of the many

729

00:31:32,640 --> 00:31:28,180

ways in which people where yields

730

00:31:37,440 --> 00:31:32,650

frontier fields data so I guess what I

731

00:31:39,810 --> 00:31:37,450

want to ask a little bit about is last

732

00:31:41,310 --> 00:31:39,820

week there was a there was a workshop or

733

00:31:43,740 --> 00:31:41,320

a lot of people got together and they

734

00:31:46,440 --> 00:31:43,750

talked about using this data and things

735

00:31:49,860 --> 00:31:46,450

like that are there other people doing

736

00:31:51,570 --> 00:31:49,870

looking at this for other galaxies like

737

00:31:55,920 --> 00:31:51,580

you guys are or is this primarily your

738

00:31:58,860 --> 00:31:55,930

bailiwick there are many groups that are

739

00:32:00,870 --> 00:31:58,870

looking at this data all of them are

740

00:32:03,780 --> 00:32:00,880

doing a great job people have found

741

00:32:05,270 --> 00:32:03,790

already in the phase cluster the same

742

00:32:08,880 --> 00:32:05,280

cluster that we found the very

743

00:32:12,500 --> 00:32:08,890

rehydrates you know if we sum up all the

744

00:32:15,480 --> 00:32:12,510

galaxies that the group would have found

745

00:32:17,250 --> 00:32:15,490

it sums up to a few dozen galaxies at

746

00:32:19,290 --> 00:32:17,260

very high redshift indeed not at a

747

00:32:22,170 --> 00:32:19,300

redshift of 10 but the redshift of 6 to

748

00:32:26,300 --> 00:32:22,180

9 for example so only by looking deep at

749

00:32:28,740 --> 00:32:26,310

one cluster we found dozens of hydrogen

750

00:32:31,430 --> 00:32:28,750

galaxies excited to see what we find

751

00:32:34,590 --> 00:32:31,440

over all six of them stores

752

00:32:36,150 --> 00:32:34,600

so Mike Hill Jobin from the Q&A app is

753

00:32:38,040 --> 00:32:36,160

poking fun amigos Tony you were

754

00:32:45,390 --> 00:32:38,050

channeling Guido Sarducci just a little

755

00:32:48,090 --> 00:32:45,400

I was father Guido Sarducci okay cool

756

00:32:50,340 --> 00:32:48,100

so let's see cecil morgan is asking also

757

00:32:53,880 --> 00:32:50,350

from the Q&A app wouldn't a redshift of

758

00:32:56,910 --> 00:32:53,890

10 take the visible spectrum out of the

759

00:32:59,190 --> 00:32:56,920

range of HSTs detectors meaning that

760

00:33:00,930 --> 00:32:59,200

what we're seeing was emitted in the UV

761

00:33:03,240 --> 00:33:00,940

range is that right and you touched on

762

00:33:06,210 --> 00:33:03,250

this already just a little bit guys but

763

00:33:07,500 --> 00:33:06,220

as Webley was you John that said that

764

00:33:10,950 --> 00:33:07,510

even though we're physically looking at

765

00:33:12,750 --> 00:33:10,960

this thing and it appears red to us if

766

00:33:16,530 --> 00:33:12,760

we were right next to it it will appear

767

00:33:18,570 --> 00:33:16,540

in the UV or visible correct yeah that's

768

00:33:20,730 --> 00:33:18,580

right I think Adi said that but

769

00:33:22,470 --> 00:33:20,740

I'm sorry it was a de I apologize no no

770

00:33:26,580 --> 00:33:22,480

that's fine but yeah that's absolutely

771

00:33:28,980 --> 00:33:26,590

true so what we're actually observing is

772

00:33:30,600 --> 00:33:28,990

light that when it left the galaxy was

773

00:33:32,909 --> 00:33:30,610

in the ultraviolet part of the

774

00:33:35,009 --> 00:33:32,919

electromagnetic spectrum and that light

775

00:33:38,310 --> 00:33:35,019

has lost energy as it has traveled

776
00:33:41,310 --> 00:33:38,320
across the cosmos and so we're receiving

777
00:33:43,409 --> 00:33:41,320
it in a different part of the

778
00:33:49,649 --> 00:33:43,419
electromagnetic spectrum called Amira

779
00:33:52,950 --> 00:33:49,659
red and but it it is within the range

780
00:33:56,070 --> 00:33:52,960
where Hubble has a detector is the Wide

781
00:33:58,830 --> 00:33:56,080
Field Camera 3 as an infrared near Fred

782
00:34:00,779 --> 00:33:58,840
Channel and so we are able to pick up

783
00:34:02,909 --> 00:34:00,789
the light but let's say we wanted to

784
00:34:08,399 --> 00:34:02,919
find galaxies at even higher redshift

785
00:34:11,329 --> 00:34:08,409
say 10 11 12 15 or 20 the that light

786
00:34:15,270 --> 00:34:11,339
would be beyond Hubble's capabilities

787
00:34:17,040 --> 00:34:15,280
and so we're I mentioned earlier where

788
00:34:19,169 --> 00:34:17,050

that we're at the edge of what Hubble

789

00:34:21,649 --> 00:34:19,179

can do for being a two and a half metre

790

00:34:24,480 --> 00:34:21,659

telescope tractor-trailer in space

791

00:34:27,149 --> 00:34:24,490

that's part of it the second part is the

792

00:34:29,550 --> 00:34:27,159

fact that the detectors just can't pick

793

00:34:32,339 --> 00:34:29,560

up light that's even further into the

794

00:34:34,619 --> 00:34:32,349

red and for that and this is my segue is

795

00:34:35,730 --> 00:34:34,629

I will have to await the James Webb

796

00:34:37,440 --> 00:34:35,740

Space Telescope

797

00:34:38,879 --> 00:34:37,450

that's correct and I've often said you

798

00:34:41,099 --> 00:34:38,889

know the future of astronomy and why I

799

00:34:42,359 --> 00:34:41,109

would I was I had a professor at the

800

00:34:44,070 --> 00:34:42,369

University of Colorado that said this

801
00:34:45,540 --> 00:34:44,080
but I stole it it was like he's always

802
00:34:47,909 --> 00:34:45,550
say the future of astronomy is in the

803
00:34:49,589 --> 00:34:47,919
infrared because of this this is if we

804
00:34:51,629 --> 00:34:49,599
want to look further back if we want to

805
00:34:53,730 --> 00:34:51,639
see these early regions or these early

806
00:34:56,520 --> 00:34:53,740
times in the universe the infrared is

807
00:34:59,460 --> 00:34:56,530
the place to go and now that infrared

808
00:35:01,410 --> 00:34:59,470
detectors have become ubiquitous there

809
00:35:03,720 --> 00:35:01,420
they used to be very difficult to make

810
00:35:05,359 --> 00:35:03,730
now they're all over the place and so as

811
00:35:08,400 --> 00:35:05,369
you mentioned JWST is going to have a

812
00:35:10,200 --> 00:35:08,410
even larger wavelength range in the

813
00:35:12,180 --> 00:35:10,210

infrared for don't you mean that the

814

00:35:16,079 --> 00:35:12,190

future and the path for the strong man I

815

00:35:18,030 --> 00:35:16,089

exactly so good question Cecil

816

00:35:21,450 --> 00:35:18,040

appreciated and peda phlox who was not

817

00:35:22,620 --> 00:35:21,460

first this time in a really basic

818

00:35:24,270 --> 00:35:22,630

question and we've touched on this a

819

00:35:27,329 --> 00:35:24,280

little bit but is there some sort of

820

00:35:28,410 --> 00:35:27,339

idea how this galaxy formed I mean these

821

00:35:30,540 --> 00:35:28,420

early galaxies we talked about

822

00:35:31,800 --> 00:35:30,550

supermassive black holes and the weather

823

00:35:32,220 --> 00:35:31,810

it's an open question about whether

824

00:35:34,200 --> 00:35:32,230

black

825

00:35:35,490 --> 00:35:34,210

holes were in this period of time how do

826

00:35:38,970 --> 00:35:35,500

these things start clumping up out of

827

00:35:41,760 --> 00:35:38,980

these galaxies start forming who wants

828

00:35:45,300 --> 00:35:41,770

to take that one John I've been

829

00:35:47,460 --> 00:35:45,310

talking ah yeah go ahead

830

00:35:50,430 --> 00:35:47,470

you dick so any idea how these high-rent

831

00:35:52,200 --> 00:35:50,440

these early galaxies get started what

832

00:35:54,720 --> 00:35:52,210

kind of is there a gravitational bump or

833

00:35:58,500 --> 00:35:54,730

some kind of sub kind that gets them

834

00:36:01,920 --> 00:35:58,510

going what does it take Adi

835

00:36:05,160 --> 00:36:01,930

are you there I just thought it was a

836

00:36:06,720 --> 00:36:05,170

better question for John but sure okay

837

00:36:11,490 --> 00:36:06,730

he's pretty tired of talking so we're

838

00:36:15,660 --> 00:36:11,500

gonna ask you to do it about 300,000

839

00:36:17,880 --> 00:36:15,670

years after the Big Bang all the very

840

00:36:20,840 --> 00:36:17,890

hot particles started recombining

841

00:36:24,359 --> 00:36:20,850

together and hydrogen was formed again

842

00:36:26,060 --> 00:36:24,369

and then you know it wasn't formed in a

843

00:36:28,230 --> 00:36:26,070

completely uniform way there were some

844

00:36:30,390 --> 00:36:28,240

regions where the density was a bit

845

00:36:32,370 --> 00:36:30,400

higher and where the density was a bit

846

00:36:35,099 --> 00:36:32,380

higher it attracted more and more

847

00:36:37,859 --> 00:36:35,109

hydrogen to that risen region when the

848

00:36:41,430 --> 00:36:37,869

mass was high enough all of that cloud

849

00:36:42,840 --> 00:36:41,440

of gas suddenly collapsed and formed you

850

00:36:45,210 --> 00:36:42,850

know started forming stars

851
00:36:48,359 --> 00:36:45,220
it got fragmented and the density was

852
00:36:51,450 --> 00:36:48,369
high enough that hydrogen began fusing

853
00:36:55,200 --> 00:36:51,460
and basically shining and these are what

854
00:36:56,310 --> 00:36:55,210
we know is stories and those clumps of

855
00:36:59,630 --> 00:36:56,320
stars slowly

856
00:37:02,940 --> 00:36:59,640
coalesced into these galaxies I say

857
00:37:04,950 --> 00:37:02,950
lovely in universal timescales it

858
00:37:06,720 --> 00:37:04,960
actually happened pretty quickly where

859
00:37:08,040 --> 00:37:06,730
these galaxies started forming basically

860
00:37:09,510 --> 00:37:08,050
from these inhomogeneities like you

861
00:37:12,030 --> 00:37:09,520
talked about these little density

862
00:37:16,080 --> 00:37:12,040
fluctuations throughout the universe and

863
00:37:18,930 --> 00:37:16,090

slowly they just started congealing into

864

00:37:23,160 --> 00:37:18,940

these galaxies so yeah the only thing I

865

00:37:24,810 --> 00:37:23,170

would add is that and and probably made

866

00:37:27,120 --> 00:37:24,820

a whole other hangout for this is that

867

00:37:30,330 --> 00:37:27,130

in fact what dominates the gravity in

868

00:37:32,099 --> 00:37:30,340

our universe is is dark matter so what

869

00:37:36,080 --> 00:37:32,109

we actually think has happened is that

870

00:37:38,940 --> 00:37:36,090

this hydrogen and get us falling into a

871

00:37:42,510 --> 00:37:38,950

gravity well made of largely of dark

872

00:37:44,880 --> 00:37:42,520

matter and so the hydrogen is just at

873

00:37:45,440 --> 00:37:44,890

the center of concentration of dark

874

00:37:47,600 --> 00:37:45,450

matter

875

00:37:49,940 --> 00:37:47,610

and as if you describe once the hydrogen

876
00:37:51,620 --> 00:37:49,950
gets dense enough you start making one

877
00:37:54,320 --> 00:37:51,630
star and once you start making one

878
00:37:58,370 --> 00:37:54,330
you're gonna make many that's right and

879
00:38:01,430 --> 00:37:58,380
and and then we were born yay thank you

880
00:38:03,110 --> 00:38:01,440
Patos a good question Michael Jobin is

881
00:38:04,820 --> 00:38:03,120
commenting so just because you don't

882
00:38:10,130 --> 00:38:04,830
find black holes you will someday

883
00:38:12,830 --> 00:38:10,140
perhaps and that is true perhaps my

884
00:38:15,020 --> 00:38:12,840
Daniel Masato from the Q&A app by

885
00:38:16,940 --> 00:38:15,030
observing a photon being gravitationally

886
00:38:19,490 --> 00:38:16,950
lensed around the galaxy are we

887
00:38:22,280 --> 00:38:19,500
determining its path billions of years

888
00:38:25,070 --> 00:38:22,290

in the paths in the past sorry like

889

00:38:26,270 --> 00:38:25,080

shown in the double slit experiment and

890

00:38:29,960 --> 00:38:26,280

we talked about this briefly before

891

00:38:31,790 --> 00:38:29,970

you're these gravitational a lens

892

00:38:35,060 --> 00:38:31,800

photons are actually going through a

893

00:38:38,080 --> 00:38:35,070

model that you mathematically created to

894

00:38:40,460 --> 00:38:38,090

sort of describe this a little bit but

895

00:38:43,640 --> 00:38:40,470

can you so are you basically just

896

00:38:45,770 --> 00:38:43,650

tracing it back the path we are tracing

897

00:38:47,570 --> 00:38:45,780

it back but I think that the double slit

898

00:38:49,340 --> 00:38:47,580

may be a bit confusing because what we

899

00:38:51,680 --> 00:38:49,350

see in the double slit experiment is a

900

00:38:53,240 --> 00:38:51,690

quantum effect which is they on a very

901
00:38:55,970 --> 00:38:53,250
small scale here we're talking about

902
00:38:58,180 --> 00:38:55,980
giant structures and basically the

903
00:39:00,380 --> 00:38:58,190
procedure is not some magical

904
00:39:03,790 --> 00:39:00,390
statistical thing as in quantum

905
00:39:06,920 --> 00:39:03,800
mechanics which is beautiful a much more

906
00:39:10,370 --> 00:39:06,930
simple thing so basically light from the

907
00:39:13,160 --> 00:39:10,380
galaxies going in one path is getting

908
00:39:17,090 --> 00:39:13,170
pulled by the cluster and getting if you

909
00:39:19,130 --> 00:39:17,100
want kicked off towards I our direction

910
00:39:21,650 --> 00:39:19,140
so that happens on one side of the

911
00:39:23,180 --> 00:39:21,660
cluster but the same but another light

912
00:39:25,490 --> 00:39:23,190
weight from the big moon galaxy is going

913
00:39:27,740 --> 00:39:25,500

to the other side of the cluster will

914

00:39:29,510 --> 00:39:27,750

experience the same thing this is why we

915

00:39:31,970 --> 00:39:29,520

see it several times so it's not a

916

00:39:34,160 --> 00:39:31,980

quantum effect it's just an effect that

917

00:39:36,440 --> 00:39:34,170

the gravity of the cluster distorts

918

00:39:39,170 --> 00:39:36,450

space in a way that stretches these

919

00:39:40,400 --> 00:39:39,180

sidelines towards us that's a really

920

00:39:41,660 --> 00:39:40,410

good question dan you know thank you for

921

00:39:43,850 --> 00:39:41,670

asking and thanks for the clarification

922

00:39:46,820 --> 00:39:43,860

on that - that was a really good

923

00:39:49,340 --> 00:39:46,830

explanation I have a question oh I had a

924

00:39:51,830 --> 00:39:49,350

comment which is that in a did sometimes

925

00:39:54,140 --> 00:39:51,840

there are multiples and sometimes those

926
00:39:56,330 --> 00:39:54,150
multiple images are actually merged into

927
00:39:57,800 --> 00:39:56,340
arc since they are stretched in two arcs

928
00:39:59,180 --> 00:39:57,810
and things like that so that's pretty

929
00:40:03,410 --> 00:39:59,190
interesting too

930
00:40:06,230 --> 00:40:03,420
look at a bill 27:44 and try to find

931
00:40:11,300 --> 00:40:06,240
those things on your own the other the

932
00:40:13,940 --> 00:40:11,310
question I had for our guests is that so

933
00:40:16,040 --> 00:40:13,950
you found this one that's at Z equals 10

934
00:40:18,200 --> 00:40:16,050
but I know you as you mentioned you

935
00:40:21,070 --> 00:40:18,210
found others right so you've looked at

936
00:40:24,740 --> 00:40:21,080
this cluster and you found galaxies at

937
00:40:26,810 --> 00:40:24,750
various redshift have you found like a

938
00:40:30,560 --> 00:40:26,820

certain redshift where there were a lot

939

00:40:34,220 --> 00:40:30,570

and then other rifts found one at Z

940

00:40:36,890 --> 00:40:34,230

equals 10 maybe there are more but at 9

941

00:40:39,950 --> 00:40:36,900

8 7 I know you that you in your paper

942

00:40:41,960 --> 00:40:39,960

you've described finding other multiples

943

00:40:44,810 --> 00:40:41,970

so I was just wondering if they were

944

00:40:47,150 --> 00:40:44,820

clustered in redshift or are they just

945

00:40:50,570 --> 00:40:47,160

kind of all over the map yeah that's a

946

00:40:53,720 --> 00:40:50,580

good question and the answer is that we

947

00:40:56,690 --> 00:40:53,730

do see a redshift dependence so we we do

948

00:40:59,210 --> 00:40:56,700

the we do get more galaxies at closer

949

00:41:01,670 --> 00:40:59,220

distances to us than the very high

950

00:41:04,550 --> 00:41:01,680

reduced ones but this is a combination

951
00:41:07,400 --> 00:41:04,560
of two effects first of all we are when

952
00:41:10,550 --> 00:41:07,410
we look to lower redshifts we are

953
00:41:12,500 --> 00:41:10,560
probing a larger volume behind the

954
00:41:17,660 --> 00:41:12,510
cluster so we expect to see more

955
00:41:19,220 --> 00:41:17,670
galaxies there and also B well that's

956
00:41:21,320 --> 00:41:19,230
the main reason basically they have the

957
00:41:24,470 --> 00:41:21,330
higher you go in redshift basically the

958
00:41:27,290 --> 00:41:24,480
lens the effective area behind the lens

959
00:41:28,460 --> 00:41:27,300
shrinks and shrinks so you are very

960
00:41:30,380 --> 00:41:28,470
susceptible to that and you're not

961
00:41:32,900 --> 00:41:30,390
likely to find many high redshift

962
00:41:35,540 --> 00:41:32,910
objects but we do most of the objects

963
00:41:36,740 --> 00:41:35,550

that we found we now know about almost

964

00:41:38,630 --> 00:41:36,750

200 objects

965

00:41:42,550 --> 00:41:38,640

magnified objects beyond this cluster or

966

00:41:45,620 --> 00:41:42,560

it is 200 images of magnified objects

967

00:41:48,170 --> 00:41:45,630

most of them are thread shift to receive

968

00:41:52,280 --> 00:41:48,180

3 and then it goes down slowly up to

969

00:41:53,900 --> 00:41:52,290

achieve them ok but also let me let me

970

00:41:56,540 --> 00:41:53,910

interject it's actually kind of

971

00:42:01,700 --> 00:41:56,550

interesting because you can ask how many

972

00:42:04,460 --> 00:42:01,710

would we have expected and which perhaps

973

00:42:09,200 --> 00:42:04,470

is what you're getting at and I think if

974

00:42:12,650 --> 00:42:09,210

you if you predict how many say redshift

975

00:42:16,430 --> 00:42:12,660

n objects and 9 or 10 objects at

976
00:42:20,329 --> 00:42:16,440
9 or 10 we should have seen then it's

977
00:42:22,670 --> 00:42:20,339
more than one it's it's a handful and

978
00:42:26,240 --> 00:42:22,680
it's uncertain because it's a rough

979
00:42:28,160 --> 00:42:26,250
estimate and so we found one there's

980
00:42:30,829 --> 00:42:28,170
maybe another one that's a possible

981
00:42:34,099 --> 00:42:30,839
candidate and so this is another really

982
00:42:37,990 --> 00:42:34,109
exciting question that we're pursuing

983
00:42:40,660 --> 00:42:38,000
because maybe there are far fewer

984
00:42:43,640 --> 00:42:40,670
galaxies at these very high redshift

985
00:42:46,190 --> 00:42:43,650
than we were anticipating in which case

986
00:42:48,829 --> 00:42:46,200
maybe we really are seeing the beginning

987
00:42:52,210 --> 00:42:48,839
the very beginning of when galaxy

988
00:42:54,980 --> 00:42:52,220

formation really started to ramp up

989

00:42:56,690 --> 00:42:54,990

alternatively maybe it's just this one

990

00:42:59,270 --> 00:42:56,700

cluster the fact that we've only looked

991

00:43:01,339 --> 00:42:59,280

at one cluster and this is one of the

992

00:43:03,829 --> 00:43:01,349

great strengths of the Hubble frontier

993

00:43:06,140 --> 00:43:03,839

field is we're not putting our eggs into

994

00:43:08,150 --> 00:43:06,150

a single basket we're looking at

995

00:43:10,730 --> 00:43:08,160

hopefully ultimately six different

996

00:43:13,579 --> 00:43:10,740

clusters right if they all tell the same

997

00:43:15,500 --> 00:43:13,589

story then we can be confident that we

998

00:43:19,339 --> 00:43:15,510

really are seeing the beginning of the

999

00:43:23,240 --> 00:43:19,349

build-up and but that'll come out in the

1000

00:43:26,150 --> 00:43:23,250

next year RN - yeah that's a good ask

1001

00:43:27,799 --> 00:43:26,160

Carol about that so the the frontier

1002

00:43:30,079 --> 00:43:27,809

fields is going to continue gathering

1003

00:43:32,920 --> 00:43:30,089

observations for roughly how long do we

1004

00:43:35,359 --> 00:43:32,930

know the entire period is through the

1005

00:43:38,299 --> 00:43:35,369

allocation of time is for three years so

1006

00:43:40,460 --> 00:43:38,309

it's roughly it it roughly takes a year

1007

00:43:43,160 --> 00:43:40,470

to do two clusters because there are

1008

00:43:44,960 --> 00:43:43,170

many many observations and also the

1009

00:43:47,450 --> 00:43:44,970

nature of getting both the advanced

1010

00:43:51,140 --> 00:43:47,460

camera for surveys and getting the Wide

1011

00:43:53,059 --> 00:43:51,150

Field Camera 3 that's yes and so that

1012

00:43:56,870 --> 00:43:53,069

takes the better part of a year to do

1013

00:43:58,849 --> 00:43:56,880

two clusters so they just just begun a

1014

00:44:01,039 --> 00:43:58,859

couple other clusters and there is new

1015

00:44:03,799 --> 00:44:01,049

data coming in a substantial amount of

1016

00:44:06,769 --> 00:44:03,809

new data coming in on a third cluster

1017

00:44:08,720 --> 00:44:06,779

and actually this is all on the webpage

1018

00:44:11,450 --> 00:44:08,730

you can just google frontier fields you

1019

00:44:14,569 --> 00:44:11,460

can see what the allocation is of when

1020

00:44:16,849 --> 00:44:14,579

the data is going to be observed what

1021

00:44:18,549 --> 00:44:16,859

data has been released all the papers

1022

00:44:22,880 --> 00:44:18,559

that have been written about these

1023

00:44:25,580 --> 00:44:22,890

clusters and so it will take another two

1024

00:44:28,760 --> 00:44:25,590

years or so - one and a half

1025

00:44:30,820 --> 00:44:28,770

years - to complete all six right and

1026

00:44:33,500 --> 00:44:30,830

what's gonna head over to the blog -

1027

00:44:36,170 --> 00:44:33,510

there is a blog as well yeah which is

1028

00:44:37,850 --> 00:44:36,180

accessible off of the main frontier

1029

00:44:39,530 --> 00:44:37,860

fields I'm sorry

1030

00:44:41,120 --> 00:44:39,540

thank you Scott yeah that's the frontier

1031

00:44:43,180 --> 00:44:41,130

fields org so you can definitely head

1032

00:44:45,740 --> 00:44:43,190

over there we're posting on that

1033

00:44:47,410 --> 00:44:45,750

regularly as we can and also there's

1034

00:44:51,290 --> 00:44:47,420

also there's also a really nice

1035

00:44:53,660 --> 00:44:51,300

scheduler or a chart showing where fluid

1036

00:44:56,630 --> 00:44:53,670

frontier fields is on the in there

1037

00:45:00,770 --> 00:44:56,640

observing program on the stsci dot edu

1038

00:45:02,270 --> 00:45:00,780

slash HS tff page and you'll be able to

1039

00:45:04,850 --> 00:45:02,280

kind of track the progress but i wanted

1040

00:45:06,350 --> 00:45:04,860

to give people kind of a sense of you

1041

00:45:10,490 --> 00:45:06,360

know the timelines that john was talking

1042

00:45:12,470 --> 00:45:10,500

about there that john makes this is an

1043

00:45:14,120 --> 00:45:12,480

important one we've all read always said

1044

00:45:17,060 --> 00:45:14,130

that about the Hubble Deep fields is

1045

00:45:21,230 --> 00:45:17,070

that these are tiny real regions of the

1046

00:45:25,190 --> 00:45:21,240

sky and a little tiny area of the of the

1047

00:45:29,480 --> 00:45:25,200

universe and so in order to confirm and

1048

00:45:32,900 --> 00:45:29,490

and quantify these results you need to

1049

00:45:35,660 --> 00:45:32,910

look at several different places and so

1050

00:45:39,020 --> 00:45:35,670

we needed several different clusters the

1051
00:45:41,120 --> 00:45:39,030
reserve Michael Joe Vinay apparently I

1052
00:45:43,850 --> 00:45:41,130
messed up your comment it was actually a

1053
00:45:45,470 --> 00:45:43,860
question the 100 block I didn't see a

1054
00:45:47,570 --> 00:45:45,480
question mark so I read it as a comment

1055
00:45:50,360 --> 00:45:47,580
but it's yeah we did talk about that

1056
00:45:51,710 --> 00:45:50,370
early in the hangout these these

1057
00:45:52,820 --> 00:45:51,720
supermassive black holes in the early

1058
00:45:55,760 --> 00:45:52,830
universe are sort of an open question

1059
00:45:58,130 --> 00:45:55,770
but yes it is I believe something that

1060
00:45:59,450 --> 00:45:58,140
hopefully can be observed going forward

1061
00:46:04,970 --> 00:45:59,460
I'm sorry I didn't read it as a question

1062
00:46:06,260 --> 00:46:04,980
so forgive me on that so I D you it says

1063
00:46:09,440 --> 00:46:06,270

on your little thing there that you're a

1064

00:46:12,080 --> 00:46:09,450

Hubble fellow yes what is that

1065

00:46:15,530 --> 00:46:12,090

what's a Hubble fellow I just to explain

1066

00:46:17,480 --> 00:46:15,540

in a second I just urge to just say one

1067

00:46:19,990 --> 00:46:17,490

more thing about the galaxy okay fair

1068

00:46:23,000 --> 00:46:20,000

enough by all means I think we didn't

1069

00:46:25,940 --> 00:46:23,010

mention that currently to date we only

1070

00:46:29,270 --> 00:46:25,950

know of about a dozen redshift N or

1071

00:46:31,850 --> 00:46:29,280

about candidates so clearly one it and

1072

00:46:34,670 --> 00:46:31,860

each another one that we think we detect

1073

00:46:36,470 --> 00:46:34,680

is a big deal is a great thing but the

1074

00:46:39,200 --> 00:46:36,480

special thing about this one is that

1075

00:46:42,440 --> 00:46:39,210

it's much increasingly fainter

1076

00:46:44,150 --> 00:46:42,450

than all of the other candidates we

1077

00:46:47,150 --> 00:46:44,160

chose again the power of the frontier

1078

00:46:49,130 --> 00:46:47,160

fields and of lensing to really see the

1079

00:46:50,870 --> 00:46:49,140

fainter and fainter galaxies in the

1080

00:46:53,270 --> 00:46:50,880

early universe because we expect that

1081

00:46:53,990 --> 00:46:53,280

most of them are much fainter than this

1082

00:46:56,660 --> 00:46:54,000

one again

1083

00:46:58,910 --> 00:46:56,670

Wow so even even more hopefully you'll

1084

00:47:00,740 --> 00:46:58,920

be able to get even more fainter ones as

1085

00:47:02,930 --> 00:47:00,750

observations we put together so that's

1086

00:47:04,100 --> 00:47:02,940

great that way and I will be happy to

1087

00:47:05,810 --> 00:47:04,110

answer your question thank you

1088

00:47:07,700 --> 00:47:05,820

yes I want to know what a Hubble fellow

1089

00:47:09,770 --> 00:47:07,710

is I want to become want to be known as

1090

00:47:11,060 --> 00:47:09,780

that I'm a Hubble I I'm a Hubble hugger

1091

00:47:13,280 --> 00:47:11,070

but I don't think that's the same thing

1092

00:47:16,130 --> 00:47:13,290

okay I guess not

1093

00:47:18,620 --> 00:47:16,140

so basically after you know we

1094

00:47:21,980 --> 00:47:18,630

astronomers do our PhD we are looking

1095

00:47:23,990 --> 00:47:21,990

for a postdoc position which is

1096

00:47:27,080 --> 00:47:24,000

basically doing some kind of internship

1097

00:47:31,040 --> 00:47:27,090

in our field doing our own research

1098

00:47:33,830 --> 00:47:31,050

usually with a very distinguished

1099

00:47:38,330 --> 00:47:33,840

professor for example so I did my first

1100

00:47:40,070 --> 00:47:38,340

postdoc in Germany and then I worked

1101

00:47:41,720 --> 00:47:40,080

mainly with the Hubble data again

1102

00:47:44,390 --> 00:47:41,730

looking for higher chief galaxies but

1103

00:47:46,190 --> 00:47:44,400

mainly doing lensing and constructing

1104

00:47:48,020 --> 00:47:46,200

lens models and I applied for a

1105

00:47:51,380 --> 00:47:48,030

fellowship which means that you will not

1106

00:47:53,990 --> 00:47:51,390

be working under our professor but more

1107

00:47:59,090 --> 00:47:54,000

freely to do whatever you want basically

1108

00:48:01,580 --> 00:47:59,100

but hopefully using Hubble data and I'm

1109

00:48:05,770 --> 00:48:01,590

happy that I've got it and then take

1110

00:48:08,090 --> 00:48:05,780

Caltech it's a three-year term basically

1111

00:48:10,460 --> 00:48:08,100

just a salary you know to do your own

1112

00:48:13,040 --> 00:48:10,470

research with Hubble and explore the

1113

00:48:13,880 --> 00:48:13,050

things that you want to explore well it

1114

00:48:15,440 --> 00:48:13,890

sounds like you've got a bright future

1115

00:48:17,680 --> 00:48:15,450

ahead of you that's a great way to get

1116

00:48:20,570 --> 00:48:17,690

started

1117

00:48:21,680 --> 00:48:20,580

awesome okay so thanks for thanks for

1118

00:48:24,260 --> 00:48:21,690

that I just wanted to give people a

1119

00:48:26,390 --> 00:48:24,270

little little insight into some of the

1120

00:48:28,430 --> 00:48:26,400

career paths astronomers take a little

1121

00:48:29,870 --> 00:48:28,440

bit now maybe I'll get back to that in a

1122

00:48:32,090 --> 00:48:29,880

minute but I have a good question here

1123

00:48:34,820 --> 00:48:32,100

from Cecil Morgan again it goes does the

1124

00:48:38,300 --> 00:48:34,830

math does the magnification effect apply

1125

00:48:41,800 --> 00:48:38,310

uniformly across the entire en spectrum

1126
00:48:45,080 --> 00:48:41,810
that's kind of good so what can you can

1127
00:48:47,120 --> 00:48:45,090
is all radiation can it be lens yes

1128
00:48:49,370 --> 00:48:47,130
that's a great question and that's one

1129
00:48:52,460 --> 00:48:49,380
of the amazing properties of lensing

1130
00:48:54,530 --> 00:48:52,470
that it's not susceptible to the wave

1131
00:48:57,140 --> 00:48:54,540
or the color so all the colors all the

1132
00:48:58,730 --> 00:48:57,150
wavelengths no matter where you are in

1133
00:49:00,470 --> 00:48:58,740
the electromagnetic spectrum they are

1134
00:49:03,020 --> 00:49:00,480
all being lens D in the same manner

1135
00:49:05,839 --> 00:49:03,030
I'm really good as a follow-up he he's

1136
00:49:08,990 --> 00:49:05,849
asking would it be useful to point Alma

1137
00:49:11,870 --> 00:49:09,000
at it Alma is the Atacama what is it I

1138
00:49:15,080 --> 00:49:11,880

become a large malaria ray yeah it's

1139

00:49:16,430 --> 00:49:15,090

this big radio telescope high in the

1140

00:49:19,160 --> 00:49:16,440

Chilean mountains and it's got a very

1141

00:49:22,520 --> 00:49:19,170

high resolution would be useful to point

1142

00:49:24,650 --> 00:49:22,530

only at something like this I it's a

1143

00:49:27,470 --> 00:49:24,660

great idea you've got a first ask

1144

00:49:28,880 --> 00:49:27,480

whether it's observable by Alma and in

1145

00:49:29,750 --> 00:49:28,890

fact that's what I was doing while we

1146

00:49:32,990 --> 00:49:29,760

were talking there

1147

00:49:35,510 --> 00:49:33,000

I am indeed a bell 27:44 is in the

1148

00:49:40,030 --> 00:49:35,520

southern hemisphere and so you could in

1149

00:49:42,470 --> 00:49:40,040

principle point Alma at this object but

1150

00:49:45,050 --> 00:49:42,480

unfortunately even though Alma is very

1151

00:49:47,450 --> 00:49:45,060

much state of the art and the most

1152

00:49:50,810 --> 00:49:47,460

powerful radio telescope millimetre

1153

00:49:54,589 --> 00:49:50,820

radio telescope ever constructed this

1154

00:49:57,130 --> 00:49:54,599

object is so distant and so faint that I

1155

00:50:00,620 --> 00:49:57,140

I think it's beyond its capabilities

1156

00:50:03,109 --> 00:50:00,630

there have been some detections so what

1157

00:50:07,099 --> 00:50:03,119

Alma allows you to probe is the gas in a

1158

00:50:10,460 --> 00:50:07,109

galaxy and it was used to try to observe

1159

00:50:13,120 --> 00:50:10,470

an object at a redshift of about six six

1160

00:50:16,490 --> 00:50:13,130

and a half and it was detected was a

1161

00:50:19,520 --> 00:50:16,500

lens a galaxy and it was in fact

1162

00:50:22,579 --> 00:50:19,530

detected there was another object at a

1163

00:50:24,770 --> 00:50:22,589

redshift of nine that we discovered in

1164

00:50:26,960 --> 00:50:24,780

another cluster field predating the

1165

00:50:29,599 --> 00:50:26,970

Hubble frontier field and that was an

1166

00:50:33,290 --> 00:50:29,609

upper limit in other words it wasn't

1167

00:50:36,079 --> 00:50:33,300

actually detected so so it's great idea

1168

00:50:38,150 --> 00:50:36,089

and it's as astronomers we're always

1169

00:50:40,250 --> 00:50:38,160

data starved and we'll take whatever

1170

00:50:42,440 --> 00:50:40,260

data we can get but we're also limited

1171

00:50:45,079 --> 00:50:42,450

by the you know the size telescopes that

1172

00:50:46,640 --> 00:50:45,089

were able to build okay and I want to

1173

00:50:48,140 --> 00:50:46,650

follow up with one more he think he had

1174

00:50:49,820 --> 00:50:48,150

three in this little one here and I like

1175

00:50:51,260 --> 00:50:49,830

this last one too because let's talk

1176

00:50:53,930 --> 00:50:51,270

about j-dub you see just a little bit

1177

00:50:56,930 --> 00:50:53,940

how does this magnified image compared

1178

00:50:58,339 --> 00:50:56,940

to what's expected of normal JWST images

1179

00:50:59,359 --> 00:50:58,349

so this is this we were able to get

1180

00:51:02,060 --> 00:50:59,369

because of the help of this

1181

00:51:03,829 --> 00:51:02,070

gravitational lens we're gonna be seeing

1182

00:51:05,480 --> 00:51:03,839

more of these smudges and JWST does

1183

00:51:05,979 --> 00:51:05,490

anybody want to speculate what we might

1184

00:51:08,660 --> 00:51:05,989

see

1185

00:51:12,609 --> 00:51:08,670

so the expectation is that we are going

1186

00:51:15,410 --> 00:51:12,619

to see we JW's to about two or three

1187

00:51:17,180 --> 00:51:15,420

magnitudes fainter which means that

1188

00:51:20,329 --> 00:51:17,190

we're going to see many more objects

1189

00:51:22,400 --> 00:51:20,339

these red shifts and higher because

1190

00:51:24,920 --> 00:51:22,410

they're primarily it's got it's got a

1191

00:51:26,599 --> 00:51:24,930

much larger primary mirror you'll be

1192

00:51:29,630 --> 00:51:26,609

able to see way too much light higher

1193

00:51:32,509 --> 00:51:29,640

resolution and also the detectors have a

1194

00:51:33,859 --> 00:51:32,519

wider infrared wavelength right so good

1195

00:51:37,699 --> 00:51:33,869

thank you see so those rules were

1196

00:51:39,469 --> 00:51:37,709

excellent questions and let's see beta

1197

00:51:41,779 --> 00:51:39,479

flux is going this is not a question but

1198

00:51:44,150 --> 00:51:41,789

I think there has to be a supermassive

1199

00:51:45,920 --> 00:51:44,160

black hole for stars to clump together I

1200

00:51:47,779 --> 00:51:45,930

also think the supermassive black holes

1201
00:51:50,630 --> 00:51:47,789
produce super powerful magnetic field

1202
00:51:52,809 --> 00:51:50,640
lines similar to the Sun's Parker spirals

1203
00:51:56,630 --> 00:51:52,819
which in turn pushes the gas together

1204
00:51:59,239 --> 00:51:56,640
triggering star birth so he's saying

1205
00:52:01,789 --> 00:51:59,249
that pretty much has to be in order for

1206
00:52:03,499 --> 00:52:01,799
these things to form Thank You peda well

1207
00:52:05,329 --> 00:52:03,509
though we're starting to see that these

1208
00:52:09,469 --> 00:52:05,339
we you know you can get aids early

1209
00:52:12,680 --> 00:52:09,479
galaxies without those without those

1210
00:52:14,870 --> 00:52:12,690
things so okay so Scott how am i doing

1211
00:52:17,299 --> 00:52:14,880
did i did i miss to be doing great i

1212
00:52:18,859 --> 00:52:17,309
think of everything else and some of the

1213
00:52:21,829 --> 00:52:18,869

things are on twitter were actually

1214

00:52:23,630 --> 00:52:21,839

answer down there so okay well thank you

1215

00:52:25,009 --> 00:52:23,640

guys for for being active on twitter i

1216

00:52:27,439 --> 00:52:25,019

appreciate i look at all this hubble

1217

00:52:31,370 --> 00:52:27,449

hangouts that's great so thank you guys

1218

00:52:34,519 --> 00:52:31,380

for for for doing that I think what oh

1219

00:52:38,539 --> 00:52:34,529

oh hold on there's another one here beta

1220

00:52:42,170 --> 00:52:38,549

fluxes what are the equations behind

1221

00:52:44,559 --> 00:52:42,180

your shoulder Adi is that your is that

1222

00:52:49,910 --> 00:52:44,569

your latest paper your latest paper

1223

00:52:54,939 --> 00:52:49,920

let's not get them scooped now looks

1224

00:52:57,739 --> 00:52:54,949

like chicken scratch are you muted Adi

1225

00:53:01,430 --> 00:52:57,749

it's just some flux calibration nothing

1226
00:53:02,719 --> 00:53:01,440
special okay okay I thought you were

1227
00:53:07,279 --> 00:53:02,729
building a TARDIS back there or

1228
00:53:10,039 --> 00:53:07,289
something like that so John you're a

1229
00:53:12,170 --> 00:53:10,049
professor at Siena College and you said

1230
00:53:14,029 --> 00:53:12,180
it's a it's a small liberal arts school

1231
00:53:17,719 --> 00:53:14,039
did you say yeah that's right

1232
00:53:19,120 --> 00:53:17,729
so what advice do you have for people

1233
00:53:22,240 --> 00:53:19,130
looking to go into it

1234
00:53:24,460 --> 00:53:22,250
as a career what what let's say you

1235
00:53:25,480 --> 00:53:24,470
wanted to they're thinking about doing

1236
00:53:28,300 --> 00:53:25,490
it would you have anything you'd say to

1237
00:53:31,720 --> 00:53:28,310
these two young people yeah let's see so

1238
00:53:34,870 --> 00:53:31,730

I think the most important thing is just

1239

00:53:36,610 --> 00:53:34,880

to be curious innately curious and

1240

00:53:39,550 --> 00:53:36,620

interested in learning about the world

1241

00:53:42,300 --> 00:53:39,560

around you another common question I get

1242

00:53:45,160 --> 00:53:42,310

it doesn't matter what you do in college

1243

00:53:48,700 --> 00:53:45,170

if you're interested ultimately in

1244

00:53:51,520 --> 00:53:48,710

astronomy it's a career or as a path

1245

00:53:53,380 --> 00:53:51,530

that you want to take it's not as

1246

00:53:56,140 --> 00:53:53,390

important that you get an undergraduate

1247

00:53:58,000 --> 00:53:56,150

astronomy education a certainly a

1248

00:54:00,730 --> 00:53:58,010

physics education is something you want

1249

00:54:03,340 --> 00:54:00,740

to you want to have a solid grounding in

1250

00:54:06,820 --> 00:54:03,350

but I many my friends and colleagues

1251
00:54:09,970 --> 00:54:06,830
have were physics as in college and then

1252
00:54:12,820 --> 00:54:09,980
did astronomy in graduate school but if

1253
00:54:16,150 --> 00:54:12,830
you are serious about astronomy as an

1254
00:54:18,460 --> 00:54:16,160
actual career you do need to and will

1255
00:54:21,220 --> 00:54:18,470
want to get your doctorate your PhD

1256
00:54:25,030 --> 00:54:21,230
which is a long grueling process but

1257
00:54:28,090 --> 00:54:25,040
also they're rewarding another path that

1258
00:54:30,850 --> 00:54:28,100
we many of our students here at Siana

1259
00:54:33,610 --> 00:54:30,860
college take is - we have a minor in

1260
00:54:36,280 --> 00:54:33,620
astrophysics and so students will major

1261
00:54:38,260 --> 00:54:36,290
in physics minor in astrophysics maybe

1262
00:54:42,070 --> 00:54:38,270
go on and get their masters in astronomy

1263
00:54:43,570 --> 00:54:42,080

and then become educators and do you

1264

00:54:45,370 --> 00:54:43,580

know make possible the kinds of things

1265

00:54:48,130 --> 00:54:45,380

that you guys do which is bringing

1266

00:54:51,760 --> 00:54:48,140

science and science education to to the

1267

00:54:54,460 --> 00:54:51,770

greater public but in terms of the

1268

00:54:57,640 --> 00:54:54,470

academic track after as addy said after

1269

00:55:00,310 --> 00:54:57,650

graduate school you're in for like one

1270

00:55:03,400 --> 00:55:00,320

or two postdoctoral fellowships within

1271

00:55:05,890 --> 00:55:03,410

three years and and I've been lucky

1272

00:55:07,630 --> 00:55:05,900

enough to to have this faculty position

1273

00:55:10,300 --> 00:55:07,640

here at Siena I've been here this was

1274

00:55:13,180 --> 00:55:10,310

start of my third year and it's a great

1275

00:55:14,860 --> 00:55:13,190

place with fantastic students so you

1276

00:55:15,400 --> 00:55:14,870

know you're in high school and you want

1277

00:55:23,100 --> 00:55:15,410

to come visit

1278

00:55:28,030 --> 00:55:25,600

good job good job one more question and

1279

00:55:29,770 --> 00:55:28,040

they were gonna have to go Daniel Masada

1280

00:55:32,200 --> 00:55:29,780

was asking if the universe was old

1281

00:55:32,800 --> 00:55:32,210

enough would we eventually see something

1282

00:55:36,190 --> 00:55:32,810

past

1283

00:55:38,050 --> 00:55:36,200

redshifted like microwave shifted and I

1284

00:55:39,280 --> 00:55:38,060

understand this properly I guess you

1285

00:55:40,750 --> 00:55:39,290

know for example the microwave

1286

00:55:44,860 --> 00:55:40,760

background radiation that we see is

1287

00:55:46,390 --> 00:55:44,870

basically the redshifted remnants of the

1288

00:55:49,150 --> 00:55:46,400

radiation from the Big Bang itself

1289

00:55:51,610 --> 00:55:49,160

correct so if so what happens when it

1290

00:55:57,310 --> 00:55:51,620

gets older well it will it go past the

1291

00:55:57,580 --> 00:55:57,320

microwave yeah I mean I can I can answer

1292

00:56:00,820 --> 00:55:57,590

that

1293

00:56:02,920 --> 00:56:00,830

going back to my auditorium analogy so

1294

00:56:04,690 --> 00:56:02,930

as you look further and further back the

1295

00:56:06,970 --> 00:56:04,700

individuals in the audience get younger

1296

00:56:08,560 --> 00:56:06,980

and younger but then way back in the

1297

00:56:10,690 --> 00:56:08,570

back of the auditorium what you would

1298

00:56:14,260 --> 00:56:10,700

see is this faint glow and that's the

1299

00:56:18,160 --> 00:56:14,270

Cosmic Microwave Background this thermal

1300

00:56:20,170 --> 00:56:18,170

relic of the Big Bang and the you can

1301
00:56:21,790 --> 00:56:20,180
measure you can actually predict the

1302
00:56:23,950 --> 00:56:21,800
redshift of the Cosmic Microwave

1303
00:56:28,300 --> 00:56:23,960
Background and it's at a redshift of

1304
00:56:30,520 --> 00:56:28,310
about 1100 or about a thousand but we

1305
00:56:34,900 --> 00:56:30,530
really can't see beyond that it's like

1306
00:56:37,780 --> 00:56:34,910
an opaque screen beyond which pass that

1307
00:56:39,580 --> 00:56:37,790
photons never light never traveled in a

1308
00:56:44,400 --> 00:56:39,590
straight line and so we'll never be able

1309
00:56:48,370 --> 00:56:44,410
to see with light beyond that beyond the

1310
00:56:50,380 --> 00:56:48,380
surface that surface is the furthest

1311
00:56:52,990 --> 00:56:50,390
back we can see it but it's also it as

1312
00:56:54,400 --> 00:56:53,000
the universe is expanding is also still

1313
00:56:57,430 --> 00:56:54,410

shifting back so that's a good question

1314

00:56:59,170 --> 00:56:57,440

on Daniel appreciate that okay guys I

1315

00:57:01,570 --> 00:56:59,180

guess we'll stop there we're at about an

1316

00:57:03,190 --> 00:57:01,580

hour thank you this was really great

1317

00:57:04,990 --> 00:57:03,200

this was really exciting thanks to both

1318

00:57:06,640 --> 00:57:05,000

of you Adi and John of her for being on

1319

00:57:08,380 --> 00:57:06,650

our hangout and talking to us about

1320

00:57:10,150 --> 00:57:08,390

distant galaxies we'll hope you'll come

1321

00:57:12,550 --> 00:57:10,160

back when you get more galaxies

1322

00:57:14,590 --> 00:57:12,560

discovered sure thank you all for

1323

00:57:16,540 --> 00:57:14,600

organizing these and all the viewers for

1324

00:57:18,180 --> 00:57:16,550

asking great questions thanks a lot

1325

00:57:20,440 --> 00:57:18,190

yeah thanks for this great opportunity

1326

00:57:23,470 --> 00:57:20,450

all right well thank you both and we'll

1327

00:57:26,080 --> 00:57:23,480

all right we looking for Carol and I to

1328

00:57:28,120 --> 00:57:26,090

contact you on on maybe doing some more

1329

00:57:29,920 --> 00:57:28,130

of these so thank you very much

1330

00:57:32,770 --> 00:57:29,930

I guess that's it for this this

1331

00:57:34,540 --> 00:57:32,780

go-around guys next week we're gonna be

1332

00:57:36,790 --> 00:57:34,550

skipping because of the Thanksgiving

1333

00:57:38,680 --> 00:57:36,800

holiday here in the United States so we

1334

00:57:41,950 --> 00:57:38,690

will not have a hangout next week but

1335

00:57:44,860 --> 00:57:41,960

the week after that the in two weeks we

1336

00:57:46,130 --> 00:57:44,870

will be back well hopefully with John

1337

00:57:48,559 --> 00:57:46,140

Davis and

1338

00:57:51,200 --> 00:57:48,569

a colleague to talk about debris disks

1339

00:57:53,420 --> 00:57:51,210

around stars and apparently there's a

1340

00:57:55,670 --> 00:57:53,430

difference between a debris disc and a

1341

00:57:57,740 --> 00:57:55,680

dust disc and a protoplanetary disc

1342

00:57:58,789 --> 00:57:57,750

those all have different reading no

1343

00:58:00,650 --> 00:57:58,799

those are they're all different they're

1344

00:58:02,210 --> 00:58:00,660

not the same so be careful what you call

1345

00:58:06,519 --> 00:58:02,220

them we're gonna be talking about debris

1346

00:58:09,589 --> 00:58:06,529

disks in two weeks right Carol yep okay

1347

00:58:11,019 --> 00:58:09,599

Scott awesome thank good driving I

1348

00:58:13,849 --> 00:58:11,029

appreciate that

1349

00:58:16,490 --> 00:58:13,859

absolutely all right everybody well