

1  
00:00:04,940 --> 00:00:09,809  
hello everybody and welcome to this

2  
00:00:07,318 --> 00:00:11,669  
week's Hubble hangout my name is Tony

3  
00:00:09,808 --> 00:00:13,468  
Darnell I work at the Space Telescope

4  
00:00:11,669 --> 00:00:16,048  
Science Center and this week we've got a

5  
00:00:13,468 --> 00:00:17,550  
really interesting hangout plan we're

6  
00:00:16,048 --> 00:00:20,278  
going to be talking about frontier

7  
00:00:17,550 --> 00:00:23,609  
fields data gravitational lensing and

8  
00:00:20,278 --> 00:00:25,410  
distant galaxies and so we're gonna be

9  
00:00:23,609 --> 00:00:26,849  
when we've got some scientists here with

10  
00:00:25,410 --> 00:00:28,618  
us who are some astronomers who've been

11  
00:00:26,849 --> 00:00:31,198  
using this Hubble data and have made an

12  
00:00:28,618 --> 00:00:33,960  
interesting discovery which we will talk

13  
00:00:31,199 --> 00:00:36,960  
about at length in just a bit but before

14  
00:00:33,960 --> 00:00:39,410  
I get started I'm gonna let Scott Lewis

15  
00:00:36,960 --> 00:00:42,929  
my cohort here he's driving the internet

16  
00:00:39,409 --> 00:00:44,218  
easily Archie we would we hope that

17  
00:00:42,929 --> 00:00:45,329  
during the course of this hangout you

18  
00:00:44,219 --> 00:00:47,609  
will give us your comments and questions

19  
00:00:45,329 --> 00:00:50,549  
and Scott please tell them how they may

20  
00:00:47,609 --> 00:00:53,429  
do that all over the place first of all

21  
00:00:50,549 --> 00:00:57,288  
Tony you work at the Space Telescope

22  
00:00:53,429 --> 00:01:00,719  
Science Institute not Science Center Oh

23  
00:00:57,289 --> 00:01:03,019  
yesterday but if you just clarifying

24  
00:01:00,719 --> 00:01:05,159  
that for you all right

25  
00:01:03,018 --> 00:01:07,259  
most likely you're watching this on

26  
00:01:05,159 --> 00:01:09,600  
youtube right now so in the bottom left

27  
00:01:07,260 --> 00:01:12,330  
you'll see in some yellow text there

28  
00:01:09,599 --> 00:01:15,059  
that allow you to open up a Q&A app you

29

00:01:12,329 --> 00:01:16,650  
can actually ask those questions live so

30  
00:01:15,060 --> 00:01:19,170  
we'll be able to select them as we go in

31  
00:01:16,650 --> 00:01:20,330  
and Carols here which are there even

32  
00:01:19,170 --> 00:01:24,509  
better

33  
00:01:20,329 --> 00:01:26,310  
it also uses on Google s and you can

34  
00:01:24,509 --> 00:01:28,219  
leave us comments and questions on the

35  
00:01:26,310 --> 00:01:30,930  
event page and the regular YouTube and

36  
00:01:28,219 --> 00:01:34,590  
on top of it all if you were on Twitter

37  
00:01:30,930 --> 00:01:36,060  
use the Hubble hangout hashtag I'll be

38  
00:01:34,590 --> 00:01:38,310  
monitoring that and tweeting things up

39  
00:01:36,060 --> 00:01:40,618  
as Hubble telescope with some of the

40  
00:01:38,310 --> 00:01:43,469  
awesome pictures and updates as we're

41  
00:01:40,618 --> 00:01:46,649  
going along that is known as a plethora

42  
00:01:43,469 --> 00:01:49,438  
of ways to interact in us throw so

43  
00:01:46,649 --> 00:01:52,500

believable cornucopia of information was

44

00:01:49,438 --> 00:01:55,589

just convinced it was all over the place

45

00:01:52,500 --> 00:01:58,200

oh and just joining us is also a regular

46

00:01:55,590 --> 00:01:59,460

with is dr. Carol Christian she's the

47

00:01:58,200 --> 00:02:01,649

outreach scientist for the Hubble Space

48

00:01:59,459 --> 00:02:05,728

Telescope almost we were worried about

49

00:02:01,649 --> 00:02:07,920

you Carol welcome thanks just I'm not in

50

00:02:05,728 --> 00:02:09,840

charge of the internet Scott is so yeah

51

00:02:07,920 --> 00:02:11,789

I know he drives that he drives that

52

00:02:09,840 --> 00:02:14,090

thing so I don't know what what he was

53

00:02:11,789 --> 00:02:14,090

doing

54

00:02:15,098 --> 00:02:20,628

okay before we get started I want to

55

00:02:17,120 --> 00:02:23,269

give a quick shout out to a staff member

56

00:02:20,628 --> 00:02:26,598

a colleague at the Institute not the

57

00:02:23,269 --> 00:02:28,670

center dr. Jason Calorie who has made an

58  
00:02:26,598 --> 00:02:31,189  
academic minute back in July that was

59  
00:02:28,669 --> 00:02:33,559  
all about exoplanets and it turns out

60  
00:02:31,189 --> 00:02:35,419  
his it's an audio it's an audio podcast

61  
00:02:33,560 --> 00:02:37,670  
little thingy and it was on it's on

62  
00:02:35,419 --> 00:02:40,789  
academic minute org and there is a link

63  
00:02:37,669 --> 00:02:42,559  
in the event description box which will

64  
00:02:40,789 --> 00:02:44,150  
which if you click on it you can show

65  
00:02:42,560 --> 00:02:45,799  
your support because he's up for a

66  
00:02:44,150 --> 00:02:47,539  
listeners Choice Award so we're like

67  
00:02:45,799 --> 00:02:49,819  
we'd like you to show your support if

68  
00:02:47,539 --> 00:02:52,578  
you would think it is a good enough

69  
00:02:49,818 --> 00:02:56,089  
podcast and vote for dr. Jason calorie

70  
00:02:52,579 --> 00:02:57,920  
so I would appreciate that okay so let's

71  
00:02:56,090 --> 00:03:00,860  
get started with today's hangout distant

72  
00:02:57,919 --> 00:03:03,018  
galaxies and frontier fields and

73  
00:03:00,860 --> 00:03:06,590  
gravitational lensing with me to talk

74  
00:03:03,019 --> 00:03:09,590  
about these is IDs it Rijn he's a NASA

75  
00:03:06,590 --> 00:03:13,340  
Hubble fellow at Caltech a high iodine

76  
00:03:09,590 --> 00:03:15,560  
welcome also is John Moustakas he's the

77  
00:03:13,340 --> 00:03:18,009  
he's a astronomer and a faculty member

78  
00:03:15,560 --> 00:03:20,509  
at Siena College where is that John

79  
00:03:18,009 --> 00:03:22,750  
Siena College is a small liberal arts

80  
00:03:20,509 --> 00:03:25,818  
school and upstate New York near Albany

81  
00:03:22,750 --> 00:03:29,180  
awesome and so we welcome to both of you

82  
00:03:25,818 --> 00:03:31,089  
guys and we'll let's let's let's go

83  
00:03:29,180 --> 00:03:35,180  
ahead and let's talk a little bit about

84  
00:03:31,090 --> 00:03:37,219  
what you are working on and and what you

85  
00:03:35,180 --> 00:03:40,010  
have found so there's a link also guys

86

00:03:37,219 --> 00:03:41,689  
in the description box of the event to a

87  
00:03:40,009 --> 00:03:43,429  
press release that came out last month

88  
00:03:41,689 --> 00:03:46,639  
and add why don't you describe to us

89  
00:03:43,430 --> 00:03:52,459  
what that press release was about okay

90  
00:03:46,639 --> 00:03:54,319  
first of all hi so let's start with a

91  
00:03:52,459 --> 00:03:56,450  
little bit of background we want to know

92  
00:03:54,318 --> 00:03:58,280  
how the universe evolves how galaxies

93  
00:03:56,449 --> 00:04:00,168  
form and how they evolve into the

94  
00:03:58,280 --> 00:04:02,629  
galaxies that we see today so one of the

95  
00:04:00,169 --> 00:04:05,870  
goals basically is looking for the most

96  
00:04:02,629 --> 00:04:09,409  
distant galaxies the very young in the

97  
00:04:05,870 --> 00:04:10,849  
early universe galaxies so we're trying

98  
00:04:09,409 --> 00:04:14,659  
to do to exploit the lens magnification

99  
00:04:10,848 --> 00:04:17,060  
of galaxy clusters which have a lot very

100  
00:04:14,659 --> 00:04:19,069

high density and a lot of gravity so the

101

00:04:17,060 --> 00:04:21,620

form gravitational lenses in the sky

102

00:04:19,069 --> 00:04:23,418

they help us magnify the background we

103

00:04:21,620 --> 00:04:25,939

look at them in order to find a very

104

00:04:23,418 --> 00:04:27,199

high redshift galaxy so in this paper we

105

00:04:25,939 --> 00:04:30,560

found one of the most

106

00:04:27,199 --> 00:04:32,120

hyah stretch of the galaxy is known and

107

00:04:30,560 --> 00:04:34,280

the interesting thing about this galaxy

108

00:04:32,120 --> 00:04:36,590

is not only that it's one of the

109

00:04:34,279 --> 00:04:38,659

highest-rated ones it's also being a

110

00:04:36,589 --> 00:04:42,109

multiply image by the cluster so we see

111

00:04:38,660 --> 00:04:43,640

it several times oh I can yeah I can't

112

00:04:42,110 --> 00:04:45,170

wait to show we're gonna we're gonna go

113

00:04:43,639 --> 00:04:47,149

back to that in just a minute and well

114

00:04:45,170 --> 00:04:49,670

actually let's go ahead Scott it's got



115  
00:04:47,149 --> 00:04:50,959  
an image up now and why don't you why

116  
00:04:49,670 --> 00:04:56,360  
don't you describe what we're looking at

117  
00:04:50,959 --> 00:04:58,870  
there okay so in the image the squares

118  
00:04:56,360 --> 00:05:01,699  
that show a B and C are the three

119  
00:04:58,870 --> 00:05:03,500  
appearances of the same galaxies that

120  
00:05:01,699 --> 00:05:05,599  
are being lens and magnified by this

121  
00:05:03,500 --> 00:05:07,610  
cluster so remember that the

122  
00:05:05,600 --> 00:05:09,290  
magnification by by the cluster is what

123  
00:05:07,610 --> 00:05:12,379  
helps us see that far to the edge of

124  
00:05:09,290 --> 00:05:14,240  
edge of the universe basically and it

125  
00:05:12,379 --> 00:05:16,550  
also multiplies the image so we see

126  
00:05:14,240 --> 00:05:18,110  
several times now the interesting thing

127  
00:05:16,550 --> 00:05:20,259  
about these data see is that the

128  
00:05:18,110 --> 00:05:23,300  
distances between a B and C

129  
00:05:20,259 --> 00:05:25,550  
independently tell us what distance of

130  
00:05:23,300 --> 00:05:28,160  
these galaxies so we don't just guess

131  
00:05:25,550 --> 00:05:30,530  
according to its colors or dimness how

132  
00:05:28,160 --> 00:05:32,900  
far away it is but also the distances

133  
00:05:30,529 --> 00:05:35,199  
between a B and C tell us independently

134  
00:05:32,899 --> 00:05:37,069  
that it is really in the early universe

135  
00:05:35,199 --> 00:05:38,569  
awesome okay well I'm gonna get to how

136  
00:05:37,069 --> 00:05:40,639  
you know that in just a minute also how

137  
00:05:38,569 --> 00:05:43,759  
you know that that little smudge is the

138  
00:05:40,639 --> 00:05:45,289  
same exact galaxy but we wish you'd

139  
00:05:43,759 --> 00:05:47,329  
probably take a step back and talk a

140  
00:05:45,290 --> 00:05:49,340  
little so that's the punchline they

141  
00:05:47,329 --> 00:05:53,060  
found them one of the most distant

142  
00:05:49,339 --> 00:05:55,219  
galaxies in the universe and but they

143

00:05:53,060 --> 00:05:57,100  
did it with kind of a little bit of a

144  
00:05:55,220 --> 00:05:59,660  
cheat now you're using something called

145  
00:05:57,100 --> 00:06:02,180  
frontier fields data and frontier fields

146  
00:05:59,660 --> 00:06:04,310  
is a project that we've talked about

147  
00:06:02,180 --> 00:06:06,110  
many times on these hangouts where there

148  
00:06:04,310 --> 00:06:08,120  
are imaging galaxy clusters and they're

149  
00:06:06,110 --> 00:06:10,490  
hoping to boost the but we're not hoping

150  
00:06:08,120 --> 00:06:12,230  
they're using the power of gravitational

151  
00:06:10,490 --> 00:06:14,629  
lenses to sort of boost the power of

152  
00:06:12,230 --> 00:06:18,050  
Hubble and see things that Hubble

153  
00:06:14,629 --> 00:06:19,430  
ordinarily wouldn't be able to see if

154  
00:06:18,050 --> 00:06:23,389  
they were just trying to look at it

155  
00:06:19,430 --> 00:06:25,189  
without the gravitational lens so maybe

156  
00:06:23,389 --> 00:06:26,810  
this would be some a good a good thing

157  
00:06:25,189 --> 00:06:28,519

for Carroll to give us a little

158

00:06:26,810 --> 00:06:31,129

introduction into can you talk a little

159

00:06:28,519 --> 00:06:32,740

bit about what frontier fields is doing

160

00:06:31,129 --> 00:06:36,829

and what they're hoping to accomplish

161

00:06:32,740 --> 00:06:38,810

sure so in the history of the Hubble

162

00:06:36,829 --> 00:06:41,000

Space Telescope we've had a number of

163

00:06:38,810 --> 00:06:43,759

initiatives that were taken on by the

164

00:06:41,000 --> 00:06:45,129

Observatory itself as we've talked about

165

00:06:43,759 --> 00:06:48,319

before

166

00:06:45,129 --> 00:06:50,629

astronomers throughout the world

167

00:06:48,319 --> 00:06:53,089

actually apply for time to use the

168

00:06:50,629 --> 00:06:56,569

telescope for specific research purposes

169

00:06:53,089 --> 00:06:58,339

the observatory also under the auspices

170

00:06:56,569 --> 00:07:02,240

of the director sometimes takes on

171

00:06:58,339 --> 00:07:04,549

projects that will need a lot of

172  
00:07:02,240 --> 00:07:07,129  
observing time and also will serve a big

173  
00:07:04,550 --> 00:07:09,290  
community and in the past some of those

174  
00:07:07,129 --> 00:07:10,819  
have been the Hubble Deep Field so there

175  
00:07:09,290 --> 00:07:12,560  
have been several Hubble Deep fields

176  
00:07:10,819 --> 00:07:14,540  
where the telescope is used for many

177  
00:07:12,560 --> 00:07:16,939  
many days just to stare at a small

178  
00:07:14,540 --> 00:07:19,189  
portion of the sky so the newest

179  
00:07:16,939 --> 00:07:22,699  
initiative is called frontier fields and

180  
00:07:19,189 --> 00:07:25,490  
the idea with frontier fields is we've

181  
00:07:22,699 --> 00:07:28,668  
tried to look back very far just by

182  
00:07:25,490 --> 00:07:30,590  
staring at part of the sky for a very

183  
00:07:28,668 --> 00:07:32,930  
long time to go fainter and fainter and

184  
00:07:30,589 --> 00:07:37,549  
fainter the idea behind frontier fields

185  
00:07:32,930 --> 00:07:39,918  
is to use a cosmic effect called a

186  
00:07:37,550 --> 00:07:41,870  
gravitational lens and so we use an

187  
00:07:39,918 --> 00:07:45,649  
additional lens which is caused by

188  
00:07:41,870 --> 00:07:48,019  
gravity to magnify objects that are

189  
00:07:45,649 --> 00:07:50,209  
behind the lens well what is this lens

190  
00:07:48,019 --> 00:07:53,120  
the lens is actually a cluster of

191  
00:07:50,209 --> 00:07:55,579  
galaxies that has a lot of mass and the

192  
00:07:53,120 --> 00:07:58,399  
mass itself distorts the light and

193  
00:07:55,579 --> 00:08:02,469  
magnifies it so it creates multiple

194  
00:07:58,399 --> 00:08:06,199  
images and also magnified images of

195  
00:08:02,470 --> 00:08:09,830  
galaxies further away so in this way we

196  
00:08:06,199 --> 00:08:13,159  
can reach much further away than we can

197  
00:08:09,829 --> 00:08:15,289  
if we just stare at the sky without one

198  
00:08:13,160 --> 00:08:18,710  
of these lenses in place the idea is to

199  
00:08:15,290 --> 00:08:21,290  
use this cosmic trick to see even deeper

200

00:08:18,709 --> 00:08:23,449  
into space and now there's an

201  
00:08:21,290 --> 00:08:27,860  
illustration of that a little movie of

202  
00:08:23,449 --> 00:08:29,629  
how a distant object the light comes

203  
00:08:27,860 --> 00:08:34,460  
from it ordinarily would come straight

204  
00:08:29,629 --> 00:08:37,279  
to us would be too faint is is acted

205  
00:08:34,460 --> 00:08:40,969  
upon by this cosmic lens it sometimes is

206  
00:08:37,279 --> 00:08:44,000  
shredded into arcs and and distorted but

207  
00:08:40,969 --> 00:08:46,610  
nonetheless it is a way of reaching very

208  
00:08:44,000 --> 00:08:49,279  
deep deeper than we ever have before and

209  
00:08:46,610 --> 00:08:51,110  
it also gives us a little teaser on what

210  
00:08:49,279 --> 00:08:54,769  
mean we might see with the James Webb

211  
00:08:51,110 --> 00:08:56,959  
telescope after 2018 right

212  
00:08:54,769 --> 00:08:58,578  
so Scott's showing one of the neatest

213  
00:08:56,958 --> 00:09:00,438  
little illustrations of what you were

214  
00:08:58,578 --> 00:09:04,338

just talking about Carol and as you can

215

00:09:00,438 --> 00:09:06,230

see this lens this galaxy cluster the

216

00:09:04,339 --> 00:09:09,050

mass from that is what is causing the

217

00:09:06,230 --> 00:09:10,808

the lens itself and so we're able to see

218

00:09:09,049 --> 00:09:14,178

things or Hubble is able to see things

219

00:09:10,808 --> 00:09:18,318

other than then otherwise wouldn't so

220

00:09:14,178 --> 00:09:20,509

right six clusters and we have now on

221

00:09:18,318 --> 00:09:22,789

behalf of the community observed three

222

00:09:20,509 --> 00:09:24,470

of them the team at space telescope

223

00:09:22,789 --> 00:09:27,198

works very hard to calibrate that data

224

00:09:24,470 --> 00:09:29,119

very carefully and then it's put out to

225

00:09:27,198 --> 00:09:31,669

the community so the entire community

226

00:09:29,119 --> 00:09:34,459

can yeah and that's something that's

227

00:09:31,669 --> 00:09:36,618

worth mentioning most Hubble data sort

228

00:09:34,458 --> 00:09:38,599

of have a little bit of a an embargo



229  
00:09:36,619 --> 00:09:40,670  
period so the scientists that asked for

230  
00:09:38,600 --> 00:09:42,048  
Hubble time can take some time to you

231  
00:09:40,669 --> 00:09:44,448  
know analyze their data before that's

232  
00:09:42,048 --> 00:09:45,919  
made public this isn't it's not true for

233  
00:09:44,448 --> 00:09:47,868  
frontier fields data it's been made

234  
00:09:45,919 --> 00:09:50,028  
available right away to the community

235  
00:09:47,869 --> 00:09:51,139  
the science community and in fact we're

236  
00:09:50,028 --> 00:09:52,278  
gonna talk about this in a little bit

237  
00:09:51,139 --> 00:09:54,709  
there was you know there was a workshop

238  
00:09:52,278 --> 00:09:56,328  
just last week that highlighted all of

239  
00:09:54,708 --> 00:09:58,609  
the science that's being done with this

240  
00:09:56,328 --> 00:10:01,368  
data as the community get it right away

241  
00:09:58,610 --> 00:10:04,850  
so John Moustakas let me let me ask you

242  
00:10:01,369 --> 00:10:07,369  
a question the the the galaxy that you

243  
00:10:04,850 --> 00:10:10,730  
found ahead of as Adi said was a very

244  
00:10:07,369 --> 00:10:13,339  
high redshift galaxy can you give us a

245  
00:10:10,730 --> 00:10:15,139  
brief description of what is meant by

246  
00:10:13,339 --> 00:10:17,240  
redshift right now I think this

247  
00:10:15,139 --> 00:10:20,959  
particular galaxy was a redshift of

248  
00:10:17,240 --> 00:10:23,720  
about ten correct that's right yeah I

249  
00:10:20,958 --> 00:10:26,028  
actually I just learned a really nice

250  
00:10:23,720 --> 00:10:29,240  
analogy that describes this so that the

251  
00:10:26,028 --> 00:10:30,828  
first important point is that and one of

252  
00:10:29,240 --> 00:10:33,678  
the most important discoveries of at

253  
00:10:30,828 --> 00:10:36,588  
least the last century is the fact that

254  
00:10:33,678 --> 00:10:42,259  
the universe isn't static it doesn't I

255  
00:10:36,589 --> 00:10:44,240  
it's not it changes in other words the

256  
00:10:42,259 --> 00:10:47,058  
universe is expanding so when we look at

257

00:10:44,240 --> 00:10:52,428  
galaxies around us we see that they're

258  
00:10:47,058 --> 00:10:54,409  
moving all moving away from us and the

259  
00:10:52,428 --> 00:10:55,938  
way that movement away from us that

260  
00:10:54,409 --> 00:10:58,668  
expansion of the universe is using this

261  
00:10:55,938 --> 00:10:59,958  
concept called red jet and so the way to

262  
00:10:58,668 --> 00:11:01,519  
think about it is imagine you're

263  
00:10:59,958 --> 00:11:06,109  
standing at the front of an auditorium

264  
00:11:01,519 --> 00:11:08,409  
and you have a seat full of odd members

265  
00:11:06,110 --> 00:11:10,639  
what you would see is that

266  
00:11:08,409 --> 00:11:12,709  
it would be like looking out at the

267  
00:11:10,639 --> 00:11:15,019  
auditorium and seeing that the people

268  
00:11:12,710 --> 00:11:17,120  
sitting in front were the oldest people

269  
00:11:15,019 --> 00:11:19,909  
and then as you looked at further and

270  
00:11:17,120 --> 00:11:21,799  
further people further and back towards

271  
00:11:19,909 --> 00:11:23,209

the back of the auditorium they looked

272

00:11:21,799 --> 00:11:26,000

like they were getting younger and

273

00:11:23,210 --> 00:11:27,350

younger and younger oh I want to be in

274

00:11:26,000 --> 00:11:28,879

the backseat then I want to be in the

275

00:11:27,350 --> 00:11:32,450

background yeah right

276

00:11:28,879 --> 00:11:34,009

and and then at the same time what you

277

00:11:32,450 --> 00:11:35,810

would see if you were just looking at

278

00:11:34,009 --> 00:11:37,789

these people is that the people in the

279

00:11:35,809 --> 00:11:41,839

front would be you know slightly pink

280

00:11:37,789 --> 00:11:43,309

and then as you look at people product

281

00:11:41,840 --> 00:11:45,920

they would get redder and redder and

282

00:11:43,309 --> 00:11:50,079

redder and grosser and rosy and rosier

283

00:11:45,919 --> 00:11:52,299

and the those two ideas there are

284

00:11:50,080 --> 00:11:55,550

essentially what we're trying to do with

285

00:11:52,299 --> 00:11:57,979

with with trying to find the youngest

286  
00:11:55,549 --> 00:12:00,859  
galaxies or the first galaxies to have

287  
00:11:57,980 --> 00:12:03,259  
formed so people are getting redder

288  
00:12:00,860 --> 00:12:05,240  
because as the universe expands it

289  
00:12:03,259 --> 00:12:08,299  
actually stretches the wavelength of

290  
00:12:05,240 --> 00:12:10,129  
light and pushes it towards redder

291  
00:12:08,299 --> 00:12:13,129  
wavelengths so that's why we call this a

292  
00:12:10,129 --> 00:12:17,299  
redshift and the amount that the light

293  
00:12:13,129 --> 00:12:18,950  
gets redshift is based on how far away

294  
00:12:17,299 --> 00:12:22,579  
it is so the further something is the

295  
00:12:18,950 --> 00:12:24,860  
more it's like it's red shifted and the

296  
00:12:22,580 --> 00:12:27,950  
reason your audience members in your

297  
00:12:24,860 --> 00:12:30,680  
hypothetical lecture here are getting

298  
00:12:27,950 --> 00:12:33,290  
younger is because it takes a finite

299  
00:12:30,679 --> 00:12:35,659  
amount of time for light to reach our

300  
00:12:33,289 --> 00:12:38,959  
eyes so but if you look at someone

301  
00:12:35,659 --> 00:12:40,579  
across the room there it takes about a

302  
00:12:38,960 --> 00:12:43,070  
billionth of a second for the light

303  
00:12:40,580 --> 00:12:45,080  
coming off of them to reach your eyes we

304  
00:12:43,070 --> 00:12:46,970  
will look at the Sun the sun's about 8

305  
00:12:45,080 --> 00:12:48,860  
light minutes away so you're actually

306  
00:12:46,970 --> 00:12:52,129  
looking at the Sun the way it appeared

307  
00:12:48,860 --> 00:12:54,200  
eight minutes ago and so as you look at

308  
00:12:52,129 --> 00:12:58,220  
more and more distant objects you've

309  
00:12:54,200 --> 00:13:01,280  
seen the way they looked a long time ago

310  
00:12:58,220 --> 00:13:04,269  
and so so that's that's the other effect

311  
00:13:01,279 --> 00:13:07,069  
that we were able to use to try to probe

312  
00:13:04,269 --> 00:13:09,169  
and understand how galaxies looked like

313  
00:13:07,070 --> 00:13:11,000  
in the past that is a good analogy I'd

314

00:13:09,169 --> 00:13:12,769  
never heard that before now - you need

315  
00:13:11,000 --> 00:13:15,919  
to continue with that analogy one other

316  
00:13:12,769 --> 00:13:19,519  
component to it is that the auditorium

317  
00:13:15,919 --> 00:13:22,309  
itself is also getting larger right so

318  
00:13:19,519 --> 00:13:23,899  
so while that's going on

319  
00:13:22,309 --> 00:13:25,189  
the auditorium is getting bigger so

320  
00:13:23,899 --> 00:13:26,929  
there's another component to that

321  
00:13:25,190 --> 00:13:29,060  
there's a lots of different distances

322  
00:13:26,929 --> 00:13:30,969  
that people use and one of the things

323  
00:13:29,059 --> 00:13:34,579  
that I read was a Ned Wright a

324  
00:13:30,970 --> 00:13:38,480  
cosmologists had a great has a great web

325  
00:13:34,580 --> 00:13:41,420  
page on how to count distances in the

326  
00:13:38,480 --> 00:13:42,759  
universe using redshift and thinking

327  
00:13:41,419 --> 00:13:45,620  
wrote was that it's probably a bad idea

328  
00:13:42,759 --> 00:13:47,960

for the press to start reporting these

329

00:13:45,620 --> 00:13:50,778

distances in light travel time because

330

00:13:47,960 --> 00:13:53,000

there's so much more involved over yes

331

00:13:50,778 --> 00:13:56,720

we may be looking at a galaxy when the

332

00:13:53,000 --> 00:14:00,169

universe was a billion years old but you

333

00:13:56,720 --> 00:14:02,720

know in the twelve or so billion ye here

334

00:14:00,169 --> 00:14:04,699

I'm the universe is also expanded and so

335

00:14:02,720 --> 00:14:06,620

the actual distance to that galaxy is

336

00:14:04,700 --> 00:14:08,930

best expressed in that in that redshift

337

00:14:06,620 --> 00:14:12,259

number you were talking about more so

338

00:14:08,929 --> 00:14:13,519

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

339

00:14:12,259 --> 00:14:14,649

an interesting idea different an

340

00:14:13,519 --> 00:14:17,480

interesting concept

341

00:14:14,649 --> 00:14:21,319

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

342

00:14:17,480 --> 00:14:23,690

redshift is now this particular galaxy



343  
00:14:21,320 --> 00:14:26,930  
is redshift about equal 10 the universe

344  
00:14:23,690 --> 00:14:29,240  
was roughly how old when when when this

345  
00:14:26,929 --> 00:14:32,989  
galaxy when the light left this galaxy

346  
00:14:29,240 --> 00:14:36,409  
so did the galaxy sorry the universe was

347  
00:14:32,990 --> 00:14:39,740  
about 450 million years which is only

348  
00:14:36,409 --> 00:14:43,429  
about 3 to 4% of its current age so in

349  
00:14:39,740 --> 00:14:44,690  
size that's really soon yeah so the

350  
00:14:43,429 --> 00:14:46,338  
reason I asked you that was because I

351  
00:14:44,690 --> 00:14:48,830  
have a comment here on YouTube that I

352  
00:14:46,339 --> 00:14:50,570  
want to get to right away it says for

353  
00:14:48,830 --> 00:14:52,520  
this is from tangent creative on YouTube

354  
00:14:50,570 --> 00:14:55,040  
he goes does this mean galaxies formed

355  
00:14:52,519 --> 00:14:58,429  
very quickly after the Big Bang I mean

356  
00:14:55,039 --> 00:14:59,659  
real fast I mean 400,000 what is a 400

357  
00:14:58,429 --> 00:15:02,629  
million years or so that's pretty quick

358  
00:14:59,659 --> 00:15:05,000  
that's pretty quick that's pretty quick

359  
00:15:02,629 --> 00:15:06,439  
and actually we at least miracle

360  
00:15:05,000 --> 00:15:08,990  
simulations we don't observe these

361  
00:15:06,440 --> 00:15:10,820  
galaxies yet but predicted they have

362  
00:15:08,990 --> 00:15:14,120  
started forming even a bit earlier so

363  
00:15:10,820 --> 00:15:16,010  
they started forming at about probably

364  
00:15:14,120 --> 00:15:17,929  
the guess is a hundred million years

365  
00:15:16,009 --> 00:15:19,069  
after the Big Bang and this is really

366  
00:15:17,929 --> 00:15:20,958  
fast yes that's

367  
00:15:19,070 --> 00:15:23,870  
Wow that that that quickly that that's

368  
00:15:20,958 --> 00:15:26,599  
pretty that's pretty pretty fast so John

369  
00:15:23,870 --> 00:15:28,990  
this particular galaxy what does that

370  
00:15:26,600 --> 00:15:31,879  
red smudge that we looked at earlier

371

00:15:28,990 --> 00:15:33,649  
tell you what what what what do you know

372  
00:15:31,879 --> 00:15:36,139  
about this galaxy based on that little

373  
00:15:33,649 --> 00:15:41,480  
red dot yeah it's a great question I

374  
00:15:36,139 --> 00:15:43,429  
wish we could infer more we we can say a

375  
00:15:41,480 --> 00:15:45,620  
few things about the object what's

376  
00:15:43,429 --> 00:15:50,359  
really amazing is that as Carol

377  
00:15:45,620 --> 00:15:51,740  
described an object this faint would not

378  
00:15:50,360 --> 00:15:54,769  
have been found

379  
00:15:51,740 --> 00:15:56,600  
in just a blank part of the sky so if

380  
00:15:54,769 --> 00:15:59,929  
you had just taken Hubble and just

381  
00:15:56,600 --> 00:16:03,860  
pointed it at a same part of the sky and

382  
00:15:59,929 --> 00:16:06,469  
just collect difficult and just collected

383  
00:16:03,860 --> 00:16:09,230  
photons the way has been done in past

384  
00:16:06,470 --> 00:16:11,360  
efforts with the Hubble Deep fields for

385  
00:16:09,230 --> 00:16:14,450

example you would not have found this

386

00:16:11,360 --> 00:16:18,950

galaxy so just thinking about how faint

387

00:16:14,450 --> 00:16:20,780

it is this is about other thing it's a

388

00:16:18,950 --> 00:16:22,820

very much at the limits of what the

389

00:16:20,779 --> 00:16:24,439

Hubble Space Telescope can do and the

390

00:16:22,820 --> 00:16:27,589

only way we can really do better is by

391

00:16:24,440 --> 00:16:30,800

putting a bigger telescope in space but

392

00:16:27,589 --> 00:16:32,900

what we know about it is that when we

393

00:16:30,799 --> 00:16:35,000

look at galaxies like our own galaxy

394

00:16:32,899 --> 00:16:38,120

we're in the Milky Way galaxy which is a

395

00:16:35,000 --> 00:16:40,639

spiral galaxy has spiral arms and the

396

00:16:38,120 --> 00:16:44,450

Sun is one Sun among roughly a hundred

397

00:16:40,639 --> 00:16:47,208

billion stars in our galaxy this galaxy

398

00:16:44,450 --> 00:16:51,020

is really you should think about it as a

399

00:16:47,208 --> 00:16:53,659

fragment it's at least one one-hundredth

400  
00:16:51,019 --> 00:16:57,799  
the size or the mass of the Milky Way

401  
00:16:53,659 --> 00:16:59,539  
galaxy and maybe even 1,000 so in that

402  
00:16:57,799 --> 00:17:01,549  
range between a hundredth and one

403  
00:16:59,539 --> 00:17:05,568  
thousandth of math mass of our own

404  
00:17:01,549 --> 00:17:08,599  
galaxy and so what we think happened is

405  
00:17:05,568 --> 00:17:09,670  
that these galaxies like the one we

406  
00:17:08,599 --> 00:17:12,919  
discovered

407  
00:17:09,670 --> 00:17:15,199  
came together through gravity to over

408  
00:17:12,920 --> 00:17:20,300  
time build up the big galaxies that we

409  
00:17:15,199 --> 00:17:23,380  
see today and so real to young its

410  
00:17:20,299 --> 00:17:27,039  
forming stars at a very fast clip

411  
00:17:23,380 --> 00:17:29,840  
because it has a lot of cold gaps and

412  
00:17:27,039 --> 00:17:32,269  
we're catching it when it was just it

413  
00:17:29,839 --> 00:17:35,779  
when there was just a fragment of the

414  
00:17:32,269 --> 00:17:38,359  
big galaxies that we see today Wow

415  
00:17:35,779 --> 00:17:39,529  
so I'm gonna there's that there's what

416  
00:17:38,359 --> 00:17:43,990  
we're talking about folks cuz I just

417  
00:17:39,529 --> 00:17:47,519  
wanted to put this up real fast so so

418  
00:17:43,990 --> 00:17:50,670  
I did you said that the this

419  
00:17:47,519 --> 00:17:53,670  
been this had appeared in the lens to

420  
00:17:50,670 --> 00:17:56,370  
galaxy several times or in the galaxy in

421  
00:17:53,670 --> 00:17:57,630  
the galaxy cluster image several times

422  
00:17:56,369 --> 00:18:01,079  
how do you know that how do you know

423  
00:17:57,630 --> 00:18:03,630  
that little dot is exactly the same

424  
00:18:01,079 --> 00:18:06,779  
galaxy and in just in different spots of

425  
00:18:03,630 --> 00:18:10,020  
the image that's a good question so the

426  
00:18:06,779 --> 00:18:11,759  
answer divides into first of all we see

427  
00:18:10,019 --> 00:18:14,099  
many galaxies which are multiplied in

428

00:18:11,759 --> 00:18:15,839  
the cluster this is not the only one

429  
00:18:14,099 --> 00:18:19,049  
and usually the galaxies that we see

430  
00:18:15,839 --> 00:18:22,769  
multiplied in the cluster if they can be

431  
00:18:19,049 --> 00:18:25,769  
giant spirals with very distinct colors

432  
00:18:22,769 --> 00:18:27,389  
or not so there is no doubt that these

433  
00:18:25,769 --> 00:18:29,609  
are the same background galaxies being

434  
00:18:27,390 --> 00:18:32,460  
multiplied imaged we can also verify it

435  
00:18:29,609 --> 00:18:35,699  
by very accurately measuring their

436  
00:18:32,460 --> 00:18:37,380  
colors so once we establish the

437  
00:18:35,700 --> 00:18:39,539  
gravitational lensing predicted

438  
00:18:37,380 --> 00:18:42,860  
according to Einstein general relativity

439  
00:18:39,539 --> 00:18:46,079  
is a real phenomenon we see galaxies

440  
00:18:42,859 --> 00:18:49,039  
multiple times in the same by multiply

441  
00:18:46,079 --> 00:18:51,359  
multiply lens by the same cluster lens

442  
00:18:49,039 --> 00:18:54,659

now it's just a question of how do we

443

00:18:51,359 --> 00:18:57,659

know that this exact galaxy the red blob

444

00:18:54,660 --> 00:19:00,210

is really the same galaxy and here we

445

00:18:57,660 --> 00:19:01,710

used basically a lens model so we

446

00:19:00,210 --> 00:19:04,319

construct the mass of the cluster

447

00:19:01,710 --> 00:19:06,269

according to all these other giant

448

00:19:04,319 --> 00:19:08,369

spirals that are being multiplied

449

00:19:06,269 --> 00:19:09,960

lengths that I told you about and then

450

00:19:08,369 --> 00:19:12,629

we can extrapolate to higher redshift

451

00:19:09,960 --> 00:19:15,809

and predict where would we expect to see

452

00:19:12,630 --> 00:19:18,480

such blobs where we to high-redshift

453

00:19:15,809 --> 00:19:20,629

galaxies okay so you mentioned these

454

00:19:18,480 --> 00:19:24,870

lens models and these are mathematical

455

00:19:20,630 --> 00:19:26,850

descriptions of the way in which this

456

00:19:24,869 --> 00:19:28,949

galaxy cluster will bend light and if



457  
00:19:26,849 --> 00:19:32,459  
specific to this particular galaxy

458  
00:19:28,950 --> 00:19:34,140  
cluster right so if you if you model

459  
00:19:32,460 --> 00:19:37,019  
that if you shine light through this

460  
00:19:34,140 --> 00:19:39,300  
this lens model you're talking about you

461  
00:19:37,019 --> 00:19:43,049  
should be able to see certain galaxies

462  
00:19:39,299 --> 00:19:45,089  
behind it in certain locations in the

463  
00:19:43,049 --> 00:19:47,639  
galaxy cluster right that's exactly

464  
00:19:45,089 --> 00:19:49,559  
correct okay good so let me interject

465  
00:19:47,640 --> 00:19:51,930  
there's there's actually a really great

466  
00:19:49,559 --> 00:19:54,990  
you can do this yourself I do this in my

467  
00:19:51,930 --> 00:19:58,230  
classroom as Carol described and we've

468  
00:19:54,990 --> 00:20:01,019  
been talking about lenses make multiple

469  
00:19:58,230 --> 00:20:05,160  
images so if you take a wineglass

470  
00:20:01,019 --> 00:20:07,650  
yes promoting alcohol or any famous wine

471  
00:20:05,160 --> 00:20:09,570  
glass yeah but if you just take a wine

472  
00:20:07,650 --> 00:20:11,759  
glass and you and you tip it and cut it

473  
00:20:09,569 --> 00:20:13,950  
sort of look off the end and take a

474  
00:20:11,759 --> 00:20:16,890  
candle or a match or something like that

475  
00:20:13,950 --> 00:20:19,890  
and hold it on the backside of the stem

476  
00:20:16,890 --> 00:20:22,740  
and if you just took the angle you can

477  
00:20:19,890 --> 00:20:24,720  
actually create multiple images making

478  
00:20:22,740 --> 00:20:27,480  
twos pretty easy if you're really good

479  
00:20:24,720 --> 00:20:29,220  
you can make three if it's perfectly

480  
00:20:27,480 --> 00:20:33,569  
lined up you get what's called an

481  
00:20:29,220 --> 00:20:35,700  
Einstein ring and really if you know how

482  
00:20:33,569 --> 00:20:38,069  
the glass is distributed that's really

483  
00:20:35,700 --> 00:20:40,860  
when we say Allen's model then you can

484  
00:20:38,069 --> 00:20:43,799  
predict where the candle light will

485

00:20:40,859 --> 00:20:45,959  
appear on your eyes right it's great

486  
00:20:43,799 --> 00:20:47,460  
it's a great demonstration up for those

487  
00:20:45,960 --> 00:20:48,900  
of you who haven't seen it yet

488  
00:20:47,460 --> 00:20:51,900  
if you look at one of our very first

489  
00:20:48,900 --> 00:20:53,460  
frontier fields hangouts Dan Coe what he

490  
00:20:51,900 --> 00:20:55,590  
did was he had a little galaxy had an

491  
00:20:53,460 --> 00:20:57,569  
image of one of his galaxies and an

492  
00:20:55,589 --> 00:20:59,599  
iPhone and then he put that in front of

493  
00:20:57,569 --> 00:21:02,099  
the glass that he had and he lens that

494  
00:20:59,599 --> 00:21:04,619  
that image of a galaxy from his iPhone

495  
00:21:02,099 --> 00:21:06,480  
and you can see for me well how how that

496  
00:21:04,619 --> 00:21:08,399  
that that works it's a really good

497  
00:21:06,480 --> 00:21:10,079  
demonstration so if you want to see that

498  
00:21:08,400 --> 00:21:12,180  
I would check out one of our past our

499  
00:21:10,079 --> 00:21:15,210

frontier fields hangouts you'll be able

500

00:21:12,180 --> 00:21:17,009

to see that so Scott would you mind

501

00:21:15,210 --> 00:21:19,470

putting that image up you had with with

502

00:21:17,009 --> 00:21:23,089

the galaxy cluster in the foreground and

503

00:21:19,470 --> 00:21:27,269

the three little in sets again this

504

00:21:23,089 --> 00:21:29,819

cluster is called a bell 27:44 and it's

505

00:21:27,269 --> 00:21:31,319

one of the clusters that frontier fields

506

00:21:29,819 --> 00:21:34,079

is there's one of the six that it's

507

00:21:31,319 --> 00:21:37,819

picked to a show I mean as soon as God

508

00:21:34,079 --> 00:21:40,799

gets it up I want to here come so these

509

00:21:37,819 --> 00:21:42,779

galaxies on the cluster itself are all

510

00:21:40,799 --> 00:21:45,019

very familiar looking they look you know

511

00:21:42,779 --> 00:21:47,369

it looked like a galaxy ah to look and

512

00:21:45,019 --> 00:21:49,440

these are galaxies that are relatively

513

00:21:47,369 --> 00:21:51,329

close by compared to what you've been

514  
00:21:49,440 --> 00:21:53,430  
observing how are and maybe John this

515  
00:21:51,329 --> 00:21:56,819  
will be a question for you how are these

516  
00:21:53,430 --> 00:21:58,440  
early galaxies different from the

517  
00:21:56,819 --> 00:22:01,589  
galaxies we see today because they're

518  
00:21:58,440 --> 00:22:04,980  
not the same at all are they that's

519  
00:22:01,589 --> 00:22:08,750  
right the typically the galaxies that

520  
00:22:04,980 --> 00:22:12,299  
make up a galaxy cluster like a Bell

521  
00:22:08,750 --> 00:22:14,269  
2744 are what we call spheroidal

522  
00:22:12,299 --> 00:22:17,898  
galaxies so if you look in

523  
00:22:14,269 --> 00:22:23,838  
as image Scott has up basically be the

524  
00:22:17,898 --> 00:22:26,329  
orangish bright blobs that are that

525  
00:22:23,838 --> 00:22:29,088  
dominate this image these are all in the

526  
00:22:26,329 --> 00:22:30,588  
foreground and their brights for auto

527  
00:22:29,088 --> 00:22:32,719  
galaxies in other words picture them as

528  
00:22:30,588 --> 00:22:34,819  
beehives essentially they have no

529  
00:22:32,719 --> 00:22:37,369  
they're not flat in one direction

530  
00:22:34,819 --> 00:22:41,418  
they're like beehives or footballs in

531  
00:22:37,368 --> 00:22:43,848  
the sky and so first of all they're

532  
00:22:41,419 --> 00:22:46,038  
they're very massive as I've described

533  
00:22:43,848 --> 00:22:48,259  
the object we found which is in the

534  
00:22:46,038 --> 00:22:54,408  
background that's far far behind this

535  
00:22:48,259 --> 00:22:58,759  
cluster is is really a fragment of a

536  
00:22:54,409 --> 00:23:01,399  
galaxy today much less massive and the

537  
00:22:58,759 --> 00:23:02,929  
galaxies in a cluster for the most part

538  
00:23:01,398 --> 00:23:04,728  
most of the galaxies have stopped

539  
00:23:02,929 --> 00:23:07,219  
forming stars in other words they don't

540  
00:23:04,729 --> 00:23:10,459  
have the fuel for star formation which

541  
00:23:07,219 --> 00:23:14,239  
is cold gas whereas this distant object

542

00:23:10,459 --> 00:23:16,489  
we've discovered has is forming stars at

543  
00:23:14,239 --> 00:23:19,159  
a significant rate compared to how

544  
00:23:16,489 --> 00:23:23,538  
massive it is which means it must have a

545  
00:23:19,159 --> 00:23:26,239  
cold gas reservoir and so there are very

546  
00:23:23,538 --> 00:23:29,598  
different parts of their life these

547  
00:23:26,239 --> 00:23:30,769  
these ferrata galaxies in the cluster a

548  
00:23:29,598 --> 00:23:33,528  
comment called

549  
00:23:30,769 --> 00:23:35,328  
red and dead galaxies because they have

550  
00:23:33,528 --> 00:23:38,388  
just stopped for me it's new stars

551  
00:23:35,328 --> 00:23:42,288  
whereas this distant object is really in

552  
00:23:38,388 --> 00:23:44,348  
its youth it's a toddler and it's you

553  
00:23:42,288 --> 00:23:47,179  
know its heyday is yet to come

554  
00:23:44,348 --> 00:23:48,798  
so indeed to follow up on what he do it

555  
00:23:47,179 --> 00:23:52,159  
with John was just saying these this

556  
00:23:48,798 --> 00:23:55,328

distant galaxies he said has a cold gas

557

00:23:52,159 --> 00:23:59,028  
reservoir would this be just the

558

00:23:55,328 --> 00:24:01,638  
hydrogen and helium from the from from

559

00:23:59,028 --> 00:24:03,558  
the early universe is that what they is

560

00:24:01,638 --> 00:24:06,408  
how he's talking about or what well why

561

00:24:03,558 --> 00:24:09,918  
would these galaxies be giving so many

562

00:24:06,409 --> 00:24:10,278  
are high rates of star birth yes that's

563

00:24:09,919 --> 00:24:12,320  
correct

564

00:24:10,278 --> 00:24:13,969  
that's the reservoirs of hydrogen and

565

00:24:12,319 --> 00:24:16,489  
also some helium from the early universe

566

00:24:13,969 --> 00:24:18,950  
I just want to mention before that John

567

00:24:16,489 --> 00:24:20,209  
mentioned that the cluster going back to

568

00:24:18,950 --> 00:24:23,179  
the redshift John mentioned that the

569

00:24:20,209 --> 00:24:24,409  
cluster galaxies are red and dead now we

570

00:24:23,179 --> 00:24:26,269  
actually see that the background



571  
00:24:24,409 --> 00:24:28,100  
galaxies which is supposed to be young

572  
00:24:26,269 --> 00:24:30,230  
in blue is much redder

573  
00:24:28,099 --> 00:24:33,109  
now this is exactly the redshift this

574  
00:24:30,230 --> 00:24:35,809  
very blue galaxy is seen

575  
00:24:33,109 --> 00:24:37,819  
extremely red to us because it's in the

576  
00:24:35,809 --> 00:24:39,950  
end of in the edge of the universe so

577  
00:24:37,819 --> 00:24:42,470  
it's very highly redshifted

578  
00:24:39,950 --> 00:24:46,539  
but it's physical color is and isn't red

579  
00:24:42,470 --> 00:24:49,730  
it's actually who's providing it or

580  
00:24:46,539 --> 00:24:51,109  
because of the star birth the rapid

581  
00:24:49,730 --> 00:24:53,660  
amount of star birth and the young stars

582  
00:24:51,109 --> 00:24:55,399  
in there correct exactly okay so we got

583  
00:24:53,660 --> 00:24:58,370  
this we got this galaxy that's really

584  
00:24:55,400 --> 00:25:01,370  
ultra violet or blue if we were to be

585  
00:24:58,369 --> 00:25:04,729  
right next to it although you know 13

586  
00:25:01,369 --> 00:25:07,699  
billion years ago but it appears red to

587  
00:25:04,730 --> 00:25:10,789  
us what are the stars like in this

588  
00:25:07,700 --> 00:25:14,930  
galaxy what do they like John why don't

589  
00:25:10,789 --> 00:25:17,750  
you take okay John I sure obviously we

590  
00:25:14,930 --> 00:25:20,390  
we can't say anything about individual

591  
00:25:17,750 --> 00:25:23,299  
stars so what we're looking at if the

592  
00:25:20,390 --> 00:25:26,930  
combined light of all the stars in this

593  
00:25:23,299 --> 00:25:29,779  
galaxy and that's true of almost any

594  
00:25:26,930 --> 00:25:32,060  
galaxy in the skies galaxies even nearby

595  
00:25:29,779 --> 00:25:34,460  
ones relatively nearby ones are so

596  
00:25:32,059 --> 00:25:36,079  
distant that we never see individual

597  
00:25:34,460 --> 00:25:38,569  
stars so when you look at this cluster

598  
00:25:36,079 --> 00:25:40,909  
image pick the biggest thing on here

599

00:25:38,569 --> 00:25:43,159  
what you're seeing is the faint that

600  
00:25:40,910 --> 00:25:46,130  
added the light that's added up from all

601  
00:25:43,160 --> 00:25:49,400  
four many billions of stars that are in

602  
00:25:46,130 --> 00:25:51,950  
here but the fact that we can say

603  
00:25:49,400 --> 00:25:57,290  
something about how fast stars are

604  
00:25:51,950 --> 00:26:00,080  
forming on average and this galaxy as

605  
00:25:57,289 --> 00:26:03,500  
forming stars at a rate of about three

606  
00:26:00,079 --> 00:26:06,980  
suns every year which might not seem

607  
00:26:03,500 --> 00:26:09,019  
like a really big number but you have to

608  
00:26:06,980 --> 00:26:11,269  
compare it to how big it is because it's

609  
00:26:09,019 --> 00:26:13,549  
so small the fact that it's forming

610  
00:26:11,269 --> 00:26:16,759  
three suns of a year what that means is

611  
00:26:13,549 --> 00:26:19,579  
that in about 200 million years it's

612  
00:26:16,759 --> 00:26:21,349  
going to get double its size and then if

613  
00:26:19,579 --> 00:26:22,849

you continue form stars at that same

614

00:26:21,349 --> 00:26:25,659

rate that means in another two hundred

615

00:26:22,849 --> 00:26:27,949

years it's going to double again and so

616

00:26:25,660 --> 00:26:31,340

even though it doesn't have a large

617

00:26:27,950 --> 00:26:33,529

absolute star formation rate it's a rate

618

00:26:31,339 --> 00:26:35,779

at which it's forming new stars this

619

00:26:33,529 --> 00:26:37,899

thing is is growing up really really

620

00:26:35,779 --> 00:26:40,750

quickly

621

00:26:37,900 --> 00:26:43,000

I see this on a growth spurt huh that's

622

00:26:40,750 --> 00:26:46,660

right okay well while we're on the topic

623

00:26:43,000 --> 00:26:49,089

of these early galaxies versus the ones

624

00:26:46,660 --> 00:26:51,820

that are more closer to us in the in the

625

00:26:49,089 --> 00:26:55,179

present day Lucas a Midori from YouTube

626

00:26:51,819 --> 00:26:56,679

has asked if there were galaxies at

627

00:26:55,180 --> 00:26:58,779

thirteen billion years ago then there

628  
00:26:56,680 --> 00:27:01,779  
must have also have been super massive

629  
00:26:58,779 --> 00:27:03,940  
black holes already hanging around to

630  
00:27:01,779 --> 00:27:05,950  
organize those galaxies together any

631  
00:27:03,940 --> 00:27:07,779  
ideas on those supermassive black holes

632  
00:27:05,950 --> 00:27:10,090  
on how those supermassive black holes

633  
00:27:07,779 --> 00:27:12,940  
might have become so enmeshed in such a

634  
00:27:10,089 --> 00:27:15,490  
relatively short time after the bang now

635  
00:27:12,940 --> 00:27:17,430  
that's assuming of course that you

636  
00:27:15,490 --> 00:27:20,079  
Deepthi

637  
00:27:17,430 --> 00:27:24,039  
that there are these are formed by

638  
00:27:20,079 --> 00:27:28,779  
supermassive black holes correct so how

639  
00:27:24,039 --> 00:27:33,339  
do you respond to that are there either

640  
00:27:28,779 --> 00:27:34,960  
one ID or John anybody I can try if I

641  
00:27:33,339 --> 00:27:36,549  
got the question correctly first of all

642  
00:27:34,960 --> 00:27:39,519  
just let me say I'm far from being an

643  
00:27:36,549 --> 00:27:41,649  
expert on black holes but one of the

644  
00:27:39,519 --> 00:27:44,680  
theories for forming the the you know

645  
00:27:41,650 --> 00:27:47,410  
the very messy or at least some of the

646  
00:27:44,680 --> 00:27:50,080  
the black holes the early ones as we

647  
00:27:47,410 --> 00:27:52,300  
know it this is to my knowledge is that

648  
00:27:50,079 --> 00:27:54,519  
massive stars explode and then collapse

649  
00:27:52,299 --> 00:27:54,869  
to form some sort of sort of a black

650  
00:27:54,519 --> 00:27:58,089  
hole

651  
00:27:54,869 --> 00:28:00,939  
now the first stars are expected

652  
00:27:58,089 --> 00:28:02,529  
expected to be much more massive than

653  
00:28:00,940 --> 00:28:04,480  
the stars that we see today so this

654  
00:28:02,529 --> 00:28:06,399  
could be one explanation but I think

655  
00:28:04,480 --> 00:28:07,990  
that there is some flowing the question

656

00:28:06,400 --> 00:28:10,530  
in the same in the the question in the

657  
00:28:07,990 --> 00:28:12,970  
sense that these galaxies are not

658  
00:28:10,529 --> 00:28:14,589  
similar in shape to the galaxies that we

659  
00:28:12,970 --> 00:28:17,110  
see today which have a black hole in

660  
00:28:14,589 --> 00:28:19,539  
their center these galaxies are fuzzy or

661  
00:28:17,109 --> 00:28:21,699  
very clumpy objects which are not well

662  
00:28:19,539 --> 00:28:23,470  
organized so we are not even sure if

663  
00:28:21,700 --> 00:28:24,970  
there are black holes in their centers

664  
00:28:23,470 --> 00:28:26,559  
that's what I was hoping you'd address

665  
00:28:24,970 --> 00:28:29,410  
because it's not necessarily the case

666  
00:28:26,559 --> 00:28:34,329  
that black holes are responsible for

667  
00:28:29,410 --> 00:28:36,340  
their formation at all their question so

668  
00:28:34,329 --> 00:28:40,000  
when I said the flow it was not against

669  
00:28:36,339 --> 00:28:41,199  
of course that somebody asking the

670  
00:28:40,000 --> 00:28:44,049

question that was a very good question

671

00:28:41,200 --> 00:28:47,350

is just that well what about the second

672

00:28:44,049 --> 00:28:49,869

part of it idea so let's just would

673

00:28:47,349 --> 00:28:51,159

would black holes form relatively soon

674

00:28:49,869 --> 00:28:53,469

after the Big Bang

675

00:28:51,160 --> 00:28:56,380

when they you said these stars are very

676

00:28:53,470 --> 00:28:58,779

massive they shine very brightly they

677

00:28:56,380 --> 00:29:01,540

die after a relatively short period of

678

00:28:58,779 --> 00:29:04,149

time presumably in soup in us I believe

679

00:29:01,539 --> 00:29:06,940

it's in a specific kind of supernova and

680

00:29:04,150 --> 00:29:10,330

so would black holes be forming that

681

00:29:06,940 --> 00:29:12,400

during this time yeah I mean I'll pick

682

00:29:10,329 --> 00:29:15,549

this up I would say this is a wide open

683

00:29:12,400 --> 00:29:17,940

question and an important one and a

684

00:29:15,549 --> 00:29:21,339

really exciting one but one that our



685  
00:29:17,940 --> 00:29:24,279  
discovery at least can't speak to but

686  
00:29:21,339 --> 00:29:28,599  
it's something that it's an open problem

687  
00:29:24,279 --> 00:29:31,480  
open question in in really in how the

688  
00:29:28,599 --> 00:29:33,159  
early universe evolved so when when you

689  
00:29:31,480 --> 00:29:35,620  
say supermassive black holes what we're

690  
00:29:33,160 --> 00:29:39,250  
talking about here are black holes at

691  
00:29:35,619 --> 00:29:42,039  
our millions or even billions times more

692  
00:29:39,250 --> 00:29:46,900  
massive than our Sun right so for

693  
00:29:42,039 --> 00:29:50,289  
example like you galaxy is is a about a

694  
00:29:46,900 --> 00:29:53,080  
four million solar mass black hole but

695  
00:29:50,289 --> 00:29:55,359  
in but Jesus supermassive black holes

696  
00:29:53,079 --> 00:29:58,089  
can be even a billion or ten billion

697  
00:29:55,359 --> 00:30:00,490  
times a massive Sun we do see

698  
00:29:58,089 --> 00:30:03,339  
supermassive black holes at high

699  
00:30:00,490 --> 00:30:07,359  
redshift so at redshifts of say six to

700  
00:30:03,339 --> 00:30:10,720  
seven which is not quite a billion years

701  
00:30:07,359 --> 00:30:14,639  
after where the object we've discovered

702  
00:30:10,720 --> 00:30:17,860  
so at some point between the end of the

703  
00:30:14,640 --> 00:30:20,259  
when galaxy formation began roughly

704  
00:30:17,859 --> 00:30:24,789  
billion years or so we do know that

705  
00:30:20,259 --> 00:30:26,410  
super moon now seen but there's no

706  
00:30:24,789 --> 00:30:29,289  
evidence that there's a supermassive

707  
00:30:26,410 --> 00:30:31,840  
black hole or that there's any kind of

708  
00:30:29,289 --> 00:30:33,609  
black hole in the the types of objects

709  
00:30:31,839 --> 00:30:34,929  
that we've discovered you know this

710  
00:30:33,609 --> 00:30:37,869  
discovery we were talking about today

711  
00:30:34,930 --> 00:30:41,160  
and and others like it so what I meant

712  
00:30:37,869 --> 00:30:44,349  
by it being an open problem is we

713

00:30:41,160 --> 00:30:46,360  
there's a missing link we we know that

714  
00:30:44,349 --> 00:30:48,250  
supermassive black holes appear at some

715  
00:30:46,359 --> 00:30:50,919  
point later we don't see them where

716  
00:30:48,250 --> 00:30:56,349  
we're finding them and so it's a

717  
00:30:50,920 --> 00:30:58,000  
discovery phase and when and how these

718  
00:30:56,349 --> 00:31:00,219  
supermassive black holes came on the

719  
00:30:58,000 --> 00:31:01,869  
scene all right thank you very good

720  
00:31:00,220 --> 00:31:05,049  
question Lucas thank you very much we

721  
00:31:01,869 --> 00:31:06,929  
appreciate that all right so

722  
00:31:05,049 --> 00:31:10,240  
we're talking about a period in time

723  
00:31:06,930 --> 00:31:11,740  
with you know obviously really really

724  
00:31:10,240 --> 00:31:14,710  
early in the universe we would not have

725  
00:31:11,740 --> 00:31:18,839  
seen this galaxy had it not been for the

726  
00:31:14,710 --> 00:31:23,289  
frontier fields there are a lot of

727  
00:31:18,839 --> 00:31:24,429

people using this data got you know

728

00:31:23,289 --> 00:31:26,170

right away like we had mentioned earlier

729

00:31:24,430 --> 00:31:28,180

in fact this is just one of the many

730

00:31:26,170 --> 00:31:32,650

ways in which people where yields

731

00:31:28,180 --> 00:31:37,450

frontier fields data so I guess what I

732

00:31:32,650 --> 00:31:39,820

want to ask a little bit about is last

733

00:31:37,450 --> 00:31:41,319

week there was a there was a workshop or

734

00:31:39,819 --> 00:31:43,750

a lot of people got together and they

735

00:31:41,319 --> 00:31:46,450

talked about using this data and things

736

00:31:43,750 --> 00:31:49,869

like that are there other people doing

737

00:31:46,450 --> 00:31:51,580

looking at this for other galaxies like

738

00:31:49,869 --> 00:31:55,929

you guys are or is this primarily your

739

00:31:51,579 --> 00:31:58,869

bailiwick there are many groups that are

740

00:31:55,930 --> 00:32:00,880

looking at this data all of them are

741

00:31:58,869 --> 00:32:03,789

doing a great job people have found

742  
00:32:00,880 --> 00:32:05,280  
already in the phase cluster the same

743  
00:32:03,789 --> 00:32:08,889  
cluster that we found the very

744  
00:32:05,279 --> 00:32:12,509  
rehydrates you know if we sum up all the

745  
00:32:08,890 --> 00:32:15,490  
galaxies that the group would have found

746  
00:32:12,509 --> 00:32:17,259  
it sums up to a few dozen galaxies at

747  
00:32:15,490 --> 00:32:19,299  
very high redshift indeed not at a

748  
00:32:17,259 --> 00:32:22,180  
redshift of 10 but the redshift of 6 to

749  
00:32:19,299 --> 00:32:26,309  
9 for example so only by looking deep at

750  
00:32:22,180 --> 00:32:28,750  
one cluster we found dozens of hydrogen

751  
00:32:26,309 --> 00:32:31,440  
galaxies excited to see what we find

752  
00:32:28,750 --> 00:32:34,599  
over all six of them stores

753  
00:32:31,440 --> 00:32:36,160  
so Mike Hill Jobin from the Q&A app is

754  
00:32:34,599 --> 00:32:38,049  
poking fun amigos Tony you were

755  
00:32:36,160 --> 00:32:45,400  
channeling Guido Sarducci just a little

756  
00:32:38,049 --> 00:32:48,099  
I was father Guido Sarducci okay cool

757  
00:32:45,400 --> 00:32:50,350  
so let's see cecil morgan is asking also

758  
00:32:48,099 --> 00:32:53,889  
from the Q&A app wouldn't a redshift of

759  
00:32:50,349 --> 00:32:56,919  
10 take the visible spectrum out of the

760  
00:32:53,890 --> 00:32:59,200  
range of HSTs detectors meaning that

761  
00:32:56,920 --> 00:33:00,940  
what we're seeing was emitted in the UV

762  
00:32:59,200 --> 00:33:03,250  
range is that right and you touched on

763  
00:33:00,940 --> 00:33:06,220  
this already just a little bit guys but

764  
00:33:03,250 --> 00:33:07,509  
as Webley was you John that said that

765  
00:33:06,220 --> 00:33:10,960  
even though we're physically looking at

766  
00:33:07,509 --> 00:33:12,759  
this thing and it appears red to us if

767  
00:33:10,960 --> 00:33:16,539  
we were right next to it it will appear

768  
00:33:12,759 --> 00:33:18,579  
in the UV or visible correct yeah that's

769  
00:33:16,539 --> 00:33:20,740  
right I think Adi said that but

770

00:33:18,579 --> 00:33:22,480  
I'm sorry it was a de I apologize no no

771  
00:33:20,740 --> 00:33:26,589  
that's fine but yeah that's absolutely

772  
00:33:22,480 --> 00:33:28,990  
true so what we're actually observing is

773  
00:33:26,589 --> 00:33:30,609  
light that when it left the galaxy was

774  
00:33:28,990 --> 00:33:32,919  
in the ultraviolet part of the

775  
00:33:30,609 --> 00:33:35,019  
electromagnetic spectrum and that light

776  
00:33:32,919 --> 00:33:38,320  
has lost energy as it has traveled

777  
00:33:35,019 --> 00:33:41,319  
across the cosmos and so we're receiving

778  
00:33:38,319 --> 00:33:43,418  
it in a different part of the

779  
00:33:41,319 --> 00:33:49,658  
electromagnetic spectrum called Amira

780  
00:33:43,419 --> 00:33:52,960  
red and but it it is within the range

781  
00:33:49,659 --> 00:33:56,080  
where Hubble has a detector is the Wide

782  
00:33:52,960 --> 00:33:58,840  
Field Camera 3 as an infrared near Fred

783  
00:33:56,079 --> 00:34:00,788  
Channel and so we are able to pick up

784  
00:33:58,839 --> 00:34:02,918

the light but let's say we wanted to

785

00:34:00,788 --> 00:34:08,409

find galaxies at even higher redshift

786

00:34:02,919 --> 00:34:11,338

say 10 11 12 15 or 20 the that light

787

00:34:08,409 --> 00:34:15,280

would be beyond Hubble's capabilities

788

00:34:11,338 --> 00:34:17,049

and so we're I mentioned earlier where

789

00:34:15,280 --> 00:34:19,179

that we're at the edge of what Hubble

790

00:34:17,050 --> 00:34:21,659

can do for being a two and a half metre

791

00:34:19,179 --> 00:34:24,490

telescope tractor-trailer in space

792

00:34:21,659 --> 00:34:27,159

that's part of it the second part is the

793

00:34:24,489 --> 00:34:29,559

fact that the detectors just can't pick

794

00:34:27,159 --> 00:34:32,349

up light that's even further into the

795

00:34:29,559 --> 00:34:34,628

red and for that and this is my segue is

796

00:34:32,349 --> 00:34:35,740

I will have to await the James Webb

797

00:34:34,628 --> 00:34:37,449

Space Telescope

798

00:34:35,739 --> 00:34:38,888

that's correct and I've often said you



799  
00:34:37,449 --> 00:34:41,108  
know the future of astronomy and why I

800  
00:34:38,889 --> 00:34:42,369  
would I was I had a professor at the

801  
00:34:41,108 --> 00:34:44,079  
University of Colorado that said this

802  
00:34:42,369 --> 00:34:45,550  
but I stole it it was like he's always

803  
00:34:44,079 --> 00:34:47,918  
say the future of astronomy is in the

804  
00:34:45,550 --> 00:34:49,599  
infrared because of this this is if we

805  
00:34:47,918 --> 00:34:51,638  
want to look further back if we want to

806  
00:34:49,599 --> 00:34:53,740  
see these early regions or these early

807  
00:34:51,639 --> 00:34:56,530  
times in the universe the infrared is

808  
00:34:53,739 --> 00:34:59,469  
the place to go and now that infrared

809  
00:34:56,530 --> 00:35:01,420  
detectors have become ubiquitous there

810  
00:34:59,469 --> 00:35:03,730  
they used to be very difficult to make

811  
00:35:01,420 --> 00:35:05,369  
now they're all over the place and so as

812  
00:35:03,730 --> 00:35:08,409  
you mentioned JWST is going to have a

813  
00:35:05,369 --> 00:35:10,210  
even larger wavelength range in the

814  
00:35:08,409 --> 00:35:12,190  
infrared for don't you mean that the

815  
00:35:10,210 --> 00:35:16,088  
future and the path for the strong man I

816  
00:35:12,190 --> 00:35:18,039  
exactly so good question Cecil

817  
00:35:16,088 --> 00:35:21,460  
appreciated and peda phlox who was not

818  
00:35:18,039 --> 00:35:22,630  
first this time in a really basic

819  
00:35:21,460 --> 00:35:24,280  
question and we've touched on this a

820  
00:35:22,630 --> 00:35:27,338  
little bit but is there some sort of

821  
00:35:24,280 --> 00:35:28,420  
idea how this galaxy formed I mean these

822  
00:35:27,338 --> 00:35:30,549  
early galaxies we talked about

823  
00:35:28,420 --> 00:35:31,809  
supermassive black holes and the weather

824  
00:35:30,550 --> 00:35:32,230  
it's an open question about whether

825  
00:35:31,809 --> 00:35:34,210  
black

826  
00:35:32,230 --> 00:35:35,500  
holes were in this period of time how do

827

00:35:34,210 --> 00:35:38,980  
these things start clumping up out of

828  
00:35:35,500 --> 00:35:41,769  
these galaxies start forming who wants

829  
00:35:38,980 --> 00:35:45,309  
to take that one John I I've been

830  
00:35:41,769 --> 00:35:47,469  
talking ah yeah go ahead

831  
00:35:45,309 --> 00:35:50,440  
you dick so any idea how these high-rent

832  
00:35:47,469 --> 00:35:52,209  
these early galaxies get started what

833  
00:35:50,440 --> 00:35:54,730  
kind of is there a gravitational bump or

834  
00:35:52,210 --> 00:35:58,510  
some kind of sub kind that gets them

835  
00:35:54,730 --> 00:36:01,929  
going what does it take Adi

836  
00:35:58,510 --> 00:36:05,170  
are you there I just thought it was a

837  
00:36:01,929 --> 00:36:06,730  
better question for John but sure okay

838  
00:36:05,170 --> 00:36:11,500  
he's pretty tired of talking so we're

839  
00:36:06,730 --> 00:36:15,670  
gonna ask you to do it about 300,000

840  
00:36:11,500 --> 00:36:17,889  
years after the Big Bang all the very

841  
00:36:15,670 --> 00:36:20,849

hot particles started recombining

842

00:36:17,889 --> 00:36:24,368

together and hydrogen was formed again

843

00:36:20,849 --> 00:36:26,069

and then you know it wasn't formed in a

844

00:36:24,369 --> 00:36:28,240

completely uniform way there were some

845

00:36:26,070 --> 00:36:30,400

regions where the density was a bit

846

00:36:28,239 --> 00:36:32,379

higher and where the density was a bit

847

00:36:30,400 --> 00:36:35,108

higher it attracted more and more

848

00:36:32,380 --> 00:36:37,869

hydrogen to that risen region when the

849

00:36:35,108 --> 00:36:41,440

mass was high enough all of that cloud

850

00:36:37,869 --> 00:36:42,850

of gas suddenly collapsed and formed you

851

00:36:41,440 --> 00:36:45,220

know started forming stars

852

00:36:42,849 --> 00:36:48,368

it got fragmented and the density was

853

00:36:45,219 --> 00:36:51,459

high enough that hydrogen began fusing

854

00:36:48,369 --> 00:36:55,210

and basically shining and these are what

855

00:36:51,460 --> 00:36:56,320

we know is stories and those clumps of

856  
00:36:55,210 --> 00:36:59,639  
stars slowly

857  
00:36:56,320 --> 00:37:02,950  
coalesced into these galaxies I say

858  
00:36:59,639 --> 00:37:04,960  
lovely in universal timescales it

859  
00:37:02,949 --> 00:37:06,730  
actually happened pretty quickly where

860  
00:37:04,960 --> 00:37:08,050  
these galaxies started forming basically

861  
00:37:06,730 --> 00:37:09,519  
from these inhomogeneities like you

862  
00:37:08,050 --> 00:37:12,039  
talked about these little density

863  
00:37:09,519 --> 00:37:16,090  
fluctuations throughout the universe and

864  
00:37:12,039 --> 00:37:18,940  
slowly they just started congealing into

865  
00:37:16,090 --> 00:37:23,170  
these galaxies so yeah the only thing I

866  
00:37:18,940 --> 00:37:24,820  
would add is that and and probably made

867  
00:37:23,170 --> 00:37:27,130  
a whole other hangout for this is that

868  
00:37:24,820 --> 00:37:30,340  
in fact what dominates the gravity in

869  
00:37:27,130 --> 00:37:32,108  
our universe is is dark matter so what

870  
00:37:30,340 --> 00:37:36,090  
we actually think has happened is that

871  
00:37:32,108 --> 00:37:38,949  
this hydrogen and get us falling into a

872  
00:37:36,090 --> 00:37:42,519  
gravity well made of largely of dark

873  
00:37:38,949 --> 00:37:44,889  
matter and so the hydrogen is just at

874  
00:37:42,519 --> 00:37:45,449  
the center of concentration of dark

875  
00:37:44,889 --> 00:37:47,609  
matter

876  
00:37:45,449 --> 00:37:49,949  
and as if you describe once the hydrogen

877  
00:37:47,610 --> 00:37:51,630  
gets dense enough you start making one

878  
00:37:49,949 --> 00:37:54,329  
star and once you start making one

879  
00:37:51,630 --> 00:37:58,380  
you're gonna make many that's right and

880  
00:37:54,329 --> 00:38:01,440  
and and then we were born yay thank you

881  
00:37:58,380 --> 00:38:03,119  
Patos a good question Michael Jobin is

882  
00:38:01,440 --> 00:38:04,829  
commenting so just because you don't

883  
00:38:03,119 --> 00:38:10,139  
find black holes you will someday

884

00:38:04,829 --> 00:38:12,840  
perhaps and that is true perhaps my

885  
00:38:10,139 --> 00:38:15,029  
Daniel Masato from the Q&A app by

886  
00:38:12,840 --> 00:38:16,950  
observing a photon being gravitationally

887  
00:38:15,030 --> 00:38:19,500  
lensed around the galaxy are we

888  
00:38:16,949 --> 00:38:22,289  
determining its path billions of years

889  
00:38:19,500 --> 00:38:25,079  
in the paths in the past sorry like

890  
00:38:22,289 --> 00:38:26,279  
shown in the double slit experiment and

891  
00:38:25,079 --> 00:38:29,969  
we talked about this briefly before

892  
00:38:26,280 --> 00:38:31,800  
you're these gravitational a lens

893  
00:38:29,969 --> 00:38:35,069  
photons are actually going through a

894  
00:38:31,800 --> 00:38:38,090  
model that you mathematically created to

895  
00:38:35,070 --> 00:38:40,470  
sort of describe this a little bit but

896  
00:38:38,090 --> 00:38:43,650  
can you so are you basically just

897  
00:38:40,469 --> 00:38:45,779  
tracing it back the path we are tracing

898  
00:38:43,650 --> 00:38:47,579

it back but I think that the double slit

899

00:38:45,780 --> 00:38:49,350

may be a bit confusing because what we

900

00:38:47,579 --> 00:38:51,690

see in the double slit experiment is a

901

00:38:49,349 --> 00:38:53,250

quantum effect which is they on a very

902

00:38:51,690 --> 00:38:55,980

small scale here we're talking about

903

00:38:53,250 --> 00:38:58,190

giant structures and basically the

904

00:38:55,980 --> 00:39:00,389

procedure is not some magical

905

00:38:58,190 --> 00:39:03,800

statistical thing as in quantum

906

00:39:00,389 --> 00:39:06,929

mechanics which is beautiful a much more

907

00:39:03,800 --> 00:39:10,380

simple thing so basically light from the

908

00:39:06,929 --> 00:39:13,169

galaxies going in one path is getting

909

00:39:10,380 --> 00:39:17,099

pulled by the cluster and getting if you

910

00:39:13,170 --> 00:39:19,139

want kicked off towards I our direction

911

00:39:17,099 --> 00:39:21,659

so that happens on one side of the

912

00:39:19,139 --> 00:39:23,190

cluster but the same but another light



913  
00:39:21,659 --> 00:39:25,500  
weight from the big moon galaxy is going

914  
00:39:23,190 --> 00:39:27,750  
to the other side of the cluster will

915  
00:39:25,500 --> 00:39:29,519  
experience the same thing this is why we

916  
00:39:27,750 --> 00:39:31,980  
see it several times so it's not a

917  
00:39:29,519 --> 00:39:34,170  
quantum effect it's just an effect that

918  
00:39:31,980 --> 00:39:36,449  
the gravity of the cluster distorts

919  
00:39:34,170 --> 00:39:39,180  
space in a way that stretches these

920  
00:39:36,449 --> 00:39:40,409  
sidelines towards us that's a really

921  
00:39:39,179 --> 00:39:41,669  
good question dan you know thank you for

922  
00:39:40,409 --> 00:39:43,859  
asking and thanks for the clarification

923  
00:39:41,670 --> 00:39:46,829  
on that - that was a really good

924  
00:39:43,860 --> 00:39:49,349  
explanation I have a question oh I had a

925  
00:39:46,829 --> 00:39:51,840  
comment which is that in a did sometimes

926  
00:39:49,349 --> 00:39:54,150  
there are multiples and sometimes those

927  
00:39:51,840 --> 00:39:56,340  
multiple images are actually merged into

928  
00:39:54,150 --> 00:39:57,809  
arc since they are stretched in two arcs

929  
00:39:56,340 --> 00:39:59,190  
and things like that so that's pretty

930  
00:39:57,809 --> 00:40:03,420  
interesting too

931  
00:39:59,190 --> 00:40:06,240  
look at a bill 27:44 and try to find

932  
00:40:03,420 --> 00:40:11,309  
those things on your own the other the

933  
00:40:06,239 --> 00:40:13,949  
question I had for our guests is that so

934  
00:40:11,309 --> 00:40:16,049  
you found this one that's at  $Z$  equals 10

935  
00:40:13,949 --> 00:40:18,210  
but I know you as you mentioned you

936  
00:40:16,050 --> 00:40:21,080  
found others right so you've looked at

937  
00:40:18,210 --> 00:40:24,750  
this cluster and you found galaxies at

938  
00:40:21,079 --> 00:40:26,819  
various redshift have you found like a

939  
00:40:24,750 --> 00:40:30,570  
certain redshift where there were a lot

940  
00:40:26,820 --> 00:40:34,230  
and then other rifts found one at  $Z$

941

00:40:30,570 --> 00:40:36,900  
equals 10 maybe there are more but at 9

942  
00:40:34,230 --> 00:40:39,960  
8 7 I know you that you in your paper

943  
00:40:36,900 --> 00:40:41,970  
you've described finding other multiples

944  
00:40:39,960 --> 00:40:44,820  
so I was just wondering if they were

945  
00:40:41,969 --> 00:40:47,159  
clustered in redshift or are they just

946  
00:40:44,820 --> 00:40:50,580  
kind of all over the map yeah that's a

947  
00:40:47,159 --> 00:40:53,730  
good question and the answer is that we

948  
00:40:50,579 --> 00:40:56,699  
do see a redshift dependence so we we do

949  
00:40:53,730 --> 00:40:59,219  
the we do get more galaxies at closer

950  
00:40:56,699 --> 00:41:01,679  
distances to us than the very high

951  
00:40:59,219 --> 00:41:04,559  
reduced ones but this is a combination

952  
00:41:01,679 --> 00:41:07,409  
of two effects first of all we are when

953  
00:41:04,559 --> 00:41:10,559  
we look to lower redshifts we are

954  
00:41:07,409 --> 00:41:12,509  
probing a larger volume behind the

955  
00:41:10,559 --> 00:41:17,670

cluster so we expect to see more

956

00:41:12,510 --> 00:41:19,230  
galaxies there and also B well that's

957

00:41:17,670 --> 00:41:21,329  
the main reason basically they have the

958

00:41:19,230 --> 00:41:24,480  
higher you go in redshift basically the

959

00:41:21,329 --> 00:41:27,299  
lens the effective area behind the lens

960

00:41:24,480 --> 00:41:28,469  
shrinks and shrinks so you are very

961

00:41:27,300 --> 00:41:30,390  
susceptible to that and you're not

962

00:41:28,469 --> 00:41:32,909  
likely to find many high redshift

963

00:41:30,389 --> 00:41:35,549  
objects but we do most of the objects

964

00:41:32,909 --> 00:41:36,750  
that we found we now know about almost

965

00:41:35,550 --> 00:41:38,640  
200 objects

966

00:41:36,750 --> 00:41:42,559  
magnified objects beyond this cluster or

967

00:41:38,639 --> 00:41:45,629  
it is 200 images of magnified objects

968

00:41:42,559 --> 00:41:48,179  
most of them are thread shift to receive

969

00:41:45,630 --> 00:41:52,289  
3 and then it goes down slowly up to

970  
00:41:48,179 --> 00:41:53,909  
achieve them ok but also let me let me

971  
00:41:52,289 --> 00:41:56,550  
interject it's actually kind of

972  
00:41:53,909 --> 00:42:01,710  
interesting because you can ask how many

973  
00:41:56,550 --> 00:42:04,470  
would we have expected and which perhaps

974  
00:42:01,710 --> 00:42:09,210  
is what you're getting at and I think if

975  
00:42:04,469 --> 00:42:12,659  
you if you predict how many say redshift

976  
00:42:09,210 --> 00:42:16,440  
n objects and 9 or 10 objects at

977  
00:42:12,659 --> 00:42:20,338  
9 or 10 we should have seen then it's

978  
00:42:16,440 --> 00:42:22,679  
more than one it's it's a handful and

979  
00:42:20,338 --> 00:42:26,250  
it's uncertain because it's a rough

980  
00:42:22,679 --> 00:42:28,169  
estimate and so we found one there's

981  
00:42:26,250 --> 00:42:30,838  
maybe another one that's a possible

982  
00:42:28,170 --> 00:42:34,108  
candidate and so this is another really

983  
00:42:30,838 --> 00:42:38,000  
exciting question that we're pursuing

984  
00:42:34,108 --> 00:42:40,670  
because maybe there are far fewer

985  
00:42:38,000 --> 00:42:43,650  
galaxies at these very high redshift

986  
00:42:40,670 --> 00:42:46,200  
than we were anticipating in which case

987  
00:42:43,650 --> 00:42:48,838  
maybe we really are seeing the beginning

988  
00:42:46,199 --> 00:42:52,219  
the very beginning of when galaxy

989  
00:42:48,838 --> 00:42:54,989  
formation really started to ramp up

990  
00:42:52,219 --> 00:42:56,699  
alternatively maybe it's just this one

991  
00:42:54,989 --> 00:42:59,279  
cluster the fact that we've only looked

992  
00:42:56,699 --> 00:43:01,348  
at one cluster and this is one of the

993  
00:42:59,280 --> 00:43:03,839  
great strengths of the Hubble frontier

994  
00:43:01,349 --> 00:43:06,150  
field is we're not putting our eggs into

995  
00:43:03,838 --> 00:43:08,159  
a single basket we're looking at

996  
00:43:06,150 --> 00:43:10,740  
hopefully ultimately six different

997  
00:43:08,159 --> 00:43:13,588  
clusters right if they all tell the same

998

00:43:10,739 --> 00:43:15,509  
story then we can be confident that we

999  
00:43:13,588 --> 00:43:19,349  
really are seeing the beginning of the

1000  
00:43:15,510 --> 00:43:23,250  
build-up and but that'll come out in the

1001  
00:43:19,349 --> 00:43:26,160  
next year RN - yeah that's a good ask

1002  
00:43:23,250 --> 00:43:27,809  
Carol about that so the the frontier

1003  
00:43:26,159 --> 00:43:30,088  
fields is going to continue gathering

1004  
00:43:27,809 --> 00:43:32,930  
observations for roughly how long do we

1005  
00:43:30,088 --> 00:43:35,369  
know the entire period is through the

1006  
00:43:32,929 --> 00:43:38,308  
allocation of time is for three years so

1007  
00:43:35,369 --> 00:43:40,470  
it's roughly it it roughly takes a year

1008  
00:43:38,309 --> 00:43:43,170  
to do two clusters because there are

1009  
00:43:40,469 --> 00:43:44,969  
many many observations and also the

1010  
00:43:43,170 --> 00:43:47,460  
nature of getting both the advanced

1011  
00:43:44,969 --> 00:43:51,149  
camera for surveys and getting the Wide

1012  
00:43:47,460 --> 00:43:53,068

Field Camera 3 that's yes and so that

1013

00:43:51,150 --> 00:43:56,880

takes the better part of a year to do

1014

00:43:53,068 --> 00:43:58,858

two clusters so they just just begun a

1015

00:43:56,880 --> 00:44:01,048

couple other clusters and there is new

1016

00:43:58,858 --> 00:44:03,808

data coming in a substantial amount of

1017

00:44:01,048 --> 00:44:06,778

new data coming in on a third cluster

1018

00:44:03,809 --> 00:44:08,730

and actually this is all on the webpage

1019

00:44:06,778 --> 00:44:11,460

you can just google frontier fields you

1020

00:44:08,730 --> 00:44:14,579

can see what the allocation is of when

1021

00:44:11,460 --> 00:44:16,858

the data is going to be observed what

1022

00:44:14,579 --> 00:44:18,559

data has been released all the papers

1023

00:44:16,858 --> 00:44:22,889

that have been written about these

1024

00:44:18,559 --> 00:44:25,590

clusters and so it will take another two

1025

00:44:22,889 --> 00:44:28,769

years or so - one and a half

1026

00:44:25,590 --> 00:44:30,829

years - to complete all six right and



1027  
00:44:28,769 --> 00:44:33,509  
what's gonna head over to the blog -

1028  
00:44:30,829 --> 00:44:36,179  
there is a blog as well yeah which is

1029  
00:44:33,510 --> 00:44:37,860  
accessible off of the main frontier

1030  
00:44:36,179 --> 00:44:39,539  
fields I'm sorry

1031  
00:44:37,860 --> 00:44:41,130  
thank you Scott yeah that's the frontier

1032  
00:44:39,539 --> 00:44:43,190  
fields org so you can definitely head

1033  
00:44:41,130 --> 00:44:45,750  
over there we're posting on that

1034  
00:44:43,190 --> 00:44:47,420  
regularly as we can and also there's

1035  
00:44:45,750 --> 00:44:51,300  
also there's also a really nice

1036  
00:44:47,420 --> 00:44:53,670  
scheduler or a chart showing where fluid

1037  
00:44:51,300 --> 00:44:56,640  
frontier fields is on the in there

1038  
00:44:53,670 --> 00:45:00,780  
observing program on the stsci dot edu

1039  
00:44:56,639 --> 00:45:02,279  
slash HS tff page and you'll be able to

1040  
00:45:00,780 --> 00:45:04,860  
kind of track the progress but i wanted

1041  
00:45:02,280 --> 00:45:06,360  
to give people kind of a sense of you

1042  
00:45:04,860 --> 00:45:10,500  
know the timelines that john was talking

1043  
00:45:06,360 --> 00:45:12,480  
about there that john makes this is an

1044  
00:45:10,500 --> 00:45:14,130  
important one we've all read always said

1045  
00:45:12,480 --> 00:45:17,070  
that about the Hubble Deep fields is

1046  
00:45:14,130 --> 00:45:21,240  
that these are tiny real regions of the

1047  
00:45:17,070 --> 00:45:25,200  
sky and a little tiny area of the of the

1048  
00:45:21,239 --> 00:45:29,489  
universe and so in order to confirm and

1049  
00:45:25,199 --> 00:45:32,909  
and quantify these results you need to

1050  
00:45:29,489 --> 00:45:35,669  
look at several different places and so

1051  
00:45:32,909 --> 00:45:39,029  
we needed several different clusters the

1052  
00:45:35,670 --> 00:45:41,130  
reserve Michael Joe Vinay apparently I

1053  
00:45:39,030 --> 00:45:43,860  
messed up your comment it was actually a

1054  
00:45:41,130 --> 00:45:45,480  
question the 100 block I didn't see a

1055

00:45:43,860 --> 00:45:47,579  
question mark so I read it as a comment

1056  
00:45:45,480 --> 00:45:50,369  
but it's yeah we did talk about that

1057  
00:45:47,579 --> 00:45:51,719  
early in the hangout these these

1058  
00:45:50,369 --> 00:45:52,829  
supermassive black holes in the early

1059  
00:45:51,719 --> 00:45:55,769  
universe are sort of an open question

1060  
00:45:52,829 --> 00:45:58,139  
but yes it is I believe something that

1061  
00:45:55,769 --> 00:45:59,460  
hopefully can be observed going forward

1062  
00:45:58,139 --> 00:46:04,980  
I'm sorry I didn't read it as a question

1063  
00:45:59,460 --> 00:46:06,269  
so forgive me on that so I D you it says

1064  
00:46:04,980 --> 00:46:09,449  
on your little thing there that you're a

1065  
00:46:06,269 --> 00:46:12,090  
Hubble fellow yes what is that

1066  
00:46:09,449 --> 00:46:15,539  
what's a Hubble fellow I just to explain

1067  
00:46:12,090 --> 00:46:17,490  
in a second I just urge to just say one

1068  
00:46:15,539 --> 00:46:20,000  
more thing about the galaxy okay fair

1069  
00:46:17,489 --> 00:46:23,009

enough by all means I think we didn't

1070

00:46:20,000 --> 00:46:25,949

mention that currently to date we only

1071

00:46:23,010 --> 00:46:29,280

know of about a dozen redshift N or

1072

00:46:25,949 --> 00:46:31,859

about candidates so clearly one it and

1073

00:46:29,280 --> 00:46:34,680

each another one that we think we detect

1074

00:46:31,860 --> 00:46:36,480

is a big deal is a great thing but the

1075

00:46:34,679 --> 00:46:39,210

special thing about this one is that

1076

00:46:36,480 --> 00:46:42,449

it's much increasingly fainter

1077

00:46:39,210 --> 00:46:44,159

than all of the other candidates we

1078

00:46:42,449 --> 00:46:47,159

chose again the power of the frontier

1079

00:46:44,159 --> 00:46:49,139

fields and of lensing to really see the

1080

00:46:47,159 --> 00:46:50,879

fainter and fainter galaxies in the

1081

00:46:49,139 --> 00:46:53,279

early universe because we expect that

1082

00:46:50,880 --> 00:46:54,000

most of them are much fainter than this

1083

00:46:53,280 --> 00:46:56,670

one again

1084  
00:46:54,000 --> 00:46:58,920  
Wow so even even more hopefully you'll

1085  
00:46:56,670 --> 00:47:00,750  
be able to get even more fainter ones as

1086  
00:46:58,920 --> 00:47:02,940  
observations we put together so that's

1087  
00:47:00,750 --> 00:47:04,110  
great that way and I will be happy to

1088  
00:47:02,940 --> 00:47:05,820  
answer your question thank you

1089  
00:47:04,110 --> 00:47:07,710  
yes I want to know what a Hubble fellow

1090  
00:47:05,820 --> 00:47:09,780  
is I want to become want to be known as

1091  
00:47:07,710 --> 00:47:11,070  
that I'm a Hubble I I'm a Hubble hugger

1092  
00:47:09,780 --> 00:47:13,290  
but I don't think that's the same thing

1093  
00:47:11,070 --> 00:47:16,140  
okay I guess not

1094  
00:47:13,289 --> 00:47:18,630  
so basically after you know we

1095  
00:47:16,139 --> 00:47:21,989  
astronomers do our PhD we are looking

1096  
00:47:18,630 --> 00:47:24,000  
for a postdoc position which is

1097  
00:47:21,989 --> 00:47:27,089  
basically doing some kind of internship

1098  
00:47:24,000 --> 00:47:31,050  
in our field doing our own research

1099  
00:47:27,090 --> 00:47:33,840  
usually with a very distinguished

1100  
00:47:31,050 --> 00:47:38,340  
professor for example so I did my first

1101  
00:47:33,840 --> 00:47:40,079  
postdoc in Germany and then I worked

1102  
00:47:38,340 --> 00:47:41,730  
mainly with the Hubble data again

1103  
00:47:40,079 --> 00:47:44,400  
looking for higher chief galaxies but

1104  
00:47:41,730 --> 00:47:46,199  
mainly doing lensing and constructing

1105  
00:47:44,400 --> 00:47:48,030  
lens models and I applied for a

1106  
00:47:46,199 --> 00:47:51,389  
fellowship which means that you will not

1107  
00:47:48,030 --> 00:47:54,000  
be working under our professor but more

1108  
00:47:51,389 --> 00:47:59,099  
freely to do whatever you want basically

1109  
00:47:54,000 --> 00:48:01,590  
but hopefully using Hubble data and I'm

1110  
00:47:59,099 --> 00:48:05,779  
happy that I've got it and then take

1111  
00:48:01,590 --> 00:48:08,100  
Caltech it's a three-year term basically

1112

00:48:05,780 --> 00:48:10,470  
just a salary you know to do your own

1113  
00:48:08,099 --> 00:48:13,049  
research with Hubble and explore the

1114  
00:48:10,469 --> 00:48:13,889  
things that you want to explore well it

1115  
00:48:13,050 --> 00:48:15,450  
sounds like you've got a bright future

1116  
00:48:13,889 --> 00:48:17,690  
ahead of you that's a great way to get

1117  
00:48:15,449 --> 00:48:20,579  
started

1118  
00:48:17,690 --> 00:48:21,690  
awesome okay so thanks for thanks for

1119  
00:48:20,579 --> 00:48:24,269  
that I just wanted to give people a

1120  
00:48:21,690 --> 00:48:26,400  
little little insight into some of the

1121  
00:48:24,269 --> 00:48:28,440  
career paths astronomers take a little

1122  
00:48:26,400 --> 00:48:29,880  
bit now maybe I'll get back to that in a

1123  
00:48:28,440 --> 00:48:32,099  
minute but I have a good question here

1124  
00:48:29,880 --> 00:48:34,829  
from Cecil Morgan again it goes does the

1125  
00:48:32,099 --> 00:48:38,309  
math does the magnification effect apply

1126  
00:48:34,829 --> 00:48:41,809

uniformly across the entire spectrum

1127

00:48:38,309 --> 00:48:45,090

that's kind of good so what can you can

1128

00:48:41,809 --> 00:48:47,130

is all radiation can it be lens yes

1129

00:48:45,090 --> 00:48:49,380

that's a great question and that's one

1130

00:48:47,130 --> 00:48:52,470

of the amazing properties of lensing

1131

00:48:49,380 --> 00:48:54,539

that it's not susceptible to the wave

1132

00:48:52,469 --> 00:48:57,149

or the color so all the colors all the

1133

00:48:54,539 --> 00:48:58,739

wavelengths no matter where you are in

1134

00:48:57,150 --> 00:49:00,480

the electromagnetic spectrum they are

1135

00:48:58,739 --> 00:49:03,029

all being lens D in the same manner

1136

00:49:00,480 --> 00:49:05,849

I'm really good as a follow-up he he's

1137

00:49:03,030 --> 00:49:09,000

asking would it be useful to point Alma

1138

00:49:05,849 --> 00:49:11,880

at it Alma is the Atacama what is it I

1139

00:49:09,000 --> 00:49:15,090

become a large malaria ray yeah it's

1140

00:49:11,880 --> 00:49:16,440

this big radio telescope high in the



1141  
00:49:15,090 --> 00:49:19,170  
Chilean mountains and it's got a very

1142  
00:49:16,440 --> 00:49:22,530  
high resolution would be useful to point

1143  
00:49:19,170 --> 00:49:24,659  
only at something like this I it's a

1144  
00:49:22,530 --> 00:49:27,480  
great idea you've got a first ask

1145  
00:49:24,659 --> 00:49:28,889  
whether it's observable by Alma and in

1146  
00:49:27,480 --> 00:49:29,760  
fact that's what I was doing while we

1147  
00:49:28,889 --> 00:49:33,000  
were talking there

1148  
00:49:29,760 --> 00:49:35,520  
I am indeed a bell 27:44 is in the

1149  
00:49:33,000 --> 00:49:40,039  
southern hemisphere and so you could in

1150  
00:49:35,519 --> 00:49:42,480  
principle point Alma at this object but

1151  
00:49:40,039 --> 00:49:45,059  
unfortunately even though Alma is very

1152  
00:49:42,480 --> 00:49:47,460  
much state of the art and the most

1153  
00:49:45,059 --> 00:49:50,820  
powerful radio telescope millimetre

1154  
00:49:47,460 --> 00:49:54,599  
radio telescope ever constructed this

1155  
00:49:50,820 --> 00:49:57,140  
object is so distant and so faint that I

1156  
00:49:54,599 --> 00:50:00,630  
I think it's beyond its capabilities

1157  
00:49:57,139 --> 00:50:03,118  
there have been some detections so what

1158  
00:50:00,630 --> 00:50:07,108  
Alma allows you to probe is the gas in a

1159  
00:50:03,119 --> 00:50:10,470  
galaxy and it was used to try to observe

1160  
00:50:07,108 --> 00:50:13,130  
an object at a redshift of about six six

1161  
00:50:10,469 --> 00:50:16,500  
and a half and it was detected was a

1162  
00:50:13,130 --> 00:50:19,530  
lens a galaxy and it was in fact

1163  
00:50:16,500 --> 00:50:22,588  
detected there was another object at a

1164  
00:50:19,530 --> 00:50:24,780  
redshift of nine that we discovered in

1165  
00:50:22,588 --> 00:50:26,969  
another cluster field predating the

1166  
00:50:24,780 --> 00:50:29,609  
Hubble frontier field and that was an

1167  
00:50:26,969 --> 00:50:33,299  
upper limit in other words it wasn't

1168  
00:50:29,608 --> 00:50:36,088  
actually detected so so it's great idea

1169

00:50:33,300 --> 00:50:38,160  
and it's as astronomers we're always

1170  
00:50:36,088 --> 00:50:40,259  
data starved and we'll take whatever

1171  
00:50:38,159 --> 00:50:42,449  
data we can get but we're also limited

1172  
00:50:40,260 --> 00:50:45,089  
by the you know the size telescopes that

1173  
00:50:42,449 --> 00:50:46,649  
were able to build okay and I want to

1174  
00:50:45,088 --> 00:50:48,150  
follow up with one more he think he had

1175  
00:50:46,650 --> 00:50:49,829  
three in this little one here and I like

1176  
00:50:48,150 --> 00:50:51,269  
this last one too because let's talk

1177  
00:50:49,829 --> 00:50:53,940  
about j-dub you see just a little bit

1178  
00:50:51,269 --> 00:50:56,940  
how does this magnified image compared

1179  
00:50:53,940 --> 00:50:58,349  
to what's expected of normal JWST images

1180  
00:50:56,940 --> 00:50:59,369  
so this is this we were able to get

1181  
00:50:58,349 --> 00:51:02,070  
because of the help of this

1182  
00:50:59,369 --> 00:51:03,838  
gravitational lens we're gonna be seeing

1183  
00:51:02,070 --> 00:51:05,490

more of these smudges and JWST does

1184

00:51:03,838 --> 00:51:05,989

anybody want to speculate what we might

1185

00:51:05,489 --> 00:51:08,669

see

1186

00:51:05,989 --> 00:51:12,619

so the expectation is that we are going

1187

00:51:08,670 --> 00:51:15,420

to see we JW's to about two or three

1188

00:51:12,619 --> 00:51:17,190

magnitudes fainter which means that

1189

00:51:15,420 --> 00:51:20,338

we're going to see many more objects

1190

00:51:17,190 --> 00:51:22,409

these red shifts and higher because

1191

00:51:20,338 --> 00:51:24,929

they're primarily it's got it's got a

1192

00:51:22,409 --> 00:51:26,608

much larger primary mirror you'll be

1193

00:51:24,929 --> 00:51:29,639

able to see way too much light higher

1194

00:51:26,608 --> 00:51:32,518

resolution and also the detectors have a

1195

00:51:29,639 --> 00:51:33,868

wider infrared wavelength right so good

1196

00:51:32,518 --> 00:51:37,708

thank you see so those rules were

1197

00:51:33,869 --> 00:51:39,479

excellent questions and let's see beta

1198  
00:51:37,708 --> 00:51:41,788  
flux is going this is not a question but

1199  
00:51:39,478 --> 00:51:44,159  
I think there has to be a supermassive

1200  
00:51:41,789 --> 00:51:45,930  
black hole for stars to clump together I

1201  
00:51:44,159 --> 00:51:47,788  
also think the supermassive black holes

1202  
00:51:45,929 --> 00:51:50,639  
produce super powerful magnetic field

1203  
00:51:47,789 --> 00:51:52,819  
lines similar to the Sun's Parker spirals

1204  
00:51:50,639 --> 00:51:56,639  
which in turn pushes the gas together

1205  
00:51:52,818 --> 00:51:59,248  
triggering star birth so he's saying

1206  
00:51:56,639 --> 00:52:01,798  
that pretty much has to be in order for

1207  
00:51:59,248 --> 00:52:03,509  
these things to form Thank You peda well

1208  
00:52:01,798 --> 00:52:05,338  
though we're starting to see that these

1209  
00:52:03,509 --> 00:52:09,478  
we you know you can get aids early

1210  
00:52:05,338 --> 00:52:12,690  
galaxies without those without those

1211  
00:52:09,478 --> 00:52:14,879  
things so okay so Scott how am i doing

1212  
00:52:12,690 --> 00:52:17,309  
did i did i miss to be doing great i

1213  
00:52:14,880 --> 00:52:18,869  
think of everything else and some of the

1214  
00:52:17,309 --> 00:52:21,839  
things are on twitter were actually

1215  
00:52:18,869 --> 00:52:23,640  
answer down there so okay well thank you

1216  
00:52:21,838 --> 00:52:25,018  
guys for for being active on twitter i

1217  
00:52:23,639 --> 00:52:27,449  
appreciate i look at all this hubble

1218  
00:52:25,018 --> 00:52:31,379  
hangouts that's great so thank you guys

1219  
00:52:27,449 --> 00:52:34,528  
for for for doing that I think what oh

1220  
00:52:31,380 --> 00:52:38,548  
oh hold on there's another one here beta

1221  
00:52:34,528 --> 00:52:42,179  
fluxes what are the equations behind

1222  
00:52:38,548 --> 00:52:44,568  
your shoulder Adi is that your is that

1223  
00:52:42,179 --> 00:52:49,919  
your latest paper your latest paper

1224  
00:52:44,568 --> 00:52:54,949  
let's not get them scooped now looks

1225  
00:52:49,920 --> 00:52:57,749  
like chicken scratch are you muted Adi

1226

00:52:54,949 --> 00:53:01,440  
it's just some flux calibration nothing

1227  
00:52:57,748 --> 00:53:02,728  
special okay okay I thought you were

1228  
00:53:01,440 --> 00:53:07,289  
building a TARDIS back there or

1229  
00:53:02,728 --> 00:53:10,048  
something like that so John you're a

1230  
00:53:07,289 --> 00:53:12,180  
professor at Siena College and you said

1231  
00:53:10,048 --> 00:53:14,038  
it's a it's a small liberal arts school

1232  
00:53:12,179 --> 00:53:17,728  
did you say yeah that's right

1233  
00:53:14,039 --> 00:53:19,130  
so what advice do you have for people

1234  
00:53:17,728 --> 00:53:22,250  
looking to go into it

1235  
00:53:19,130 --> 00:53:24,470  
as a career what what let's say you

1236  
00:53:22,250 --> 00:53:25,489  
wanted to they're thinking about doing

1237  
00:53:24,469 --> 00:53:28,309  
it would you have anything you'd say to

1238  
00:53:25,489 --> 00:53:31,729  
these two young people yeah let's see so

1239  
00:53:28,309 --> 00:53:34,880  
I think the most important thing is just

1240  
00:53:31,730 --> 00:53:36,619

to be curious innately curious and

1241  
00:53:34,880 --> 00:53:39,559  
interested in learning about the world

1242  
00:53:36,619 --> 00:53:42,309  
around you another common question I get

1243  
00:53:39,559 --> 00:53:45,170  
it doesn't matter what you do in college

1244  
00:53:42,309 --> 00:53:48,710  
if you're interested ultimately in

1245  
00:53:45,170 --> 00:53:51,530  
astronomy it's a career or as a path

1246  
00:53:48,710 --> 00:53:53,389  
that you want to take it's not as

1247  
00:53:51,530 --> 00:53:56,150  
important that you get an undergraduate

1248  
00:53:53,389 --> 00:53:58,009  
astronomy education a certainly a

1249  
00:53:56,150 --> 00:54:00,740  
physics education is something you want

1250  
00:53:58,010 --> 00:54:03,350  
to you want to have a solid grounding in

1251  
00:54:00,739 --> 00:54:06,829  
but I many my friends and colleagues

1252  
00:54:03,349 --> 00:54:09,980  
have were physics as in college and then

1253  
00:54:06,829 --> 00:54:12,829  
did astronomy in graduate school but if

1254  
00:54:09,980 --> 00:54:16,159  
you are serious about astronomy as an



1255  
00:54:12,829 --> 00:54:18,469  
actual career you do need to and will

1256  
00:54:16,159 --> 00:54:21,230  
want to get your doctorate your PhD

1257  
00:54:18,469 --> 00:54:25,039  
which is a long grueling process but

1258  
00:54:21,230 --> 00:54:28,099  
also they're rewarding another path that

1259  
00:54:25,039 --> 00:54:30,860  
we many of our students here at Siana

1260  
00:54:28,099 --> 00:54:33,619  
college take is - we have a minor in

1261  
00:54:30,860 --> 00:54:36,289  
astrophysics and so students will major

1262  
00:54:33,619 --> 00:54:38,269  
in physics minor in astrophysics maybe

1263  
00:54:36,289 --> 00:54:42,079  
go on and get their masters in astronomy

1264  
00:54:38,269 --> 00:54:43,579  
and then become educators and do you

1265  
00:54:42,079 --> 00:54:45,380  
know make possible the kinds of things

1266  
00:54:43,579 --> 00:54:48,139  
that you guys do which is bringing

1267  
00:54:45,380 --> 00:54:51,769  
science and science education to to the

1268  
00:54:48,139 --> 00:54:54,469  
greater public but in terms of the

1269  
00:54:51,769 --> 00:54:57,650  
academic track after as addy said after

1270  
00:54:54,469 --> 00:55:00,319  
graduate school you're in for like one

1271  
00:54:57,650 --> 00:55:03,410  
or two postdoctoral fellowships within

1272  
00:55:00,320 --> 00:55:05,900  
three years and and I've been lucky

1273  
00:55:03,409 --> 00:55:07,639  
enough to to have this faculty position

1274  
00:55:05,900 --> 00:55:10,309  
here at Siena I've been here this was

1275  
00:55:07,639 --> 00:55:13,190  
start of my third year and it's a great

1276  
00:55:10,309 --> 00:55:14,869  
place with fantastic students so you

1277  
00:55:13,190 --> 00:55:15,409  
know you're in high school and you want

1278  
00:55:14,869 --> 00:55:19,809  
to come visit

1279  
00:55:15,409 --> 00:55:19,809  
send me some email well you recruit oh

1280  
00:55:23,110 --> 00:55:28,039  
good job good job one more question and

1281  
00:55:25,610 --> 00:55:29,780  
they were gonna have to go Daniel Masada

1282  
00:55:28,039 --> 00:55:32,210  
was asking if the universe was old

1283

00:55:29,780 --> 00:55:32,810  
enough would we eventually see something

1284  
00:55:32,210 --> 00:55:36,199  
past

1285  
00:55:32,809 --> 00:55:38,059  
redshifted like microwave shifted and I

1286  
00:55:36,199 --> 00:55:39,289  
understand this properly I guess you

1287  
00:55:38,059 --> 00:55:40,759  
know for example the microwave

1288  
00:55:39,289 --> 00:55:44,869  
background radiation that we see is

1289  
00:55:40,760 --> 00:55:46,400  
basically the redshifted remnants of the

1290  
00:55:44,869 --> 00:55:49,159  
radiation from the Big Bang itself

1291  
00:55:46,400 --> 00:55:51,619  
correct so if so what happens when it

1292  
00:55:49,159 --> 00:55:57,319  
gets older well it will it go past the

1293  
00:55:51,619 --> 00:55:57,589  
microwave yeah I mean I can I can answer

1294  
00:55:57,320 --> 00:56:00,830  
that

1295  
00:55:57,590 --> 00:56:02,930  
going back to my auditorium analogy so

1296  
00:56:00,829 --> 00:56:04,699  
as you look further and further back the

1297  
00:56:02,929 --> 00:56:06,980

individuals in the audience get younger

1298

00:56:04,699 --> 00:56:08,569

and younger but then way back in the

1299

00:56:06,980 --> 00:56:10,699

back of the auditorium what you would

1300

00:56:08,570 --> 00:56:14,269

see is this faint glow and that's the

1301

00:56:10,699 --> 00:56:18,169

Cosmic Microwave Background this thermal

1302

00:56:14,269 --> 00:56:20,179

relic of the Big Bang and the you can

1303

00:56:18,170 --> 00:56:21,800

measure you can actually predict the

1304

00:56:20,179 --> 00:56:23,960

redshift of the Cosmic Microwave

1305

00:56:21,800 --> 00:56:28,310

Background and it's at a redshift of

1306

00:56:23,960 --> 00:56:30,530

about 1100 or about a thousand but we

1307

00:56:28,309 --> 00:56:34,909

really can't see beyond that it's like

1308

00:56:30,530 --> 00:56:37,790

an opaque screen beyond which pass that

1309

00:56:34,909 --> 00:56:39,589

photons never light never traveled in a

1310

00:56:37,789 --> 00:56:44,409

straight line and so we'll never be able

1311

00:56:39,590 --> 00:56:48,380

to see with light beyond that beyond the

1312  
00:56:44,409 --> 00:56:50,389  
surface that surface is the furthest

1313  
00:56:48,380 --> 00:56:53,000  
back we can see it but it's also it as

1314  
00:56:50,389 --> 00:56:54,409  
the universe is expanding is also still

1315  
00:56:53,000 --> 00:56:57,440  
shifting back so that's a good question

1316  
00:56:54,409 --> 00:56:59,179  
on Daniel appreciate that okay guys I

1317  
00:56:57,440 --> 00:57:01,579  
guess we'll stop there we're at about an

1318  
00:56:59,179 --> 00:57:03,199  
hour thank you this was really great

1319  
00:57:01,579 --> 00:57:05,000  
this was really exciting thanks to both

1320  
00:57:03,199 --> 00:57:06,649  
of you Adi and John of her for being on

1321  
00:57:05,000 --> 00:57:08,389  
our hangout and talking to us about

1322  
00:57:06,650 --> 00:57:10,160  
distant galaxies we'll hope you'll come

1323  
00:57:08,389 --> 00:57:12,559  
back when you get more galaxies

1324  
00:57:10,159 --> 00:57:14,599  
discovered sure thank you all for

1325  
00:57:12,559 --> 00:57:16,549  
organizing these and all the viewers for

1326  
00:57:14,599 --> 00:57:18,190  
asking great questions thanks a lot

1327  
00:57:16,550 --> 00:57:20,450  
yeah thanks for this great opportunity

1328  
00:57:18,190 --> 00:57:23,480  
all right well thank you both and we'll

1329  
00:57:20,449 --> 00:57:26,089  
all right we looking for Carol and I to

1330  
00:57:23,480 --> 00:57:28,130  
contact you on on maybe doing some more

1331  
00:57:26,090 --> 00:57:29,930  
of these so thank you very much

1332  
00:57:28,130 --> 00:57:32,780  
I guess that's it for this this

1333  
00:57:29,929 --> 00:57:34,549  
go-around guys next week we're gonna be

1334  
00:57:32,780 --> 00:57:36,800  
skipping because of the Thanksgiving

1335  
00:57:34,550 --> 00:57:38,690  
holiday here in the United States so we

1336  
00:57:36,800 --> 00:57:41,960  
will not have a hangout next week but

1337  
00:57:38,690 --> 00:57:44,869  
the week after that the in two weeks we

1338  
00:57:41,960 --> 00:57:46,139  
will be back well hopefully with John

1339  
00:57:44,869 --> 00:57:48,568  
Davis and

1340

00:57:46,139 --> 00:57:51,210  
a colleague to talk about debris disks

1341  
00:57:48,568 --> 00:57:53,429  
around stars and apparently there's a

1342  
00:57:51,210 --> 00:57:55,679  
difference between a debris disc and a

1343  
00:57:53,429 --> 00:57:57,750  
dust disc and a protoplanetary disc

1344  
00:57:55,679 --> 00:57:58,798  
those all have different reading no

1345  
00:57:57,750 --> 00:58:00,659  
those are they're all different they're

1346  
00:57:58,798 --> 00:58:02,219  
not the same so be careful what you call

1347  
00:58:00,659 --> 00:58:06,528  
them we're gonna be talking about debris

1348  
00:58:02,219 --> 00:58:09,598  
disks in two weeks right Carol yep okay

1349  
00:58:06,528 --> 00:58:11,028  
Scott awesome thank good driving I

1350  
00:58:09,599 --> 00:58:13,859  
appreciate that

1351  
00:58:11,028 --> 00:58:16,500  
absolutely all right everybody well

1352  
00:58:13,858 --> 00:58:18,679  
thank you guys for watching thanks very

1353  
00:58:16,500 --> 00:58:18,679  
much