

1
00:00:08,210 --> 00:00:19,949
or back oh my gosh hello hello and

2
00:00:17,010 --> 00:00:22,939
welcome to the first Hubble hang out of

3
00:00:19,949 --> 00:00:26,429
2016 and it begins auspicious Lorraine

4
00:00:22,939 --> 00:00:28,759
initially a telephone call the instant

5
00:00:26,429 --> 00:00:31,079
we had started broadcast thats hilarious

6
00:00:28,760 --> 00:00:33,030
anyway my name is Tony Darnell and I'm

7
00:00:31,079 --> 00:00:34,679
really excited to be back doing these

8
00:00:33,030 --> 00:00:36,630
hangouts for this year we've got a lot

9
00:00:34,679 --> 00:00:38,909
of great hangouts plan for you and in

10
00:00:36,630 --> 00:00:40,890
fact today in particular we're going to

11
00:00:38,909 --> 00:00:43,289
be talking about galaxy clusters in the

12
00:00:40,890 --> 00:00:46,140
early universe because astronomers using

13
00:00:43,289 --> 00:00:48,179
three of NASA's great observatories the

14
00:00:46,140 --> 00:00:49,859
Hubble Space Telescope the Chandra x-ray

15
00:00:48,179 --> 00:00:52,378
telescope and the Spitzer Space

16
00:00:49,859 --> 00:00:55,378
Telescope along with the Keck

17
00:00:52,378 --> 00:00:58,170
Observatory in Hawaii have been looking

18
00:00:55,378 --> 00:01:01,259
at a have found one of the earliest and

19
00:00:58,170 --> 00:01:03,539
most massive galaxy clusters ever seen

20
00:01:01,259 --> 00:01:05,399
and we're going to talk about why that

21
00:01:03,539 --> 00:01:07,650
is important and we're going to put that

22
00:01:05,400 --> 00:01:09,859
in perspective for you with my with the

23
00:01:07,650 --> 00:01:12,210
help of my friends and colleagues

24
00:01:09,859 --> 00:01:13,709
joining me again this year dr. carol

25
00:01:12,209 --> 00:01:16,408
christian she's the Hubble Space

26
00:01:13,709 --> 00:01:18,149
Telescope outreach scientist and Scott

27
00:01:16,409 --> 00:01:21,180
Lewis is also here with us to help us

28
00:01:18,150 --> 00:01:23,460
just bring us back to earth and get the

29

00:01:21,180 --> 00:01:26,070
and tell us what's going on with the

30
00:01:23,459 --> 00:01:27,780
levity in this conversation yeah yeah

31
00:01:26,069 --> 00:01:32,819
yeah you might even be way out there I

32
00:01:27,780 --> 00:01:34,409
got ya the welcome back guy is a happy

33
00:01:32,819 --> 00:01:36,328
new year and all that kind of girl I

34
00:01:34,409 --> 00:01:42,030
mean it's good to be back doing these

35
00:01:36,328 --> 00:01:43,859
again um the UH the I guess usually this

36
00:01:42,030 --> 00:01:45,299
time of the the hangout we have some

37
00:01:43,859 --> 00:01:46,438
announcements but I don't really have

38
00:01:45,299 --> 00:01:48,420
any Carol do you have anything you'd

39
00:01:46,438 --> 00:01:51,389
like to point out anybody what's for

40
00:01:48,420 --> 00:01:52,920
just that James Webb telescope is doing

41
00:01:51,390 --> 00:01:55,618
really well and searching all the

42
00:01:52,920 --> 00:01:58,879
mirrors so let's come along we had a

43
00:01:55,618 --> 00:02:03,540

great american astronomical society

44

00:01:58,879 --> 00:02:06,030
meeting last week where results were

45

00:02:03,540 --> 00:02:08,729
presented in including this one right

46

00:02:06,030 --> 00:02:11,370
and that's right it was presented at the

47

00:02:08,729 --> 00:02:13,379
double-a s last week it was a lot there

48

00:02:11,370 --> 00:02:13,830
there were a lot of interesting results

49

00:02:13,378 --> 00:02:17,729
that

50

00:02:13,830 --> 00:02:21,420
came out and Hubble's doing well and

51

00:02:17,729 --> 00:02:23,759
we're off to a new cycle of proposals so

52

00:02:21,419 --> 00:02:26,579
we'll get to ask people oh are you going

53

00:02:23,759 --> 00:02:29,879
to propose for this in cycle 24 problem

54

00:02:26,580 --> 00:02:31,410
that's right now is the season it begins

55

00:02:29,879 --> 00:02:33,990
the season of asking for Hubble time

56

00:02:31,409 --> 00:02:38,430
isn't that right yeah that's right cool

57

00:02:33,990 --> 00:02:40,170
all right well uh so the so before we

58
00:02:38,430 --> 00:02:41,370
want to introduce my guest but before I

59
00:02:40,169 --> 00:02:44,399
get started I'm going to have Scott

60
00:02:41,370 --> 00:02:45,719
Lewis tell you guys how we'd like to get

61
00:02:44,400 --> 00:02:47,219
your questions and comments throughout

62
00:02:45,719 --> 00:02:49,919
the Hangout so we hope you'll engage

63
00:02:47,219 --> 00:02:52,109
with us and ask questions Scott tell

64
00:02:49,919 --> 00:02:53,759
people how they can do that alright so

65
00:02:52,110 --> 00:02:55,020
the the best and easiest way for you to

66
00:02:53,759 --> 00:02:56,639
get in touch with us while we're live

67
00:02:55,020 --> 00:02:58,860
since you're watching the streams on the

68
00:02:56,639 --> 00:03:00,599
very bottom left o be some texture that

69
00:02:58,860 --> 00:03:03,390
says that we're answering questions and

70
00:03:00,599 --> 00:03:05,340
we are it opens up to Q&A and it allows

71
00:03:03,389 --> 00:03:07,769
you to watch us and on the right hand

72
00:03:05,340 --> 00:03:09,300
side you'll have some you'll have a

73
00:03:07,770 --> 00:03:10,770
little menu in there where you can type

74
00:03:09,300 --> 00:03:12,719
in questions you can upload other

75
00:03:10,770 --> 00:03:15,120
questions too and so when we're going to

76
00:03:12,719 --> 00:03:16,590
our Q&A time we can actually select it

77
00:03:15,120 --> 00:03:18,269
and i'll actually notify you that we're

78
00:03:16,590 --> 00:03:20,519
answering those questions so that's a

79
00:03:18,269 --> 00:03:22,890
really really good way to engage with us

80
00:03:20,519 --> 00:03:24,810
while we're live broadcasting the other

81
00:03:22,889 --> 00:03:26,579
best way for you to get in touch with us

82
00:03:24,810 --> 00:03:29,280
is grover on Twitter so we are live

83
00:03:26,580 --> 00:03:32,040
tweeting right now as at Hubble

84
00:03:29,280 --> 00:03:33,930
telescope using the hashtag Hubble hang

85
00:03:32,039 --> 00:03:35,879
out so i'll be live tweeting as we're

86

00:03:33,930 --> 00:03:38,189
going on so if you have any questions or

87
00:03:35,879 --> 00:03:39,870
interesting insights I please use that

88
00:03:38,189 --> 00:03:41,969
hashtag and I'll be going back and forth

89
00:03:39,870 --> 00:03:45,390
with their i also have an event open on

90
00:03:41,969 --> 00:03:46,830
facebook and and we can check the

91
00:03:45,389 --> 00:03:48,268
regular YouTube comments as well so

92
00:03:46,830 --> 00:03:49,380
we'll be checking all over the place for

93
00:03:48,269 --> 00:03:52,050
any of the comments you have but the

94
00:03:49,379 --> 00:03:54,000
best way is using the Q&A app or using

95
00:03:52,050 --> 00:03:56,250
Twitter that's how we'll get in touch

96
00:03:54,000 --> 00:03:57,120
with you Oh some thank you so we look

97
00:03:56,250 --> 00:03:59,250
forward to your comments and questions

98
00:03:57,120 --> 00:04:00,900
and we'll read them as we go along or

99
00:03:59,250 --> 00:04:02,939
we'll have some time on set aside at the

100
00:04:00,900 --> 00:04:04,650

end to also read them out so we look

101

00:04:02,939 --> 00:04:08,189

forward to that so let me get to today's

102

00:04:04,650 --> 00:04:10,170

hangout as I said three of NASA's great

103

00:04:08,189 --> 00:04:11,819

observers how many are there Carol how

104

00:04:10,169 --> 00:04:15,479

many great observatories are there any

105

00:04:11,819 --> 00:04:19,769

way I'd other more than 3 billions and

106

00:04:15,479 --> 00:04:22,019

billions now after all right you know

107

00:04:19,769 --> 00:04:25,228

because nowadays the NASA has set these

108

00:04:22,019 --> 00:04:27,599

aside specifically as a yes the

109

00:04:25,228 --> 00:04:31,740

gamma-ray observatory was a grade of

110

00:04:27,600 --> 00:04:34,740

ritory Oh bit Spitzer which is infrared

111

00:04:31,740 --> 00:04:37,620

Hubble which is UV optical infrared and

112

00:04:34,740 --> 00:04:40,680

Chandra which is the x-ray Observatory

113

00:04:37,620 --> 00:04:43,889

so the bar be good they're not great or

114

00:04:40,680 --> 00:04:47,400

they swell are they danamon turns yeah

115
00:04:43,889 --> 00:04:52,860
pretty good you know awesome but yeah

116
00:04:47,399 --> 00:04:58,229
yeah they're just not great okay so well

117
00:04:52,860 --> 00:05:01,939
good so colleagues out there yeah yeah

118
00:04:58,230 --> 00:05:06,509
mom it's 2016 and work grumpy okay hey

119
00:05:01,939 --> 00:05:07,740
NASA Colton gray right okay so so a lot

120
00:05:06,509 --> 00:05:09,089
of a lot of wavelengths a lot of

121
00:05:07,740 --> 00:05:10,920
eyeballs were brought to bear on this

122
00:05:09,089 --> 00:05:12,089
particular set of observations so let's

123
00:05:10,920 --> 00:05:14,939
get to them but let me introduce our

124
00:05:12,089 --> 00:05:17,279
guests joining me is the the lead author

125
00:05:14,939 --> 00:05:20,219
on the on the paper dr. mark broad when

126
00:05:17,279 --> 00:05:22,409
he is a US and is an assistant professor

127
00:05:20,220 --> 00:05:24,380
at MIT he's also a member of the

128
00:05:22,410 --> 00:05:28,800
Cavalier for astrophysics and space

129
00:05:24,379 --> 00:05:31,219
research also dr. Anthony Gonzales he's

130
00:05:28,800 --> 00:05:33,930
a professor at the University of Florida

131
00:05:31,220 --> 00:05:37,080
very near where I'm at my where my home

132
00:05:33,930 --> 00:05:40,079
is actually also dr. Mike McDonald from

133
00:05:37,079 --> 00:05:42,000
from oh wait a minute did I get I got a

134
00:05:40,079 --> 00:05:44,819
backwards in my fraud when is university

135
00:05:42,000 --> 00:05:46,649
of missouri at kansas sorry about that I

136
00:05:44,819 --> 00:05:48,449
apologize he's at the university of

137
00:05:46,649 --> 00:05:50,459
missouri at kansas it's mike mcdonald

138
00:05:48,449 --> 00:05:52,949
who's from MIT an assistant professor a

139
00:05:50,459 --> 00:05:54,209
member or and a member of the MIT my

140
00:05:52,949 --> 00:05:57,089
teas carefully Center for Astrophysics

141
00:05:54,209 --> 00:05:58,859
based research here to talk about all

142
00:05:57,089 --> 00:06:00,810
these things so welcome to our hangout

143

00:05:58,860 --> 00:06:02,930
guys I'm glad we didn't scare you off

144
00:06:00,810 --> 00:06:06,030
and after we got through all of the

145
00:06:02,930 --> 00:06:07,500
initial browser difficulties we're back

146
00:06:06,029 --> 00:06:09,209
on track so let's talk about this a

147
00:06:07,500 --> 00:06:13,319
let's talk about this mark I'm going to

148
00:06:09,209 --> 00:06:15,569
start with you so you guys obviously got

149
00:06:13,319 --> 00:06:19,980
a lot of telescope time here to do this

150
00:06:15,569 --> 00:06:21,899
but the the you you guys have found not

151
00:06:19,980 --> 00:06:27,360
just found but you've characterized and

152
00:06:21,899 --> 00:06:29,669
measured the mass of one of the largest

153
00:06:27,360 --> 00:06:32,580
galaxy clusters in the early universe

154
00:06:29,670 --> 00:06:33,960
now astronomers you know it takes

155
00:06:32,579 --> 00:06:35,759
hundreds of millions of years for

156
00:06:33,959 --> 00:06:38,250
galaxies to form but even longer for

157
00:06:35,759 --> 00:06:39,659

galaxy clusters to form so I want to

158

00:06:38,250 --> 00:06:41,009

talk a little bit about your work and

159

00:06:39,660 --> 00:06:42,150

what you're doing and

160

00:06:41,009 --> 00:06:45,689

which are going to be presenting to us

161

00:06:42,149 --> 00:06:47,609

today okay thanks Tony yeah this this is

162

00:06:45,689 --> 00:06:49,259

a really exciting cluster that needed

163

00:06:47,610 --> 00:06:51,689

all of NASA's great observatories as

164

00:06:49,259 --> 00:06:53,968

well as some some awesome facilities on

165

00:06:51,689 --> 00:06:56,430

the ground in order to to both find and

166

00:06:53,968 --> 00:06:59,218

characterize we actually found it with

167

00:06:56,430 --> 00:07:00,749

Spitzer in 2012 and as Carol mentioned

168

00:06:59,218 --> 00:07:03,209

Spitzer's an infrared telescope that

169

00:07:00,749 --> 00:07:04,889

lets us see galaxies you know pretty

170

00:07:03,209 --> 00:07:06,930

massive galaxies all the way out in the

171

00:07:04,889 --> 00:07:09,210

universe unlike an optical they don't

172
00:07:06,930 --> 00:07:11,249
really fade so we can find them and you

173
00:07:09,209 --> 00:07:13,468
just God has a copy or Scott has an

174
00:07:11,249 --> 00:07:14,699
image of the 2012 cluster and while

175
00:07:13,468 --> 00:07:17,908
you're talking if he can pull that up

176
00:07:14,699 --> 00:07:20,759
that'd be great okay and so we actually

177
00:07:17,908 --> 00:07:22,860
found this cluster with Spitzer and we

178
00:07:20,759 --> 00:07:25,169
used Hubble back then not just to get

179
00:07:22,860 --> 00:07:26,520
pretty pictures but also to measure the

180
00:07:25,168 --> 00:07:28,649
distance to the cluster Hubble was

181
00:07:26,519 --> 00:07:30,478
actually the key facility in getting

182
00:07:28,649 --> 00:07:33,228
what we call a spectroscopic redshift

183
00:07:30,478 --> 00:07:35,968
although we also used Keck the 10-meter

184
00:07:33,228 --> 00:07:38,308
diameter mirror in Hawaii to help

185
00:07:35,968 --> 00:07:39,899
without that also together we were able

186
00:07:38,309 --> 00:07:42,270
to confirm that the distance is about 10

187
00:07:39,899 --> 00:07:44,430
billion light years away then we turned

188
00:07:42,269 --> 00:07:46,258
our attention to a radio telescope on

189
00:07:44,430 --> 00:07:48,598
the ground that no longer is in

190
00:07:46,259 --> 00:07:50,520
operation sadly but it was called karma

191
00:07:48,598 --> 00:07:52,998
and it allowed us to measure a first

192
00:07:50,519 --> 00:07:55,228
estimate of the mass of the cluster

193
00:07:52,999 --> 00:07:56,719
basically the way that works is if you

194
00:07:55,228 --> 00:07:59,008
look at the Cosmic Microwave Background

195
00:07:56,718 --> 00:08:00,808
when there's a cluster in the way it

196
00:07:59,009 --> 00:08:02,218
looks different the cluster gas affects

197
00:08:00,809 --> 00:08:04,409
the light coming from the cosmic

198
00:08:02,218 --> 00:08:06,629
microwave background and from how much

199
00:08:04,408 --> 00:08:08,248
the spectrum changes we can measure the

200

00:08:06,629 --> 00:08:10,289
mass of the cluster and we did that and

201
00:08:08,249 --> 00:08:12,149
got a mass of something like four

202
00:08:10,288 --> 00:08:16,068
hundred trillion times the mass of our

203
00:08:12,149 --> 00:08:18,418
Sun truly with a tea with a tea yeah Wow

204
00:08:16,069 --> 00:08:19,740
okay now let me make sure I understood

205
00:08:18,418 --> 00:08:21,120
what you just said so you said you

206
00:08:19,740 --> 00:08:24,149
looked at this with karma and radio

207
00:08:21,120 --> 00:08:25,978
waves rant based on the amount of

208
00:08:24,149 --> 00:08:27,809
distortion in the Cosmic Microwave

209
00:08:25,978 --> 00:08:29,699
Background in that wavelength you were

210
00:08:27,809 --> 00:08:33,389
able to get an idea how massive it was

211
00:08:29,699 --> 00:08:34,469
that's right yeah the basically the the

212
00:08:33,389 --> 00:08:37,019
photons from the Cosmic Microwave

213
00:08:34,469 --> 00:08:38,940
Background hit are they scatter they hit

214
00:08:37,019 --> 00:08:41,639

the electrons in the cluster and they

215

00:08:38,940 --> 00:08:43,649

change what the CMB looks like in fact

216

00:08:41,639 --> 00:08:45,329

at you the same be kind of disappears a

217

00:08:43,649 --> 00:08:46,679

little bit at the right if you look in

218

00:08:45,328 --> 00:08:49,259

the right frequency so you're kind of

219

00:08:46,679 --> 00:08:51,208

looking for holes in the sky and the

220

00:08:49,259 --> 00:08:53,789

deeper the whole the greater the mass of

221

00:08:51,208 --> 00:08:54,689

the cluster so those observations back

222

00:08:53,789 --> 00:08:58,139

in 2012

223

00:08:54,690 --> 00:09:00,060

kind of set the stage then for knowing

224

00:08:58,139 --> 00:09:02,610

that this was something very massive and

225

00:09:00,059 --> 00:09:05,519

very very far away correct yeah exactly

226

00:09:02,610 --> 00:09:08,009

and and the logical thing to do next was

227

00:09:05,519 --> 00:09:09,960

to try and get Shandra time shaundra's

228

00:09:08,009 --> 00:09:11,909

the premier facility for studying galaxy

229
00:09:09,960 --> 00:09:14,400
clusters in the x-ray and why was that

230
00:09:11,909 --> 00:09:16,529
why was that the logical next step why

231
00:09:14,399 --> 00:09:19,740
did you go from from radio all the way

232
00:09:16,529 --> 00:09:22,319
to x-ray it is a long way to go that's

233
00:09:19,740 --> 00:09:24,919
right as far as you can go but the

234
00:09:22,320 --> 00:09:26,970
reason is because the Chandra is the

235
00:09:24,919 --> 00:09:29,219
facility that's best able to

236
00:09:26,970 --> 00:09:31,639
characterize galaxy clusters all aspects

237
00:09:29,220 --> 00:09:33,810
of galaxy clusters and so that's when

238
00:09:31,639 --> 00:09:35,909
professor McDonald got involved I

239
00:09:33,809 --> 00:09:37,559
actually wrote the proposal but he did a

240
00:09:35,909 --> 00:09:40,889
lot of the analysis on the extra David

241
00:09:37,559 --> 00:09:42,449
he can speak to that okay Michael so you

242
00:09:40,889 --> 00:09:43,799
want to talk a little bit about some of

243
00:09:42,450 --> 00:09:45,680
the some of the x-ray data that you took

244
00:09:43,799 --> 00:09:48,870
from this image or from this cluster

245
00:09:45,679 --> 00:09:51,779
sure so the the x-ray data it gets a

246
00:09:48,870 --> 00:09:53,490
sense of not only how massive the

247
00:09:51,779 --> 00:09:55,230
cluster is but how that mass is

248
00:09:53,490 --> 00:09:58,470
distributed and sort of where the bulk

249
00:09:55,230 --> 00:10:00,800
of the matter is in the cluster because

250
00:09:58,470 --> 00:10:04,529
the bulk of the matter is in a very hot

251
00:10:00,799 --> 00:10:07,469
diffuse gas phase which is bright x-ray

252
00:10:04,529 --> 00:10:10,049
so Scott has scott has something very

253
00:10:07,470 --> 00:10:11,790
fuzzy and blue up is that what you're

254
00:10:10,049 --> 00:10:15,629
talking about that is exactly what I'm

255
00:10:11,789 --> 00:10:18,269
talking about yeah so this is an x-ray

256
00:10:15,629 --> 00:10:21,059
image of the cluster after we've hit the

257

00:10:18,269 --> 00:10:23,730
enhance button a few times to sort of

258
00:10:21,059 --> 00:10:25,829
improve their data quality but what

259
00:10:23,730 --> 00:10:28,440
you're seeing there is sort of a diffuse

260
00:10:25,830 --> 00:10:30,840
component that's you know a million

261
00:10:28,440 --> 00:10:33,620
light years across and then there's

262
00:10:30,840 --> 00:10:36,840
three peaks two of those Peaks are

263
00:10:33,620 --> 00:10:39,419
active actively creating black holes and

264
00:10:36,840 --> 00:10:41,940
the center of the three peaks the center

265
00:10:39,419 --> 00:10:45,120
is it's just the densest part of the ha

266
00:10:41,940 --> 00:10:47,880
Ozma ok so wait every bright spot we see

267
00:10:45,120 --> 00:10:49,879
here the really bright spot is a is a

268
00:10:47,879 --> 00:10:54,029
supermassive black hole in the galaxy

269
00:10:49,879 --> 00:10:55,529
burning so every every spot that we see

270
00:10:54,029 --> 00:10:57,569
here bright spot we see here in this

271
00:10:55,529 --> 00:11:00,389

image that's they the center of a galaxy

272

00:10:57,570 --> 00:11:02,490

or supermassive black hole right so all

273

00:11:00,389 --> 00:11:05,309

the peaks are either the center of the

274

00:11:02,490 --> 00:11:08,480

galaxy or a clump of galaxies but the

275

00:11:05,309 --> 00:11:10,789

diffuse stuff extends over the full

276

00:11:08,480 --> 00:11:14,360

for volume so the cluster the cluster

277

00:11:10,789 --> 00:11:17,028

galaxies are basically in a hot bath at

278

00:11:14,360 --> 00:11:21,110

this path is who's admitting in the next

279

00:11:17,028 --> 00:11:22,820

ways so this gas is by nature of the

280

00:11:21,110 --> 00:11:26,120

fact you're seeing in an x rays is

281

00:11:22,820 --> 00:11:28,820

extremely hot right or at least

282

00:11:26,120 --> 00:11:30,940

energetic correctness and its affiliates

283

00:11:28,820 --> 00:11:35,449

of degrees or millions of degrees thirty

284

00:11:30,940 --> 00:11:37,279

and does do all galaxy clusters have

285

00:11:35,448 --> 00:11:39,740

this kind of characters to gas I mean

286

00:11:37,278 --> 00:11:40,850
are they or is it just is this one I'm

287

00:11:39,740 --> 00:11:44,329
trying to I'm trying to get a sense of

288

00:11:40,850 --> 00:11:46,129
it is this special too early galaxy

289

00:11:44,328 --> 00:11:48,289
clusters or do all galaxy clusters know

290

00:11:46,129 --> 00:11:50,929
so so in fact the temperature of the gas

291

00:11:48,289 --> 00:11:52,879
tells us something about the mass or it

292

00:11:50,929 --> 00:11:56,448
tells us a lot about the mass so as you

293

00:11:52,879 --> 00:11:58,610
compressed gas it gets hotter and so the

294

00:11:56,448 --> 00:12:00,919
more mass you have that's pushing the

295

00:11:58,610 --> 00:12:03,649
cluster down and compressing it in the

296

00:12:00,919 --> 00:12:05,120
center the hotter the gas will be so by

297

00:12:03,649 --> 00:12:08,870
measuring the temperature of these

298

00:12:05,120 --> 00:12:10,639
x-rays we get a sense of how much matter

299

00:12:08,870 --> 00:12:12,740
is is sort of pulling in on the cluster

300
00:12:10,639 --> 00:12:15,049
that gives us a estimate of the total

301
00:12:12,740 --> 00:12:18,620
mass which is much more accurate than

302
00:12:15,049 --> 00:12:20,419
the radio s okay so that's why it was

303
00:12:18,620 --> 00:12:22,068
the next logical step to go from Radio

304
00:12:20,419 --> 00:12:25,458
to x-rays to get a bit more accurate

305
00:12:22,068 --> 00:12:28,490
mass then right okay alright so these

306
00:12:25,458 --> 00:12:32,289
also you have a question so why why do

307
00:12:28,490 --> 00:12:35,600
these galaxies clusters have like a

308
00:12:32,289 --> 00:12:39,620
regular mass that we can see presumably

309
00:12:35,600 --> 00:12:41,480
there's dark matter and then it has this

310
00:12:39,620 --> 00:12:45,889
hot gas what's the relationship between

311
00:12:41,480 --> 00:12:48,289
the hot gas and the galaxy galaxies we

312
00:12:45,889 --> 00:12:50,448
see which will we'll see later on and

313
00:12:48,289 --> 00:12:54,409
images that were taken by Hubble and

314

00:12:50,448 --> 00:12:58,159
Spitzer so most of this hot gas was

315
00:12:54,409 --> 00:13:00,139
probably once in galaxies and it's been

316
00:12:58,159 --> 00:13:02,389
either stripped as the galaxies fall

317
00:13:00,139 --> 00:13:05,360
into the cluster or it's been expelled

318
00:13:02,389 --> 00:13:08,480
by things like supernova or active

319
00:13:05,360 --> 00:13:11,959
galaxies so this is the cluster kind of

320
00:13:08,480 --> 00:13:14,480
all shares all of this gas okay end it

321
00:13:11,958 --> 00:13:18,278
but it was probably once a part of the

322
00:13:14,480 --> 00:13:20,300
galaxies that were in the cluster okay

323
00:13:18,278 --> 00:13:23,080
so I just want to comment real quickly

324
00:13:20,299 --> 00:13:25,729
on a something Andrew planet

325
00:13:23,080 --> 00:13:28,580
put on the Q&A app about having problems

326
00:13:25,730 --> 00:13:31,220
with the streaming it sometimes helps if

327
00:13:28,580 --> 00:13:32,690
you just refresh the browser window or

328
00:13:31,220 --> 00:13:35,180

close in the browser window and getting

329

00:13:32,690 --> 00:13:36,530

back to it again sometimes that helps

330

00:13:35,179 --> 00:13:37,759

but that's really your only course of

331

00:13:36,529 --> 00:13:40,100

action I'm sorry you guys are having

332

00:13:37,759 --> 00:13:42,549

trouble while watching the stream

333

00:13:40,100 --> 00:13:46,399

hopefully it'll sort itself out soon

334

00:13:42,549 --> 00:13:48,139

okay so so Anthony I want to get you

335

00:13:46,399 --> 00:13:51,230

involved here a little bit and want to

336

00:13:48,139 --> 00:13:53,419

ask you about the give us a sense of the

337

00:13:51,230 --> 00:13:55,190

timeline here we've already you've

338

00:13:53,419 --> 00:13:57,469

already told us the punchline that this

339

00:13:55,190 --> 00:14:01,190

thing is worth this thing weighs 45

340

00:13:57,470 --> 00:14:02,690

hundred trillion Suns so it's very very

341

00:14:01,190 --> 00:14:05,180

very massive in fact it's the most

342

00:14:02,690 --> 00:14:08,690

massive I think the press release states

343
00:14:05,179 --> 00:14:11,809
a galaxy cluster of this period in the

344
00:14:08,690 --> 00:14:14,140
in the history of the universe but give

345
00:14:11,809 --> 00:14:16,699
us a sense of the timeline so we

346
00:14:14,139 --> 00:14:19,189
presumably we have stars followed by

347
00:14:16,700 --> 00:14:20,690
galaxies followed by clusters of

348
00:14:19,190 --> 00:14:24,460
galaxies right can you give us a sense

349
00:14:20,690 --> 00:14:26,390
of just how long that might take sure so

350
00:14:24,460 --> 00:14:27,710
when you're building a structure in the

351
00:14:26,389 --> 00:14:29,210
universe the smallest things are

352
00:14:27,710 --> 00:14:32,840
building up first so you form the first

353
00:14:29,210 --> 00:14:34,639
stars very early on as soon as matter

354
00:14:32,840 --> 00:14:37,280
starts having a chance to collapse down

355
00:14:34,639 --> 00:14:39,169
enough to that you get structures class

356
00:14:37,279 --> 00:14:41,480
structures and you keep building up

357
00:14:39,169 --> 00:14:42,919
larger and larger things so you get

358
00:14:41,480 --> 00:14:45,110
galaxies forming within the first

359
00:14:42,919 --> 00:14:47,509
billion years after the big bang and

360
00:14:45,110 --> 00:14:49,639
then first billionaire as we're going

361
00:14:47,509 --> 00:14:51,889
with yes within the first billion years

362
00:14:49,639 --> 00:14:53,240
day the first there are these galaxies

363
00:14:51,889 --> 00:14:55,819
we've seen are actually even a bit

364
00:14:53,240 --> 00:14:56,960
further back than that but then you have

365
00:14:55,820 --> 00:14:59,210
to wait while you're building up these

366
00:14:56,960 --> 00:15:01,960
larger and larger structures these

367
00:14:59,210 --> 00:15:04,370
galaxy clusters have as much mass as a

368
00:15:01,960 --> 00:15:07,370
thousand galaxies aside from Milky Way

369
00:15:04,370 --> 00:15:09,470
more or less so and so it's only when

370
00:15:07,370 --> 00:15:11,509
you only you only expect to get its arms

371

00:15:09,470 --> 00:15:13,220
as long as when you're approaching a

372
00:15:11,509 --> 00:15:16,189
little under a mile under happening

373
00:15:13,220 --> 00:15:19,550
already so yes wait another five or six

374
00:15:16,190 --> 00:15:23,000
islands and audio we go but your your

375
00:15:19,549 --> 00:15:27,319
audio just but yeah when my I am yeah

376
00:15:23,000 --> 00:15:29,480
unfortunately it's yet maybe mmm sounds

377
00:15:27,320 --> 00:15:31,340
like you're part cyborg Anthony yeah

378
00:15:29,480 --> 00:15:32,870
yeah I get a lot of things got a lot of

379
00:15:31,340 --> 00:15:34,460
noise in the Indy audio but now you're

380
00:15:32,870 --> 00:15:35,200
better go so I'm sorry go ahead and

381
00:15:34,460 --> 00:15:37,180
continue

382
00:15:35,200 --> 00:15:39,430
oh sure I was just saying that it takes

383
00:15:37,179 --> 00:15:41,109
much longer before galaxy clusters have

384
00:15:39,429 --> 00:15:42,429
time to assemble in form because there's

385
00:15:41,110 --> 00:15:45,279

so much more massive than individual

386

00:15:42,429 --> 00:15:46,569

galaxies and so you don't expect to

387

00:15:45,279 --> 00:15:47,860

start getting galaxy clusters that's

388

00:15:46,570 --> 00:15:49,660

massive until the universe is

389

00:15:47,860 --> 00:15:52,269

approaching roughly half its current age

390

00:15:49,659 --> 00:15:54,480

so when it's getting to be more like six

391

00:15:52,269 --> 00:15:57,189

billion years or seven billion years old

392

00:15:54,480 --> 00:15:58,750

so that's the time skills you formed

393

00:15:57,190 --> 00:16:01,000

start forming the first star is very

394

00:15:58,750 --> 00:16:02,139

quickly the galaxies a bit after that

395

00:16:01,000 --> 00:16:05,470

and then you have to wait a while before

396

00:16:02,139 --> 00:16:06,759

you start seeing these and so at the

397

00:16:05,470 --> 00:16:09,040

distance we're looking at for this

398

00:16:06,759 --> 00:16:11,069

cluster you really at the era where

399

00:16:09,039 --> 00:16:14,469

you're starting to see the very first

400
00:16:11,070 --> 00:16:17,140
cluster is formed so we're really this

401
00:16:14,470 --> 00:16:18,820
is kind of the burthen very early days

402
00:16:17,139 --> 00:16:22,120
or toddler days as it were for cluster

403
00:16:18,820 --> 00:16:24,940
formation ok so I'm sorry I'm going to

404
00:16:22,120 --> 00:16:26,649
comment again on the people having

405
00:16:24,940 --> 00:16:28,360
trouble seeing this dream Scott is there

406
00:16:26,649 --> 00:16:30,480
a way you could post the youtube link on

407
00:16:28,360 --> 00:16:32,500
the comments maybe that will help people

408
00:16:30,480 --> 00:16:34,600
maybe if they go straight to YouTube

409
00:16:32,500 --> 00:16:36,909
they might be able to see it better ok

410
00:16:34,600 --> 00:16:40,899
so don't another bad out there all right

411
00:16:36,909 --> 00:16:43,419
thank you so the so I guess the the

412
00:16:40,899 --> 00:16:46,990
surprise here then with this particular

413
00:16:43,419 --> 00:16:49,569
one is that we is that you saw so you

414
00:16:46,990 --> 00:16:52,240
saw this this particular galaxy cluster

415
00:16:49,570 --> 00:16:54,129
when it was you said universe was was

416
00:16:52,240 --> 00:16:56,379
his 10 billion light years away so the

417
00:16:54,129 --> 00:16:58,120
universe is 13.8 billion years old so

418
00:16:56,379 --> 00:16:59,980
this is about when the universe was

419
00:16:58,120 --> 00:17:03,639
roughly three point eight to four

420
00:16:59,980 --> 00:17:07,269
billion years old correct right so and

421
00:17:03,639 --> 00:17:09,039
how is point the survey that we actually

422
00:17:07,269 --> 00:17:11,769
found this galaxy cluster in was fairly

423
00:17:09,039 --> 00:17:13,480
small in the sky so we elected an area

424
00:17:11,769 --> 00:17:16,029
of about ten square degrees on the sky

425
00:17:13,480 --> 00:17:18,940
which the whole sky is about 42,000

426
00:17:16,029 --> 00:17:20,588
square degrees and you would not have

427
00:17:18,940 --> 00:17:23,380
necessarily expected to find something

428

00:17:20,588 --> 00:17:26,230
this extreme looking in such a small

429
00:17:23,380 --> 00:17:27,790
patch of sky you might expect to find a

430
00:17:26,230 --> 00:17:31,599
few of these across the sky but not

431
00:17:27,789 --> 00:17:33,190
within such a small area so it was a

432
00:17:31,599 --> 00:17:36,579
pleasant surprise that we found this I

433
00:17:33,190 --> 00:17:41,799
think it was fair thing to say okay so

434
00:17:36,579 --> 00:17:43,359
the so the galaxy comes so we use are

435
00:17:41,799 --> 00:17:47,349
you saying this particular cluster then

436
00:17:43,359 --> 00:17:48,990
is is small compared to other other

437
00:17:47,349 --> 00:17:53,339
known galaxy clusters that are older

438
00:17:48,990 --> 00:17:57,509
I so they believe like a small area of

439
00:17:53,339 --> 00:17:58,889
sky it's exceptionally massive it it's

440
00:17:57,509 --> 00:18:00,660
one of the most massive that you would

441
00:17:58,890 --> 00:18:02,929
expect to be out there at this distance

442
00:18:00,660 --> 00:18:05,100

away from us it will grow to something

443

00:18:02,929 --> 00:18:07,350

that will be one of the most massive

444

00:18:05,099 --> 00:18:08,969

clusters in the universe but their real

445

00:18:07,349 --> 00:18:11,189

universe by the time it gets the present

446

00:18:08,970 --> 00:18:14,670

day so it will continue to grow but it's

447

00:18:11,190 --> 00:18:16,950

a very extreme cluster I say okay so we

448

00:18:14,670 --> 00:18:20,160

got so we have so there's our rough

449

00:18:16,950 --> 00:18:22,140

there's roughly our timeline we without

450

00:18:20,160 --> 00:18:23,970

within the first billion years or so the

451

00:18:22,140 --> 00:18:25,440

first stars are the first stars go and

452

00:18:23,970 --> 00:18:27,058

when did you say the first galaxies I'm

453

00:18:25,440 --> 00:18:28,950

sorry because your audio was messed up

454

00:18:27,058 --> 00:18:30,779

then when were the first galaxies came

455

00:18:28,950 --> 00:18:32,730

along a rut for galaxies are within the

456

00:18:30,779 --> 00:18:35,549

first billion years the first stirred in

457
00:18:32,730 --> 00:18:37,110
the first boner yes saying okay you you

458
00:18:35,549 --> 00:18:39,240
form the first stars fairly quickly

459
00:18:37,109 --> 00:18:40,709
after a matter starts having crime to

460
00:18:39,240 --> 00:18:42,960
collapse and you form start forming

461
00:18:40,710 --> 00:18:45,179
galaxies the first galaxies within the

462
00:18:42,960 --> 00:18:46,860
first billion years as well okay so from

463
00:18:45,179 --> 00:18:49,110
what I know about the first stars and

464
00:18:46,859 --> 00:18:51,178
galaxies and what I've learned talking

465
00:18:49,109 --> 00:18:52,889
to people working on things like jwst

466
00:18:51,179 --> 00:18:54,900
and things like this these first stars

467
00:18:52,890 --> 00:18:57,030
and by definition the first galaxies

468
00:18:54,900 --> 00:18:59,580
were pretty strange beasts right i mean

469
00:18:57,029 --> 00:19:01,289
these galaxies that were made up of

470
00:18:59,579 --> 00:19:03,299
stars that were very hot very they

471
00:19:01,289 --> 00:19:05,519
burned out very quickly they died in

472
00:19:03,299 --> 00:19:08,789
core collapse supernovae and they're

473
00:19:05,519 --> 00:19:10,349
very strange massive hot stars and so

474
00:19:08,789 --> 00:19:12,750
bright presumably the galaxies would be

475
00:19:10,349 --> 00:19:16,500
like that is that what the galaxies are

476
00:19:12,750 --> 00:19:19,190
like in this particular cluster are they

477
00:19:16,500 --> 00:19:22,200
they have stars that are reminiscent or

478
00:19:19,190 --> 00:19:24,539
indicative of early stars let me ask let

479
00:19:22,200 --> 00:19:26,400
me ask mark that question no these

480
00:19:24,539 --> 00:19:28,529
you're speaking about a much earlier

481
00:19:26,400 --> 00:19:31,019
time in the universe when stars are

482
00:19:28,529 --> 00:19:33,299
forming from gas that is relatively

483
00:19:31,019 --> 00:19:35,129
pristine also by the time the four

484
00:19:33,299 --> 00:19:37,259
billion years hits for this galaxy

485

00:19:35,130 --> 00:19:40,290
cluster it's we've gone through several

486
00:19:37,259 --> 00:19:43,049
generations well yeah at least one and

487
00:19:40,289 --> 00:19:44,940
and so the the galaxies the stars in

488
00:19:43,049 --> 00:19:47,399
these galaxies are pretty you know

489
00:19:44,940 --> 00:19:48,660
typical stars and the start you know the

490
00:19:47,400 --> 00:19:51,000
star formation activity that's going on

491
00:19:48,660 --> 00:19:53,308
is substantial but it's not appreciably

492
00:19:51,000 --> 00:19:55,950
different than then you know then what's

493
00:19:53,308 --> 00:20:00,960
happening in the local universe okay

494
00:19:55,950 --> 00:20:01,590
that's a very high okay so so the okay

495
00:20:00,960 --> 00:20:03,028
so

496
00:20:01,589 --> 00:20:05,699
just talk a little bit about some of the

497
00:20:03,028 --> 00:20:07,980
other observations so we haven't we have

498
00:20:05,700 --> 00:20:11,429
Scott's already shown the x-ray the

499
00:20:07,980 --> 00:20:14,069

x-ray version but there's also a sort of

500

00:20:11,429 --> 00:20:15,179

a composite of with Hubble and the

501

00:20:14,069 --> 00:20:16,980

different wavelengths that we're up

502

00:20:15,179 --> 00:20:18,419

there and while Scott if you could put

503

00:20:16,980 --> 00:20:19,679

that up I think it was the press release

504

00:20:18,419 --> 00:20:22,140

image that's what I'm is the one I'm

505

00:20:19,679 --> 00:20:25,080

referring to and then I want to have

506

00:20:22,140 --> 00:20:28,320

maybe Mike remark talk a little bit

507

00:20:25,079 --> 00:20:29,970

about that image here it is so what so

508

00:20:28,319 --> 00:20:32,220

this is what were you guys released last

509

00:20:29,970 --> 00:20:33,839

week correct yeah that's right this was

510

00:20:32,220 --> 00:20:36,210

the press release image that the

511

00:20:33,839 --> 00:20:38,819

accompanied the actual press release and

512

00:20:36,210 --> 00:20:41,850

it's it's really a beautiful image I

513

00:20:38,819 --> 00:20:45,028

think you can see a lot of massive

514
00:20:41,849 --> 00:20:46,589
galaxies the ones that are redder or red

515
00:20:45,028 --> 00:20:48,390
redness here basically indicates a lot

516
00:20:46,589 --> 00:20:51,178
of stellar mass that's the Spitzer data

517
00:20:48,390 --> 00:20:52,980
coming in and you see you know the

518
00:20:51,179 --> 00:20:54,778
gravitational arc to the sort of

519
00:20:52,980 --> 00:20:57,839
straight north of the middle of the

520
00:20:54,778 --> 00:21:02,579
cluster there's a very thin arc of light

521
00:20:57,839 --> 00:21:05,639
which which is the image of a distant

522
00:21:02,579 --> 00:21:08,069
galaxies whose light is being bent by

523
00:21:05,640 --> 00:21:10,230
the you know by the mass of this cluster

524
00:21:08,069 --> 00:21:13,139
a Scott could you use your pointer to

525
00:21:10,230 --> 00:21:16,548
kind of outline that for us please can

526
00:21:13,140 --> 00:21:22,679
you there ya know a little bit lower

527
00:21:16,548 --> 00:21:24,210
yeah there you go okay it's right center

528
00:21:22,679 --> 00:21:25,919
of the image now where he's got is his

529
00:21:24,210 --> 00:21:28,048
cursor yeah just to the left of the

530
00:21:25,919 --> 00:21:32,250
cursor that's right so that is that

531
00:21:28,048 --> 00:21:33,929
smudge is a galaxy that's a distant

532
00:21:32,250 --> 00:21:36,569
galaxies whose light is being distorted

533
00:21:33,929 --> 00:21:39,840
as it passes through the bent space-time

534
00:21:36,569 --> 00:21:43,079
but of the cluster and in fact that that

535
00:21:39,839 --> 00:21:46,109
arc provided us with another independent

536
00:21:43,079 --> 00:21:48,839
estimate of the mass which which was the

537
00:21:46,109 --> 00:21:51,769
subject of a paper that Anthony put out

538
00:21:48,839 --> 00:21:56,038
in 2012 you can speak to that Anthony

539
00:21:51,769 --> 00:21:57,990
sure so if you have us when you see

540
00:21:56,038 --> 00:22:00,829
something that's elongated like that's

541
00:21:57,990 --> 00:22:03,120
called a strong gravitational arc and

542

00:22:00,829 --> 00:22:04,678
just like a magnifying glass will

543
00:22:03,119 --> 00:22:06,449
distort light coming through it the mass

544
00:22:04,679 --> 00:22:08,220
of that cluster is bending the light

545
00:22:06,450 --> 00:22:11,279
from the background galaxies as it comes

546
00:22:08,220 --> 00:22:13,259
towards us and you can use the distance

547
00:22:11,279 --> 00:22:15,148
but the shape of that arc you can figure

548
00:22:13,259 --> 00:22:15,460
out where the center of it is and you

549
00:22:15,148 --> 00:22:17,469
can

550
00:22:15,460 --> 00:22:20,798
use that distortion and how large an

551
00:22:17,470 --> 00:22:22,659
area is enclosed by that circle to get

552
00:22:20,798 --> 00:22:23,980
an estimate for how much matter is

553
00:22:22,659 --> 00:22:26,890
enclosed and that includes the dark

554
00:22:23,980 --> 00:22:30,339
matter and the x-ray gas and the

555
00:22:26,890 --> 00:22:31,840
galaxies and then you can based on what

556
00:22:30,339 --> 00:22:33,970

you think the shape of a galaxy cluster

557

00:22:31,839 --> 00:22:36,459

should look like get an estimate for

558

00:22:33,970 --> 00:22:38,620

what the total mass is as well and when

559

00:22:36,460 --> 00:22:40,028

you do that you get a value that's very

560

00:22:38,619 --> 00:22:42,339

consistent with what we're now seeing

561

00:22:40,028 --> 00:22:44,798

with the x-ray okay I guess we chose me

562

00:22:42,339 --> 00:22:46,928

oh go ahead I'm just goes like this

563

00:22:44,798 --> 00:22:48,940

reminds me of what you would see in the

564

00:22:46,929 --> 00:22:50,440

frontier field survey where they're

565

00:22:48,940 --> 00:22:51,788

looking at all these galaxy clusters

566

00:22:50,440 --> 00:22:54,370

that are seeing smudges all over the

567

00:22:51,788 --> 00:22:56,169

place and they use they have models what

568

00:22:54,369 --> 00:22:59,619

they're calling lensing models for all

569

00:22:56,169 --> 00:23:03,130

of galaxy clusters you do that with this

570

00:22:59,619 --> 00:23:04,689

or is this one smudge not enough it

571
00:23:03,130 --> 00:23:06,640
seems to me like this one cleansed

572
00:23:04,690 --> 00:23:09,190
Galaxy isn't enough to make a model of

573
00:23:06,640 --> 00:23:10,690
the whole thing and right you to carol's

574
00:23:09,190 --> 00:23:12,190
point about dark matter what does this

575
00:23:10,690 --> 00:23:14,798
tell you about the distribution of dark

576
00:23:12,190 --> 00:23:17,980
matter in this cluster writes a very

577
00:23:14,798 --> 00:23:19,778
good question so first the frontier

578
00:23:17,980 --> 00:23:21,909
fields data is phenomenal with all the

579
00:23:19,778 --> 00:23:23,829
multiple different images of different

580
00:23:21,909 --> 00:23:25,210
galaxies there we are not at a stage

581
00:23:23,829 --> 00:23:27,278
where we can do anything like that right

582
00:23:25,210 --> 00:23:30,100
now we can just do a very crude estimate

583
00:23:27,278 --> 00:23:32,500
based on where that arc is of how much

584
00:23:30,099 --> 00:23:34,569
matter should be enclosed with inside of

585
00:23:32,500 --> 00:23:35,589
it so we're not close to trying to do

586
00:23:34,569 --> 00:23:38,168
something like they're doing with the

587
00:23:35,589 --> 00:23:42,158
frontier fields but you can get a first

588
00:23:38,169 --> 00:23:44,799
order estimate and what it also what

589
00:23:42,159 --> 00:23:45,820
else is interesting about it is a number

590
00:23:44,798 --> 00:23:47,889
of different people have made

591
00:23:45,819 --> 00:23:49,629
predictions for how many such

592
00:23:47,890 --> 00:23:51,399
gravitational arcs your you should be

593
00:23:49,630 --> 00:23:53,610
finding behind galaxy clusters at

594
00:23:51,398 --> 00:23:56,288
different distances away from us and

595
00:23:53,609 --> 00:23:58,329
generally for something this far away

596
00:23:56,288 --> 00:24:01,119
you would not have expected to find any

597
00:23:58,329 --> 00:24:03,099
arcs at all and if you looked already

598
00:24:01,119 --> 00:24:06,250
inspires that's really interesting so

599

00:24:03,099 --> 00:24:08,500
you're saying that the further away a

600
00:24:06,250 --> 00:24:10,419
galaxy cluster is the fewer are it

601
00:24:08,500 --> 00:24:12,819
there's a relation between distance and

602
00:24:10,419 --> 00:24:14,500
how many are you should see yeah so at

603
00:24:12,819 --> 00:24:16,269
some point the expectation is that you

604
00:24:14,500 --> 00:24:19,000
just start running out of background

605
00:24:16,269 --> 00:24:20,829
galaxies that are at proverbs sure that

606
00:24:19,000 --> 00:24:22,538
makes perfect sense yeah that does make

607
00:24:20,829 --> 00:24:24,250
sense so there's not that many earlier

608
00:24:22,538 --> 00:24:28,148
galaxies that can be detected by these

609
00:24:24,250 --> 00:24:29,319
telescopes right and so predictions if

610
00:24:28,148 --> 00:24:31,388
you look at before we found

611
00:24:29,319 --> 00:24:35,019
sorry that you really were not expecting

612
00:24:31,388 --> 00:24:36,908
to find one and that's means not

613
00:24:35,019 --> 00:24:39,819

expecting to find one behind any galaxy

614

00:24:36,909 --> 00:24:41,409

cluster over the entire sky so that

615

00:24:39,819 --> 00:24:43,058

starts telling you that there's

616

00:24:41,409 --> 00:24:46,299

something wrong with those expectations

617

00:24:43,058 --> 00:24:48,548

and still working on trying to get a

618

00:24:46,298 --> 00:24:50,918

handle on what exactly that is but one

619

00:24:48,548 --> 00:24:52,480

plausible candidate is if the dark

620

00:24:50,919 --> 00:24:55,179

matter in this cluster is more

621

00:24:52,480 --> 00:24:56,919

concentrated towards the center then you

622

00:24:55,179 --> 00:24:59,440

expect for the standard profile the

623

00:24:56,919 --> 00:25:01,778

galaxy cluster that can help you in

624

00:24:59,440 --> 00:25:03,909

terms of increasing the probability that

625

00:25:01,778 --> 00:25:08,019

some galaxy behind it will get magnified

626

00:25:03,909 --> 00:25:10,450

in this way so okay that's the first

627

00:25:08,019 --> 00:25:13,179

here so I had a question you talked

628
00:25:10,450 --> 00:25:15,909
about early on you all were talking

629
00:25:13,179 --> 00:25:18,759
about there's the radio data you had a

630
00:25:15,909 --> 00:25:21,460
radio JT had a hole that suggested that

631
00:25:18,759 --> 00:25:24,069
the microwave background was disturbed

632
00:25:21,460 --> 00:25:27,460
and there was a mass there and then you

633
00:25:24,069 --> 00:25:31,000
have the x-ray data and then you have

634
00:25:27,460 --> 00:25:35,110
the lensing phenomenon now receiving the

635
00:25:31,000 --> 00:25:36,849
optical do all those masses agree yeah

636
00:25:35,109 --> 00:25:39,158
in fact they do that was that was the

637
00:25:36,849 --> 00:25:41,918
main result of the paper that came out

638
00:25:39,159 --> 00:25:44,230
this year right it is pretty awesome

639
00:25:41,919 --> 00:25:45,909
because there are assumptions to go into

640
00:25:44,230 --> 00:25:47,860
all of those who are and they're

641
00:25:45,909 --> 00:25:49,240
different there's fewer assumptions in

642
00:25:47,859 --> 00:25:51,219
the lensing but there's still some

643
00:25:49,240 --> 00:25:53,950
there's definitely assumptions on the

644
00:25:51,220 --> 00:25:56,048
state and maturity of the gas and the

645
00:25:53,950 --> 00:25:58,179
how relax the dynamics is the cluster

646
00:25:56,048 --> 00:26:00,730
that comes into play for both the x-ray

647
00:25:58,179 --> 00:26:02,379
and for the radio data and they're all

648
00:26:00,730 --> 00:26:03,970
different that's right they all you know

649
00:26:02,378 --> 00:26:06,069
there there are different physics and

650
00:26:03,970 --> 00:26:07,839
different assumptions and and they yet

651
00:26:06,069 --> 00:26:09,970
the mass is all agree perfectly

652
00:26:07,839 --> 00:26:12,548
basically within the errors and that's

653
00:26:09,970 --> 00:26:14,379
astonishing and this is why one of the

654
00:26:12,548 --> 00:26:16,388
main conclusions is that this cluster

655
00:26:14,378 --> 00:26:18,668
seems to be relatively advanced and

656

00:26:16,388 --> 00:26:21,758
mature for its age you know it's not

657
00:26:18,669 --> 00:26:23,970
shocking to find a galaxy cluster at

658
00:26:21,759 --> 00:26:26,769
redshifts like this handfuls are known

659
00:26:23,970 --> 00:26:28,629
but mostly they look like train wrecks

660
00:26:26,769 --> 00:26:30,069
they're still forming you know they look

661
00:26:28,628 --> 00:26:31,750
like you expect them to look at that age

662
00:26:30,069 --> 00:26:33,668
where they will only look mature at a

663
00:26:31,750 --> 00:26:35,798
much later time but this one looks

664
00:26:33,669 --> 00:26:37,929
mature in place 10 billion light years

665
00:26:35,798 --> 00:26:40,329
away and you know and a lot of the

666
00:26:37,929 --> 00:26:41,649
evidence for that is that the masses are

667
00:26:40,329 --> 00:26:42,908
all the same from these different

668
00:26:41,648 --> 00:26:44,408
measurements

669
00:26:42,909 --> 00:26:46,330
you know that there's that there's the

670
00:26:44,409 --> 00:26:48,970

existence of a cool core in the cluster

671

00:26:46,329 --> 00:26:51,069

which might can speak more to but that's

672

00:26:48,970 --> 00:26:52,839

a property of an evolved cluster we

673

00:26:51,069 --> 00:26:54,189

don't usually see that in the early

674

00:26:52,839 --> 00:26:55,988

universe we see it today much more

675

00:26:54,190 --> 00:26:57,999

frequently so there's a lot of evidence

676

00:26:55,989 --> 00:26:59,440

pointing to the fact that this is an

677

00:26:57,999 --> 00:27:01,479

involved cluster at such an early time

678

00:26:59,440 --> 00:27:04,389

and the significance of that is that

679

00:27:01,479 --> 00:27:07,298

basically it's a signpost for one of the

680

00:27:04,388 --> 00:27:08,918

earliest very dense you know parts of

681

00:27:07,298 --> 00:27:11,589

the early universe it had to get a head

682

00:27:08,919 --> 00:27:13,899

start early to be finished so early and

683

00:27:11,589 --> 00:27:16,658

so this was really a very dense region

684

00:27:13,898 --> 00:27:19,089

in the very early universe so you've all

685
00:27:16,659 --> 00:27:21,278
seen that sort of cosmic web view of the

686
00:27:19,089 --> 00:27:22,628
universe with all these galaxies dancing

687
00:27:21,278 --> 00:27:23,739
around each other and these long thin

688
00:27:22,628 --> 00:27:26,858
thread so you're saying that it's

689
00:27:23,739 --> 00:27:29,079
possible this galaxy cluster was

690
00:27:26,858 --> 00:27:31,239
probably in a more dense region early in

691
00:27:29,079 --> 00:27:33,069
the universe's history that allowed it

692
00:27:31,239 --> 00:27:35,200
to get this mature correct exactly

693
00:27:33,069 --> 00:27:37,569
exactly it's a very extreme peak in the

694
00:27:35,200 --> 00:27:40,149
early density distribution and you know

695
00:27:37,569 --> 00:27:42,098
in 2012 we asked her cells if it was if

696
00:27:40,148 --> 00:27:44,469
it in fact it was allowed by modern

697
00:27:42,098 --> 00:27:45,970
cosmic by our theory should there be

698
00:27:44,470 --> 00:27:48,339
something this massive so early because

699
00:27:45,970 --> 00:27:50,319
it wasn't obvious we did the calculation

700
00:27:48,339 --> 00:27:52,658
and in fact it's okay there are a few

701
00:27:50,319 --> 00:27:54,939
all scythes that we reverse it you told

702
00:27:52,659 --> 00:27:56,799
right yeah it's actually okay there's a

703
00:27:54,940 --> 00:27:59,710
handful you know a dozen or so all sky

704
00:27:56,798 --> 00:28:01,929
we found one in a tiny tiny fraction of

705
00:27:59,710 --> 00:28:03,940
the sky which is what was strange and

706
00:28:01,929 --> 00:28:05,619
why we were so lucky we all we had way

707
00:28:03,940 --> 00:28:08,288
less than one percent chance of finding

708
00:28:05,618 --> 00:28:10,358
it in that area but we did okay all

709
00:28:08,288 --> 00:28:12,489
right so yeah let's go back to this cool

710
00:28:10,358 --> 00:28:14,470
core that you were just mentioning marca

711
00:28:12,489 --> 00:28:17,348
Mike do you want to comment a little but

712
00:28:14,470 --> 00:28:20,889
what do they mean by that is a cool cool

713

00:28:17,348 --> 00:28:23,710
for sure um let me just quickly sort of

714
00:28:20,888 --> 00:28:26,108
throw in the analogy I like to sort of

715
00:28:23,710 --> 00:28:28,149
put this resulting contents of analogies

716
00:28:26,108 --> 00:28:30,220
yeah so sorry I mean you can think of a

717
00:28:28,148 --> 00:28:32,858
galaxy cluster as like a city right of

718
00:28:30,220 --> 00:28:36,940
the galaxies of the people right and so

719
00:28:32,858 --> 00:28:38,829
as time goes by in human history cities

720
00:28:36,940 --> 00:28:40,929
become bigger you know that it go from

721
00:28:38,829 --> 00:28:43,720
villages 2 tallis the cities to drop

722
00:28:40,929 --> 00:28:46,419
traffic snorts I mean yeah right yeah so

723
00:28:43,720 --> 00:28:48,548
this is that I mean in my mind kind of

724
00:28:46,419 --> 00:28:52,830
like finding Rome you know we're finding

725
00:28:48,548 --> 00:28:55,210
one of these really advanced older

726
00:28:52,829 --> 00:28:56,470
civilizations oh no that is a good

727
00:28:55,210 --> 00:28:58,600

analogy so

728

00:28:56,470 --> 00:29:00,429
so so we found a civilization of

729

00:28:58,599 --> 00:29:03,519
galaxies that's that's probably

730

00:29:00,429 --> 00:29:05,470
benchmarking the era that it it's it's

731

00:29:03,519 --> 00:29:11,048
observed that it's the most advanced

732

00:29:05,470 --> 00:29:14,140
civilization at that innocence okay so

733

00:29:11,048 --> 00:29:16,298
that boy my simple well that begs the

734

00:29:14,140 --> 00:29:19,630
question so I guess my next thing is

735

00:29:16,298 --> 00:29:23,408
that you know you found Rome any chance

736

00:29:19,630 --> 00:29:25,120
any chance of finding a ancient Egyptian

737

00:29:23,409 --> 00:29:26,559
stuff i mean you know they were pretty

738

00:29:25,119 --> 00:29:29,168
advanced to so what do you think the

739

00:29:26,558 --> 00:29:30,879
chances are of maybe finding something

740

00:29:29,169 --> 00:29:32,620
any earlier do you think this is a

741

00:29:30,880 --> 00:29:34,090
horror limit not let anyone have you

742
00:29:32,619 --> 00:29:35,788
comment on that well i think i think

743
00:29:34,089 --> 00:29:39,009
what Mark was saying is that this is

744
00:29:35,788 --> 00:29:40,690
this is about that massive as you expect

745
00:29:39,009 --> 00:29:42,940
the universe to produce a cluster at

746
00:29:40,690 --> 00:29:45,400
this right shift at this distance so as

747
00:29:42,940 --> 00:29:48,610
I said about 10 billion light years this

748
00:29:45,400 --> 00:29:49,900
is about as good or as mature a galaxy

749
00:29:48,609 --> 00:29:51,849
clusters you're ever going to see you

750
00:29:49,900 --> 00:29:54,548
won't anything earlier is going to be

751
00:29:51,849 --> 00:29:56,889
like he said more disheveled less less

752
00:29:54,548 --> 00:30:01,179
organized the more of a mess but these

753
00:29:56,890 --> 00:30:04,210
are in like me a lot yeah it out loud

754
00:30:01,179 --> 00:30:07,659
but yeah you are thinking it in 2016

755
00:30:04,210 --> 00:30:10,840
they seek the truth yes well I glad

756
00:30:07,659 --> 00:30:14,830
that's a good resolution I'll help you a

757
00:30:10,839 --> 00:30:16,089
help you keep usually mind why don't

758
00:30:14,829 --> 00:30:18,460
your those we can name it after you

759
00:30:16,089 --> 00:30:20,678
perfect it's i'm done with let the IE

760
00:30:18,460 --> 00:30:22,210
you know we'll get it set well it's

761
00:30:20,679 --> 00:30:25,288
better than the name that the that

762
00:30:22,210 --> 00:30:28,600
you've given this thing we never see SJ

763
00:30:25,288 --> 00:30:30,908
1426 I mean Scott Lewis cluster I'd be

764
00:30:28,599 --> 00:30:34,119
much willing to come I sorry that's not

765
00:30:30,909 --> 00:30:37,620
their fault I'm okay with that too they

766
00:30:34,119 --> 00:30:40,209
do not mislead of Scott Lewis cluster

767
00:30:37,619 --> 00:30:45,279
supermassive and not as the shell that

768
00:30:40,210 --> 00:30:51,370
was as it was a few just just messed all

769
00:30:45,279 --> 00:30:53,440
up with Dark Matters ok so astral girl 1

770

00:30:51,369 --> 00:30:54,428
USA is asking a good question out that

771
00:30:53,440 --> 00:30:56,919
kind of goes along with the

772
00:30:54,429 --> 00:30:59,530
gravitational lensing i can't select it

773
00:30:56,919 --> 00:31:01,090
so if maybe Elena or someone who has the

774
00:30:59,529 --> 00:31:04,000
ability to do that can maybe click on

775
00:31:01,089 --> 00:31:05,439
her comment she's asking you may have

776
00:31:04,000 --> 00:31:06,548
covered this already i missed quite a

777
00:31:05,440 --> 00:31:08,679
bit fooling around trying to get the

778
00:31:06,548 --> 00:31:09,349
video to work but is there a difference

779
00:31:08,679 --> 00:31:11,620
in what

780
00:31:09,349 --> 00:31:13,639
causes an Einstein cross and

781
00:31:11,619 --> 00:31:15,798
gravitational arcing like what we just

782
00:31:13,640 --> 00:31:18,380
saw in that one galaxy that you should

783
00:31:15,798 --> 00:31:19,668
have in this image and she also adds I

784
00:31:18,380 --> 00:31:23,600

have to say this is a very interesting

785

00:31:19,669 --> 00:31:25,160

session well thank you astral one USA so

786

00:31:23,599 --> 00:31:27,589

let's talk about that and maybe this is

787

00:31:25,160 --> 00:31:30,620

a good one for you Anthony gravitational

788

00:31:27,589 --> 00:31:33,918

lensing arcing Einstein crosses we've

789

00:31:30,619 --> 00:31:36,529

seen a supernova recently in an Einstein

790

00:31:33,919 --> 00:31:38,960

cross so what is there this is the same

791

00:31:36,529 --> 00:31:41,029

physics at work here yes indeed in both

792

00:31:38,960 --> 00:31:43,490

cases it is just the bending of light by

793

00:31:41,029 --> 00:31:45,349

gravity as predicted by Einstein the

794

00:31:43,490 --> 00:31:48,230

main difference is just the geometry of

795

00:31:45,349 --> 00:31:50,509

exactly how the background galaxy or the

796

00:31:48,230 --> 00:31:52,548

background quasar is lined up with the

797

00:31:50,509 --> 00:31:55,849

foreground matter that's doing the

798

00:31:52,548 --> 00:31:57,970

lensing so at a fundamental physical

799

00:31:55,849 --> 00:32:00,469

level though it's it's identical physics

800

00:31:57,970 --> 00:32:02,900

okay good that's good question asker

801

00:32:00,470 --> 00:32:04,548

girl1 thank you Andrew Hamilton Einstein

802

00:32:02,900 --> 00:32:06,679

cross by the way yes we talked about

803

00:32:04,548 --> 00:32:09,829

that's the supernova ref stall i believe

804

00:32:06,679 --> 00:32:12,440

it was or something yes okay Andrew

805

00:32:09,829 --> 00:32:14,298

planet is asking would massive galaxies

806

00:32:12,440 --> 00:32:18,080

have been more prone to form right after

807

00:32:14,298 --> 00:32:19,609

the Big Bang having them there having

808

00:32:18,079 --> 00:32:22,240

been far more of a preponderant

809

00:32:19,609 --> 00:32:24,740

preponderance of material available to

810

00:32:22,240 --> 00:32:27,589

gravitationally mutually attract to

811

00:32:24,740 --> 00:32:28,940

itself the last part confused me but I'm

812

00:32:27,589 --> 00:32:31,189

gonna go back to the beginning would the

813
00:32:28,940 --> 00:32:33,409
massive galaxies have been more prone to

814
00:32:31,190 --> 00:32:35,690
form right after the Big Bang well I'll

815
00:32:33,409 --> 00:32:37,429
take that generically it's true the

816
00:32:35,690 --> 00:32:39,110
universe was denser because it was all

817
00:32:37,429 --> 00:32:40,669
the materials closer together and that

818
00:32:39,109 --> 00:32:42,408
is a plus if you're trying to form

819
00:32:40,669 --> 00:32:45,200
galaxies but it was also a lot hotter

820
00:32:42,409 --> 00:32:47,030
and you can't make gas collapse if it's

821
00:32:45,200 --> 00:32:48,980
hot so the universe has to expand and

822
00:32:47,029 --> 00:32:51,500
cool to a point where you can actually

823
00:32:48,980 --> 00:32:53,298
have gravitational collapse so it has to

824
00:32:51,500 --> 00:32:55,190
happen a bit after the Big Bang so on

825
00:32:53,298 --> 00:32:56,629
the one hand the universe is smaller but

826
00:32:55,190 --> 00:32:59,058
on the other hand it's also very hot and

827

00:32:56,630 --> 00:33:01,610
it's hard to get things to to sort of

828
00:32:59,058 --> 00:33:04,279
coalesce right right collapsing down

829
00:33:01,609 --> 00:33:06,079
means you have to have cold gas if it's

830
00:33:04,279 --> 00:33:07,369
hot temperature is basically the same

831
00:33:06,079 --> 00:33:09,079
thing as the velocity of the gas

832
00:33:07,369 --> 00:33:10,339
particles and if it's hot they're moving

833
00:33:09,079 --> 00:33:13,158
very fast and they can't come close

834
00:33:10,339 --> 00:33:14,599
together but the corollary to that if I

835
00:33:13,159 --> 00:33:16,820
understood the second part of the

836
00:33:14,599 --> 00:33:19,308
question is you're more likely to form

837
00:33:16,819 --> 00:33:20,720
very massive galaxies earlier where you

838
00:33:19,308 --> 00:33:22,908
have the densest locations in the

839
00:33:20,720 --> 00:33:23,210
universe which would be sites like where

840
00:33:22,909 --> 00:33:25,190
you're

841
00:33:23,210 --> 00:33:26,808

he's mask right so that's dense that's

842

00:33:25,190 --> 00:33:28,548
dark matter density which doesn't get

843

00:33:26,808 --> 00:33:30,798
care about the temperature as much as

844

00:33:28,548 --> 00:33:33,109
the gas dose good alright thank you

845

00:33:30,798 --> 00:33:34,908
andrea was a good question um alright so

846

00:33:33,109 --> 00:33:38,148
we want to I want to ask you briefly

847

00:33:34,909 --> 00:33:39,679
about with the radio detection you said

848

00:33:38,148 --> 00:33:43,339
that you all of these different methods

849

00:33:39,679 --> 00:33:45,200
have sort of gone in in hand in hand

850

00:33:43,339 --> 00:33:47,480
between the gravitational lensing of the

851

00:33:45,200 --> 00:33:51,288
galaxy that the art gravitational arc

852

00:33:47,480 --> 00:33:52,759
the temperature of the x-ray gas and you

853

00:33:51,288 --> 00:33:54,470
said you initially got an initial

854

00:33:52,759 --> 00:33:57,769
estimate of the mass for using radio

855

00:33:54,470 --> 00:34:01,069
data is it something Alma can do I mean

856

00:33:57,769 --> 00:34:02,750

I'm just wonder it that's that is that a

857

00:34:01,069 --> 00:34:05,629

wavelength that can give you any more

858

00:34:02,750 --> 00:34:07,788

information or is it well necessary it's

859

00:34:05,630 --> 00:34:09,559

always necessary we would be where we're

860

00:34:07,788 --> 00:34:10,878

lacking in radio facilities right now

861

00:34:09,559 --> 00:34:13,279

that can make this kind of measurement

862

00:34:10,878 --> 00:34:14,480

actually all night at you all know

863

00:34:13,280 --> 00:34:17,450

watches that went out what all you

864

00:34:14,480 --> 00:34:19,219

mentioned would only do just so all well

865

00:34:17,449 --> 00:34:21,230

ok let me just say Alma is a radio

866

00:34:19,219 --> 00:34:22,819

interferon interfer metric array it's a

867

00:34:21,230 --> 00:34:24,889

bunch of dishes in the mountains of

868

00:34:22,820 --> 00:34:27,559

chili and when you use them all together

869

00:34:24,889 --> 00:34:31,730

you can gather you can sort of

870
00:34:27,559 --> 00:34:33,710
approximate the the resolution of a huge

871
00:34:31,730 --> 00:34:35,119
dish as big as the the largest linear

872
00:34:33,710 --> 00:34:37,010
extent between you know the largest

873
00:34:35,119 --> 00:34:39,649
separation between any of those two

874
00:34:37,010 --> 00:34:41,780
small dishes that's great for resolution

875
00:34:39,648 --> 00:34:42,829
the that's actually a bad thing though

876
00:34:41,780 --> 00:34:45,500
if you're trying to make this

877
00:34:42,829 --> 00:34:47,809
measurement use a solution is a bad

878
00:34:45,500 --> 00:34:51,500
thing yeah because you end up we're

879
00:34:47,809 --> 00:34:53,690
looking at if you if you think about the

880
00:34:51,500 --> 00:34:56,269
x-ray image and maybe we can call that

881
00:34:53,690 --> 00:34:58,700
up again the blue fuzzy image the the

882
00:34:56,269 --> 00:35:00,800
galaxy cluster is not a point it's it's

883
00:34:58,699 --> 00:35:03,319
actually a very big area it's a big

884

00:35:00,800 --> 00:35:05,480
extended area of light and if you're

885
00:35:03,320 --> 00:35:07,910
using an interferometric array a bunch

886
00:35:05,480 --> 00:35:09,230
of small dishes you actually are it's

887
00:35:07,909 --> 00:35:11,779
very good at detecting the point sources

888
00:35:09,230 --> 00:35:13,460
but it resolves it resolves out the

889
00:35:11,780 --> 00:35:16,070
light you you want to sort of not lose

890
00:35:13,460 --> 00:35:17,539
that light if you had a very big single

891
00:35:16,070 --> 00:35:19,760
dish in the radio that wouldn't happen

892
00:35:17,539 --> 00:35:22,460
and that would be fabulous for that kind

893
00:35:19,760 --> 00:35:24,859
of analysis but Alma is not great

894
00:35:22,460 --> 00:35:28,130
actually for measuring things like the

895
00:35:24,858 --> 00:35:29,900
the the effect of the CMB spectral

896
00:35:28,130 --> 00:35:31,760
distortion because it's a very large

897
00:35:29,900 --> 00:35:33,619
scale distortion and being so high

898
00:35:31,760 --> 00:35:35,780

resolution you actually can't see it

899

00:35:33,619 --> 00:35:36,950

basically the idea is you do a you

900

00:35:35,780 --> 00:35:39,230

subtract effect

901

00:35:36,949 --> 00:35:40,489

you subtract what's around it's locally

902

00:35:39,230 --> 00:35:41,690

around the object that you're looking at

903

00:35:40,489 --> 00:35:43,039

and if it's all the same brightness

904

00:35:41,690 --> 00:35:44,570

where you're looking in the background

905

00:35:43,039 --> 00:35:47,900

around it then it subtracts away

906

00:35:44,570 --> 00:35:49,670

entirely you get zero so so that's why

907

00:35:47,900 --> 00:35:51,980

Alma's not the perfect instrument for

908

00:35:49,670 --> 00:35:55,760

that kind of okay all right Oh Scott

909

00:35:51,980 --> 00:35:59,030

head up so here's the IR that Spitzer

910

00:35:55,760 --> 00:36:01,970

right right okay and then you said you

911

00:35:59,030 --> 00:36:04,609

want to Chandra yeah yeah this is the IR

912

00:36:01,969 --> 00:36:06,078

on now and you see a few of the galaxies

913
00:36:04,608 --> 00:36:07,670
so they're shaundra and if you ignore

914
00:36:06,079 --> 00:36:10,010
the point so you look at the big blue

915
00:36:07,670 --> 00:36:12,619
fuzzy region in the middle that's the

916
00:36:10,010 --> 00:36:14,930
sort of the extent of the hot gas in the

917
00:36:12,619 --> 00:36:18,740
cluster it's a very big extended region

918
00:36:14,929 --> 00:36:21,500
sort of 30 arc seconds on the side okay

919
00:36:18,739 --> 00:36:23,269
so well while we're on trays then let me

920
00:36:21,500 --> 00:36:25,608
ask you this and resolution doesn't

921
00:36:23,269 --> 00:36:28,250
matter or at least it's not as is as

922
00:36:25,608 --> 00:36:31,159
critical as it might be an optical image

923
00:36:28,250 --> 00:36:33,108
but what about new star is that

924
00:36:31,159 --> 00:36:34,578
something that can give you I mean it's

925
00:36:33,108 --> 00:36:37,400
a slightly different energy level I know

926
00:36:34,579 --> 00:36:39,619
that but it have you thought about maybe

927
00:36:37,400 --> 00:36:42,289
what do you think new Tsar might show if

928
00:36:39,619 --> 00:36:44,119
well I'll toss this one to Mike but

929
00:36:42,289 --> 00:36:45,650
generically it's just too high energy

930
00:36:44,119 --> 00:36:48,950
but Mike probably can get some color on

931
00:36:45,650 --> 00:36:51,139
that right I'll also add a little the

932
00:36:48,949 --> 00:36:54,169
easy answer for the Alma question is

933
00:36:51,139 --> 00:36:58,719
that this targets in the north well

934
00:36:54,170 --> 00:37:01,068
there we actually you're gonna say that

935
00:36:58,719 --> 00:37:03,259
this was in the north right yeah we

936
00:37:01,068 --> 00:37:04,730
actually can we actually can it's doable

937
00:37:03,260 --> 00:37:08,660
but you can see it right on the horizon

938
00:37:04,730 --> 00:37:11,389
yeah you guys ground-based telescopes

939
00:37:08,659 --> 00:37:13,368
yes so with with regard did you say

940
00:37:11,389 --> 00:37:15,500
Fermi which tells before you know I was

941

00:37:13,369 --> 00:37:18,710
I was wondering about new store start

942
00:37:15,500 --> 00:37:20,889
right yeah so we so if there was another

943
00:37:18,710 --> 00:37:25,068
process going on that wasn't thermal

944
00:37:20,889 --> 00:37:26,358
you'd expect new star to pick it up we

945
00:37:25,068 --> 00:37:29,329
have no reason to believe that's the

946
00:37:26,358 --> 00:37:33,078
case here so so all of our thermal

947
00:37:29,329 --> 00:37:34,490
emission is captured by a Chandra ok

948
00:37:33,079 --> 00:37:36,470
that's a good end so you're saying that

949
00:37:34,489 --> 00:37:39,169
what Chandra is looking at is thermal

950
00:37:36,469 --> 00:37:41,000
emission in x-rays right what else is

951
00:37:39,170 --> 00:37:42,559
there i mean it's some kind of what

952
00:37:41,000 --> 00:37:45,769
other kind of x-ray emission would there

953
00:37:42,559 --> 00:37:47,599
be then so accretion disks shop

954
00:37:45,769 --> 00:37:49,440
accelerating shop celebrating

955
00:37:47,599 --> 00:37:51,599

accelerating charged particles maybe

956

00:37:49,440 --> 00:37:54,510

Thank kind of thing yeah so very very

957

00:37:51,599 --> 00:37:57,088

energetic Austin sees but I mean we

958

00:37:54,510 --> 00:38:00,119

struggle to measure that those types of

959

00:37:57,088 --> 00:38:04,039

things in nearby clusters so this is not

960

00:38:00,119 --> 00:38:06,240

a test fit for brand new star I think

961

00:38:04,039 --> 00:38:08,460

okay well no that's good to know I mean

962

00:38:06,239 --> 00:38:10,949

I I just learned about new star died

963

00:38:08,460 --> 00:38:12,420

about a year ago and it was pretty

964

00:38:10,949 --> 00:38:14,519

amazing some of the stuff I've seen come

965

00:38:12,420 --> 00:38:16,108

out of there they would I think they

966

00:38:14,519 --> 00:38:17,550

just looked at the Andromeda galaxy with

967

00:38:16,108 --> 00:38:18,989

it recently if i'm not mistaken so

968

00:38:17,550 --> 00:38:23,099

here's a good question from Craig

969

00:38:18,989 --> 00:38:25,439

kranthi ugh oh gosh good good hot am I'm

970
00:38:23,099 --> 00:38:29,430
sorry if I screwed that up but he's

971
00:38:25,440 --> 00:38:32,338
asking is big is does this galaxy

972
00:38:29,429 --> 00:38:35,669
cluster have any net rotation or is

973
00:38:32,338 --> 00:38:41,099
there any overall motion of the galaxy

974
00:38:35,670 --> 00:38:43,079
cluster itself ah almost certainly any

975
00:38:41,099 --> 00:38:47,609
other are you yeah are you able to

976
00:38:43,079 --> 00:38:49,470
measure it we only have detailed sort of

977
00:38:47,608 --> 00:38:52,559
dynamical information for a handful of

978
00:38:49,469 --> 00:38:55,679
the galaxies as I said using Hubble and

979
00:38:52,559 --> 00:38:58,980
keck spectroscopy most of that isn't

980
00:38:55,679 --> 00:39:00,809
even at sufficient precision to do much

981
00:38:58,980 --> 00:39:03,150
with other than know the distance from

982
00:39:00,809 --> 00:39:06,568
us to the galaxy so yeah it would take a

983
00:39:03,150 --> 00:39:07,829
pretty dedicated survey over a long

984
00:39:06,568 --> 00:39:09,599
period of time to build even start to

985
00:39:07,829 --> 00:39:11,460
answer that question yeah i think the

986
00:39:09,599 --> 00:39:14,460
echo what Mike was saying a second ago

987
00:39:11,460 --> 00:39:16,588
this is hard to do even locally right so

988
00:39:14,460 --> 00:39:18,150
it's a bit out of the realm for right

989
00:39:16,588 --> 00:39:21,750
now for this movie so you're saying

990
00:39:18,150 --> 00:39:23,608
looking at at these galaxies clusters is

991
00:39:21,750 --> 00:39:25,650
hard to do even for closer clusters but

992
00:39:23,608 --> 00:39:27,389
trying to measure the rotation of them

993
00:39:25,650 --> 00:39:30,450
even for a little monsters is not an

994
00:39:27,389 --> 00:39:32,460
easy job okay well mark I'm glad you

995
00:39:30,449 --> 00:39:36,419
reminded me about heck I wanted to ask

996
00:39:32,460 --> 00:39:37,318
you what data you used for that from

997
00:39:36,420 --> 00:39:40,559
them and you're saying it was

998

00:39:37,318 --> 00:39:43,858
spectroscopy yeah back in 2012 we did

999
00:39:40,559 --> 00:39:45,239
some pretty heroic observations given

1000
00:39:43,858 --> 00:39:48,750
the redshift of the cluster and the

1001
00:39:45,239 --> 00:39:51,449
screen galaxies yeah we'd we observed

1002
00:39:48,750 --> 00:39:53,639
with the Elridge spectrograph the low

1003
00:39:51,449 --> 00:39:55,348
resolution imaging spectrograph on the

1004
00:39:53,639 --> 00:39:58,500
Keck one telescope but I think that's

1005
00:39:55,349 --> 00:40:01,500
what it was and and observed for you

1006
00:39:58,500 --> 00:40:03,420
know four or five hours normally you can

1007
00:40:01,500 --> 00:40:05,608
get the distances to

1008
00:40:03,420 --> 00:40:07,740
Buster's at more normal red ships you

1009
00:40:05,608 --> 00:40:09,509
know the clusters that are around seven

1010
00:40:07,739 --> 00:40:12,298
or eight or nine billion light-years

1011
00:40:09,510 --> 00:40:14,040
away well eight anyway in an hour and a

1012
00:40:12,298 --> 00:40:15,929

half or two but this was pretty heroic

1013

00:40:14,039 --> 00:40:17,759

because of the distance and it was a

1014

00:40:15,929 --> 00:40:20,699

difficult redshift range to do from the

1015

00:40:17,760 --> 00:40:23,220

ground we only ended up actually only

1016

00:40:20,699 --> 00:40:27,480

getting as I recall one spectroscopic

1017

00:40:23,219 --> 00:40:28,919

member ha from from we targeted many all

1018

00:40:27,480 --> 00:40:31,260

at the same time in parallel but we only

1019

00:40:28,920 --> 00:40:33,659

got a redshift for one of them and it's

1020

00:40:31,260 --> 00:40:35,130

Hubble actually from space that was much

1021

00:40:33,659 --> 00:40:37,618

better able to give us the distance we

1022

00:40:35,130 --> 00:40:40,108

got six or seven pretty quickly from

1023

00:40:37,619 --> 00:40:43,769

from observations with the the grizzin

1024

00:40:40,108 --> 00:40:45,929

from the infrared camera okay well now

1025

00:40:43,769 --> 00:40:47,849

it's time for the grand question the

1026

00:40:45,929 --> 00:40:50,519

bloody scale questions that I love to

1027
00:40:47,849 --> 00:40:52,880
ask so let me these observations in this

1028
00:40:50,519 --> 00:40:58,889
study of this particular galaxy cluster

1029
00:40:52,880 --> 00:41:01,079
was it has it it has it disproven or

1030
00:40:58,889 --> 00:41:03,838
lent support to any of the current

1031
00:41:01,079 --> 00:41:05,160
theories of gravity of how galaxies form

1032
00:41:03,838 --> 00:41:06,869
in the early universe and more

1033
00:41:05,159 --> 00:41:09,629
importantly galaxy clusters in other

1034
00:41:06,869 --> 00:41:12,210
words observations we have more theories

1035
00:41:09,630 --> 00:41:14,190
than observations usually have any have

1036
00:41:12,210 --> 00:41:15,869
any come under fire as a result of what

1037
00:41:14,190 --> 00:41:18,568
you found or have you supported any

1038
00:41:15,869 --> 00:41:21,450
theories um generically everything makes

1039
00:41:18,568 --> 00:41:23,670
sense with one big exception the the

1040
00:41:21,449 --> 00:41:25,558
mass of the cluster is high but it does

1041
00:41:23,670 --> 00:41:27,690
it's not unusual it's not surprising

1042
00:41:25,559 --> 00:41:28,890
that you would find it you know it's

1043
00:41:27,690 --> 00:41:31,289
surprising that we found it in such a

1044
00:41:28,889 --> 00:41:33,659
small area so when we're able to conduct

1045
00:41:31,289 --> 00:41:35,308
a full Sky Survey to the same depth we

1046
00:41:33,659 --> 00:41:37,108
should find the remaining handful that

1047
00:41:35,309 --> 00:41:39,089
we expect there to be if we find many

1048
00:41:37,108 --> 00:41:40,289
many more than that then that would be a

1049
00:41:39,088 --> 00:41:43,380
problem but right now there's no

1050
00:41:40,289 --> 00:41:46,048
indication of a problem on that side the

1051
00:41:43,380 --> 00:41:48,119
on in terms of the the gas properties of

1052
00:41:46,048 --> 00:41:50,880
the cluster it's it's pretty advanced

1053
00:41:48,119 --> 00:41:54,030
but you know it doesn't you know it

1054
00:41:50,880 --> 00:41:55,920
doesn't make its not worrisome in any

1055

00:41:54,030 --> 00:41:57,510
way the problem there is hard to predict

1056
00:41:55,920 --> 00:41:59,940
what you expect to see because you need

1057
00:41:57,510 --> 00:42:02,160
very advanced simulations that that are

1058
00:41:59,940 --> 00:42:04,019
right now not up to the task actually of

1059
00:42:02,159 --> 00:42:05,940
making a prediction that we could go

1060
00:42:04,019 --> 00:42:07,829
test in terms of the gas inside of

1061
00:42:05,940 --> 00:42:10,230
clusters at high redshift though the one

1062
00:42:07,829 --> 00:42:11,609
case that's still rather puzzling is the

1063
00:42:10,230 --> 00:42:15,269
one Anthony brought up about the arc

1064
00:42:11,608 --> 00:42:17,269
because you know we really tried to to

1065
00:42:15,269 --> 00:42:19,730
break that you know we do we tried to

1066
00:42:17,269 --> 00:42:21,050
to test our measurement you know or

1067
00:42:19,730 --> 00:42:23,659
rather the prediction that there should

1068
00:42:21,050 --> 00:42:26,960
be none robustly none all sky we tried

1069
00:42:23,659 --> 00:42:29,299

to every which way that we can make it

1070

00:42:26,960 --> 00:42:30,920

less severe of a contradiction but no

1071

00:42:29,300 --> 00:42:33,140

matter what we did it's really just not

1072

00:42:30,920 --> 00:42:36,079

you don't expect any and and the fact

1073

00:42:33,139 --> 00:42:40,519

that we see one is still a surprise it

1074

00:42:36,079 --> 00:42:42,849

is possible that that very cigar like

1075

00:42:40,519 --> 00:42:44,809

yeah like a cigar in the sky

1076

00:42:42,849 --> 00:42:46,699

distribution of dark matter all along

1077

00:42:44,809 --> 00:42:51,079

the line of sight might help alleviate

1078

00:42:46,699 --> 00:42:52,939

that somewhat but but I mind personnel

1079

00:42:51,079 --> 00:42:54,889

still a little confused by for them but

1080

00:42:52,940 --> 00:42:57,139

if that was the case you'd have an extra

1081

00:42:54,889 --> 00:42:58,699

problem because in that case the

1082

00:42:57,139 --> 00:43:00,079

different masses that we get Fred the

1083

00:42:58,699 --> 00:43:03,469

different techniques wouldn't agree with

1084
00:43:00,079 --> 00:43:05,440
each other yeah and very likely yeah

1085
00:43:03,469 --> 00:43:07,699
well we didn't mention before actually

1086
00:43:05,440 --> 00:43:08,900
started to say I've had a student who's

1087
00:43:07,699 --> 00:43:10,159
working on what's called weak

1088
00:43:08,900 --> 00:43:12,050
gravitational lensing were you looking

1089
00:43:10,159 --> 00:43:14,899
to deflections of all the small galaxies

1090
00:43:12,050 --> 00:43:16,280
around and her name's when we mow and

1091
00:43:14,900 --> 00:43:18,650
she's just finishing up a paper that

1092
00:43:16,280 --> 00:43:21,650
shows that that mass more or less agrees

1093
00:43:18,650 --> 00:43:23,210
with the other ones as well yeah yeah so

1094
00:43:21,650 --> 00:43:25,070
the fact that this arc was there really

1095
00:43:23,210 --> 00:43:26,179
kind of was was bothersome but if it

1096
00:43:25,070 --> 00:43:28,039
weren't there then you wouldn't have

1097
00:43:26,179 --> 00:43:30,529
these agreements among the different

1098
00:43:28,039 --> 00:43:32,480
methods on this mass so well we have one

1099
00:43:30,530 --> 00:43:35,360
less mass to throw up on the plot yeah

1100
00:43:32,480 --> 00:43:37,219
but it would be it would be less

1101
00:43:35,360 --> 00:43:39,980
surprising surprising is good surprising

1102
00:43:37,219 --> 00:43:42,289
is why we do this yes I a bothersome as

1103
00:43:39,980 --> 00:43:46,039
much as intriguing in front hey

1104
00:43:42,289 --> 00:43:47,989
bothering okay so I'd like to point out

1105
00:43:46,039 --> 00:43:50,539
also that this gravitational lensing

1106
00:43:47,989 --> 00:43:52,000
technique of measuring mass or inferring

1107
00:43:50,539 --> 00:43:54,529
mass I guess is what you're really doing

1108
00:43:52,000 --> 00:43:57,079
doesn't differentiate between the mass

1109
00:43:54,530 --> 00:43:59,630
and the stuff that we can see the normal

1110
00:43:57,079 --> 00:44:03,710
matter and dark matter does it it really

1111
00:43:59,630 --> 00:44:06,829
is all of it combined correct okay so

1112

00:44:03,710 --> 00:44:09,380
the the it does it is it helping us

1113
00:44:06,829 --> 00:44:11,840
understand the nature of dark matter in

1114
00:44:09,380 --> 00:44:14,180
the early universe at all or is it just

1115
00:44:11,840 --> 00:44:17,170
you just know it's there and so it's

1116
00:44:14,179 --> 00:44:21,109
made this a fact or its had this effect

1117
00:44:17,170 --> 00:44:23,990
it's a more oh go ahead go ahead you go

1118
00:44:21,110 --> 00:44:25,490
ahead I would say it's more along the

1119
00:44:23,989 --> 00:44:26,989
lines of you know it's there you're

1120
00:44:25,489 --> 00:44:28,309
still seeing the same evidence for dark

1121
00:44:26,989 --> 00:44:31,068
matter here that you're seeing more

1122
00:44:28,309 --> 00:44:33,318
locally there's nothing there

1123
00:44:31,068 --> 00:44:34,880
is clearly no dramatic change right

1124
00:44:33,318 --> 00:44:36,949
there's no evidence for evolution and if

1125
00:44:34,880 --> 00:44:39,229
you wanted to use clusters to study dark

1126
00:44:36,949 --> 00:44:40,639

matter which is a great thing to do you

1127

00:44:39,228 --> 00:44:42,858

would want to do it more locally where

1128

00:44:40,639 --> 00:44:44,929

you have a much better ability to study

1129

00:44:42,858 --> 00:44:46,248

them in detail okay well I guess where I

1130

00:44:44,929 --> 00:44:47,929

was heading with that is that in the

1131

00:44:46,248 --> 00:44:50,899

same way that people are trying to

1132

00:44:47,929 --> 00:44:53,419

understand the characteristics of dark

1133

00:44:50,900 --> 00:44:55,369

energy over over the history of universe

1134

00:44:53,420 --> 00:44:58,430

like was it this isn't the same

1135

00:44:55,369 --> 00:44:59,869

everywhere is it you know it was it were

1136

00:44:58,429 --> 00:45:01,940

there different amounts of it at

1137

00:44:59,869 --> 00:45:03,528

different periods and the history of the

1138

00:45:01,940 --> 00:45:05,059

universe I'm trying to figure out if

1139

00:45:03,528 --> 00:45:06,978

maybe something analogous could be

1140

00:45:05,059 --> 00:45:08,690

learned by the nature of dark matter

1141
00:45:06,978 --> 00:45:10,548
like I know the universe was smaller I

1142
00:45:08,690 --> 00:45:13,489
know that this particular galaxy cluster

1143
00:45:10,548 --> 00:45:16,219
is mature and and small for its eyes are

1144
00:45:13,489 --> 00:45:17,869
small for its mass but I just wondered

1145
00:45:16,219 --> 00:45:19,190
what that might tell us if anything

1146
00:45:17,869 --> 00:45:21,920
about dark matter and it sounds like

1147
00:45:19,190 --> 00:45:23,869
only that it's there is the ulcer from

1148
00:45:21,920 --> 00:45:27,079
the from the x-ray you can get a

1149
00:45:23,869 --> 00:45:29,749
measurement of the luminous matter as

1150
00:45:27,079 --> 00:45:32,180
well and if you remove the or if you

1151
00:45:29,748 --> 00:45:33,528
compare the luminous to dark matter the

1152
00:45:32,179 --> 00:45:35,509
Dark Matters about eighty-five percent

1153
00:45:33,528 --> 00:45:37,518
of the mass in this cluster which is a

1154
00:45:35,509 --> 00:45:40,880
bit of what it is throughout the whole

1155
00:45:37,518 --> 00:45:43,068
universe so I mean in this one case you

1156
00:45:40,880 --> 00:45:45,709
know with a data point one single data

1157
00:45:43,068 --> 00:45:48,798
point we can say that the Dark Matter

1158
00:45:45,708 --> 00:45:51,429
fraction isn't really changing ok right

1159
00:45:48,798 --> 00:45:53,719
look to me that's important I think that

1160
00:45:51,429 --> 00:45:54,708
but it sort of had to be actually

1161
00:45:53,719 --> 00:45:56,298
because you know your question about

1162
00:45:54,708 --> 00:45:59,179
Direct Energy is right there's a huge

1163
00:45:56,298 --> 00:46:01,400
search on for you know to study its its

1164
00:45:59,179 --> 00:46:03,469
nature in particular is it changing is

1165
00:46:01,400 --> 00:46:05,838
it evolving with time because if it is

1166
00:46:03,469 --> 00:46:08,690
then it's not Einstein's cosmological

1167
00:46:05,838 --> 00:46:11,239
constant it's an even weirder kind of

1168
00:46:08,690 --> 00:46:13,548
quantum field and so that's an active

1169

00:46:11,239 --> 00:46:15,559
area of research Dark Matter on the

1170
00:46:13,548 --> 00:46:16,998
other hand you know we talk about all

1171
00:46:15,559 --> 00:46:18,528
our models and whether or not these

1172
00:46:16,998 --> 00:46:19,939
observations agree with the models the

1173
00:46:18,528 --> 00:46:21,739
models are all predicated on non

1174
00:46:19,940 --> 00:46:23,599
evolving dark matter dark matter has

1175
00:46:21,739 --> 00:46:25,458
whatever properties it has in the big

1176
00:46:23,599 --> 00:46:28,400
bang as that far back it has the same

1177
00:46:25,458 --> 00:46:29,958
properties today it's a little slower

1178
00:46:28,400 --> 00:46:32,660
moving today because universe is cool

1179
00:46:29,958 --> 00:46:34,639
but it's the same basic dark matter with

1180
00:46:32,659 --> 00:46:36,228
no evolution and if you brought in the

1181
00:46:34,639 --> 00:46:37,879
ability for dark matter to evolve and

1182
00:46:36,228 --> 00:46:39,210
change then the models will get much

1183
00:46:37,880 --> 00:46:42,450

more complicated

1184

00:46:39,210 --> 00:46:43,710

so dark matter is more or less what it

1185

00:46:42,449 --> 00:46:45,299

was at the beginning of the it was the

1186

00:46:43,710 --> 00:46:47,849

amount of it was set at the beginning of

1187

00:46:45,300 --> 00:46:49,050

the universe and that's what we have to

1188

00:46:47,849 --> 00:46:51,420

work with is what you're saying right

1189

00:46:49,050 --> 00:46:53,760

and its properties and its properties so

1190

00:46:51,420 --> 00:46:55,079

whatever it is we find hopefully we'll

1191

00:46:53,760 --> 00:46:57,000

find out at one point but it doesn't

1192

00:46:55,079 --> 00:46:59,489

seem to change all that much I guess I

1193

00:46:57,000 --> 00:47:01,050

was I guess it would be really freaky if

1194

00:46:59,489 --> 00:47:03,419

it wasn't conserved right i mean if you

1195

00:47:01,050 --> 00:47:04,980

suddenly went from Dark Matter more of

1196

00:47:03,420 --> 00:47:06,869

it in the early universe than later it

1197

00:47:04,980 --> 00:47:09,389

would probably be a real real problems

1198
00:47:06,869 --> 00:47:11,400
what we're going to animal you can

1199
00:47:09,389 --> 00:47:12,659
imagine doing that if it was going from

1200
00:47:11,400 --> 00:47:15,588
dark matter to turning into something

1201
00:47:12,659 --> 00:47:18,029
else other types of particles however

1202
00:47:15,588 --> 00:47:19,980
given all the other observations we have

1203
00:47:18,030 --> 00:47:23,070
from the Cosmic Microwave Background for

1204
00:47:19,980 --> 00:47:25,559
instance and that really constrains that

1205
00:47:23,070 --> 00:47:26,609
you can't have much changing okay all

1206
00:47:25,559 --> 00:47:27,960
right well I'd love to talk about that

1207
00:47:26,608 --> 00:47:29,789
at some point but I think it's a little

1208
00:47:27,960 --> 00:47:33,358
beyond what we're doing here so okay

1209
00:47:29,789 --> 00:47:36,750
well um so let me turn to Scott have you

1210
00:47:33,358 --> 00:47:38,130
noticed anything on the Twitterverse or

1211
00:47:36,750 --> 00:47:41,250
any other of the channels I'm only

1212
00:47:38,130 --> 00:47:42,869
looking at the at the q no no everything

1213
00:47:41,250 --> 00:47:45,300
on twitter has actually been pretty much

1214
00:47:42,869 --> 00:47:48,990
answered overall we were on air which is

1215
00:47:45,300 --> 00:47:50,789
always good um besides that I'm not

1216
00:47:48,989 --> 00:47:53,549
saying anything over on google+ and

1217
00:47:50,789 --> 00:47:55,529
facebook let me just check if you

1218
00:47:53,550 --> 00:47:57,539
there's a youtube comments real quick

1219
00:47:55,530 --> 00:47:58,800
you know everything's been great there's

1220
00:47:57,539 --> 00:48:00,900
been a lot of really good activity as

1221
00:47:58,800 --> 00:48:03,510
far as engagement on Twitter so thank

1222
00:48:00,900 --> 00:48:06,960
you guys for for tweeting with us as

1223
00:48:03,510 --> 00:48:09,510
we're going on I I guess I had a couple

1224
00:48:06,960 --> 00:48:15,119
questions and one is that so there's

1225
00:48:09,510 --> 00:48:17,940
this cluster and you somewhat said that

1226

00:48:15,119 --> 00:48:20,849
it's a little bit unusual but not hugely

1227
00:48:17,940 --> 00:48:25,639
unusual but is there anything in this

1228
00:48:20,849 --> 00:48:29,609
cluster that suggests a merging or

1229
00:48:25,639 --> 00:48:32,098
hierarchical galaxy formation or

1230
00:48:29,608 --> 00:48:36,690
anything like that any hints of what

1231
00:48:32,099 --> 00:48:39,359
went on before is this a tracer of any

1232
00:48:36,690 --> 00:48:43,139
of those mechanisms for creating

1233
00:48:39,358 --> 00:48:48,440
galaxies and then galaxy clusters yeah

1234
00:48:43,139 --> 00:48:51,269
I'll take that one so in the x-ray a map

1235
00:48:48,440 --> 00:48:53,099
if you have the composite image I'd be a

1236
00:48:51,269 --> 00:48:57,119
good one to show

1237
00:48:53,099 --> 00:48:59,940
the x-ray gas is sort of offset from the

1238
00:48:57,119 --> 00:49:03,889
center of the cluster and so if you

1239
00:48:59,940 --> 00:49:06,420
imagine the cluster of the clusters this

1240
00:49:03,889 --> 00:49:08,849

don't matter potential it's full of hot

1241

00:49:06,420 --> 00:49:11,280
gas and if it's disturb the gas it's

1242

00:49:08,849 --> 00:49:13,860
going to splash around in that dark

1243

00:49:11,280 --> 00:49:16,110
matter world just like glass of wine in

1244

00:49:13,860 --> 00:49:18,750
the glass and so we're seeing that the

1245

00:49:16,110 --> 00:49:20,220
gas is sort of sloshing from the center

1246

00:49:18,750 --> 00:49:22,500
of the cluster and eventually it'll sort

1247

00:49:20,219 --> 00:49:24,839
of fall back in towards the center but

1248

00:49:22,500 --> 00:49:26,610
that's sort of a signature that that

1249

00:49:24,840 --> 00:49:29,370
it's been knocked around a little bit or

1250

00:49:26,610 --> 00:49:33,090
that it's had a bit of a violent past so

1251

00:49:29,369 --> 00:49:34,559
to speak okay well I want to go back to

1252

00:49:33,090 --> 00:49:37,380
something I heard I think it was Mark

1253

00:49:34,559 --> 00:49:41,039
say about it if we could get an all-sky

1254

00:49:37,380 --> 00:49:43,110
survey of the same depth yeah is there

1255
00:49:41,039 --> 00:49:45,869
what could get work where could we go to

1256
00:49:43,110 --> 00:49:50,430
get one of those well funny you should

1257
00:49:45,869 --> 00:49:52,199
ask none of us are actually working on

1258
00:49:50,429 --> 00:49:53,940
that right now there's a there's a

1259
00:49:52,199 --> 00:49:57,059
mission called Euclid that is being

1260
00:49:53,940 --> 00:49:58,980
built in Europe and it's designed

1261
00:49:57,059 --> 00:50:00,809
actually to measure dark energy that's

1262
00:49:58,980 --> 00:50:04,909
the prime mission Euclid is of course

1263
00:50:00,809 --> 00:50:07,829
the famous geometry Greek professor and

1264
00:50:04,909 --> 00:50:10,529
and it's all about the geometry

1265
00:50:07,829 --> 00:50:13,170
basically is is the key question in dark

1266
00:50:10,530 --> 00:50:15,900
energy you know what is the nature of

1267
00:50:13,170 --> 00:50:18,300
space-time itself but a side effect of

1268
00:50:15,900 --> 00:50:19,889
that survey is that it you know will be

1269
00:50:18,300 --> 00:50:22,380
able to do an amazing cluster search

1270
00:50:19,889 --> 00:50:24,420
with it it's going to image basically

1271
00:50:22,380 --> 00:50:25,890
the whole extra galactic sky that

1272
00:50:24,420 --> 00:50:27,030
doesn't you know that does the part of

1273
00:50:25,889 --> 00:50:28,889
the guy that doesn't have our galaxy

1274
00:50:27,030 --> 00:50:30,750
blocking it so the whole rest of the sky

1275
00:50:28,889 --> 00:50:32,849
which is a milky way band that you see

1276
00:50:30,750 --> 00:50:35,190
in a really dark sky or at least yeah

1277
00:50:32,849 --> 00:50:39,150
it's gonna look not there everywhere

1278
00:50:35,190 --> 00:50:41,700
else and and it's going to take very

1279
00:50:39,150 --> 00:50:43,410
deep high-resolution images almost

1280
00:50:41,699 --> 00:50:45,599
Hubble how about half the resolution of

1281
00:50:43,409 --> 00:50:49,139
public because it's half the size and

1282
00:50:45,599 --> 00:50:51,059
have the linear size and from those data

1283

00:50:49,139 --> 00:50:53,879
we will be able to find galaxy clusters

1284
00:50:51,059 --> 00:50:56,219
to this red shift and even further if

1285
00:50:53,880 --> 00:50:59,460
they should exist in fact that's where

1286
00:50:56,219 --> 00:51:01,409
that Anthony and I are working on we're

1287
00:50:59,460 --> 00:51:04,889
part of the NASA contribution to that

1288
00:51:01,409 --> 00:51:06,179
the NASA science team and it's a like I

1289
00:51:04,889 --> 00:51:06,900
said a majority European mission but

1290
00:51:06,179 --> 00:51:09,069
we're

1291
00:51:06,900 --> 00:51:10,869
working on the cluster the galaxy

1292
00:51:09,070 --> 00:51:13,240
cluster part among other parts so that's

1293
00:51:10,869 --> 00:51:15,940
supposed to launch in 2020 or maybe 20

1294
00:51:13,239 --> 00:51:17,409
21 more realistically and the next few

1295
00:51:15,940 --> 00:51:19,420
years after that we will have amazing

1296
00:51:17,409 --> 00:51:22,299
data that should allow us to find the

1297
00:51:19,420 --> 00:51:25,960

rest of these all the friends of I dcs

1298

00:51:22,300 --> 00:51:29,530

1426 the entire sky minus the plane of

1299

00:51:25,960 --> 00:51:31,900

the galaxy about half this yeah wow

1300

00:51:29,530 --> 00:51:33,160

that's going to be a man net and so 2021

1301

00:51:31,900 --> 00:51:35,410

excellent well you're gonna have to come

1302

00:51:33,159 --> 00:51:37,089

back way before then and tell us how

1303

00:51:35,409 --> 00:51:39,309

things are going because I that sounds

1304

00:51:37,090 --> 00:51:41,019

like an amazing serve and it's going to

1305

00:51:39,309 --> 00:51:43,960

be a survey telescope right meaning that

1306

00:51:41,019 --> 00:51:45,429

it's gonna just systematically look at

1307

00:51:43,960 --> 00:51:47,289

the entire sky instead of people

1308

00:51:45,429 --> 00:51:48,969

applying for time and looking at that's

1309

00:51:47,289 --> 00:51:50,769

right yeah that's right it's a pure it's

1310

00:51:48,969 --> 00:51:52,299

a pure mission it's going to carry out

1311

00:51:50,769 --> 00:51:54,400

its mission like the plunk did for

1312
00:51:52,300 --> 00:51:56,650
instance and and all the data will be

1313
00:51:54,400 --> 00:51:58,690
there for people to exploit you know on

1314
00:51:56,650 --> 00:52:00,579
the US side more directly w first of

1315
00:51:58,690 --> 00:52:02,860
course we had the news of the ee s is

1316
00:52:00,579 --> 00:52:04,469
really officially it happen which is

1317
00:52:02,860 --> 00:52:06,640
awesome and double first is a good

1318
00:52:04,469 --> 00:52:08,169
complementary telescope it's going to go

1319
00:52:06,639 --> 00:52:09,670
for a small double size so it's going to

1320
00:52:08,170 --> 00:52:11,829
be higher resolution it's going to go

1321
00:52:09,670 --> 00:52:14,980
deeper in a smaller area of the sky and

1322
00:52:11,829 --> 00:52:16,809
so it will allow us to find either you

1323
00:52:14,980 --> 00:52:19,000
know the the little brothers of this the

1324
00:52:16,809 --> 00:52:20,829
small clusters that are groups of

1325
00:52:19,000 --> 00:52:23,110
clusters that are forming even you know

1326
00:52:20,829 --> 00:52:25,210
in the very early universe you know

1327
00:52:23,110 --> 00:52:26,470
above above red shifted to and maybe

1328
00:52:25,210 --> 00:52:28,240
even a little higher so that'll be

1329
00:52:26,469 --> 00:52:30,250
working together we'll see the full

1330
00:52:28,239 --> 00:52:31,629
picture of growth I was about to ask you

1331
00:52:30,250 --> 00:52:33,820
about W first because that is a

1332
00:52:31,630 --> 00:52:34,869
compliment it is also a survey telescope

1333
00:52:33,820 --> 00:52:36,580
and it's an important distinction

1334
00:52:34,869 --> 00:52:38,319
because when you think about the first

1335
00:52:36,579 --> 00:52:39,579
stars first galaxies first galaxies

1336
00:52:38,320 --> 00:52:41,769
clusters that you're talking about

1337
00:52:39,579 --> 00:52:43,539
understanding these survey telescopes

1338
00:52:41,769 --> 00:52:45,789
are going to give you more than say even

1339
00:52:43,539 --> 00:52:47,769
though jwst and telescopes like it might

1340

00:52:45,789 --> 00:52:50,739
be able to see these things it's not a

1341
00:52:47,769 --> 00:52:53,050
survey it's not the survey telescopes we

1342
00:52:50,739 --> 00:52:54,849
can't systematically look at all the

1343
00:52:53,050 --> 00:52:56,019
areas of the sky like we're talking

1344
00:52:54,849 --> 00:52:59,259
about here and that's important

1345
00:52:56,019 --> 00:53:01,150
distinction so great w first is I guess

1346
00:52:59,260 --> 00:53:04,030
go and I guess it'll be launched

1347
00:53:01,150 --> 00:53:05,889
sometime next decade but yeah this will

1348
00:53:04,030 --> 00:53:07,600
but Euclid's going to be coming up much

1349
00:53:05,889 --> 00:53:11,589
sooner so that sounds really exciting

1350
00:53:07,599 --> 00:53:13,179
okay Andrew planet is asking does all

1351
00:53:11,590 --> 00:53:15,760
the new work on dark matter and dark

1352
00:53:13,179 --> 00:53:17,739
energy and tail mentally conceiving of a

1353
00:53:15,760 --> 00:53:20,410
universe much larger than we originally

1354
00:53:17,739 --> 00:53:20,739

thought in terms of different scales of

1355

00:53:20,409 --> 00:53:22,539

the end

1356

00:53:20,739 --> 00:53:25,539

in other words does this have any effect

1357

00:53:22,539 --> 00:53:30,099

on what we perceive is the size of our

1358

00:53:25,539 --> 00:53:35,110

universe I'll let you take the kids I'm

1359

00:53:30,099 --> 00:53:43,589

hearing crickets our mind is expanding

1360

00:53:35,110 --> 00:53:45,849

right now I'd say no okay well thank you

1361

00:53:43,590 --> 00:53:47,860

it's true it's true that the nature of

1362

00:53:45,849 --> 00:53:50,170

dark matter how much there is etc would

1363

00:53:47,860 --> 00:53:51,940

affect the evolution of the universe how

1364

00:53:50,170 --> 00:53:54,070

big it gets as a function of time but

1365

00:53:51,940 --> 00:53:55,690

this doesn't change any of what we

1366

00:53:54,070 --> 00:53:58,780

understood before about dark matter so

1367

00:53:55,690 --> 00:54:02,260

this discovery itself has has no no

1368

00:53:58,780 --> 00:54:03,760

impact on on that aspect of theory okay

1369
00:54:02,260 --> 00:54:05,920
well thank you for answering thank you

1370
00:54:03,760 --> 00:54:08,470
for stumping us Andrew as you usually do

1371
00:54:05,920 --> 00:54:09,820
on these hangouts so we a lot a lot of

1372
00:54:08,469 --> 00:54:11,469
our regular viewers I have some some

1373
00:54:09,820 --> 00:54:16,390
pretty amazing questions and sometimes I

1374
00:54:11,469 --> 00:54:18,368
just go I don't know ok well the I guess

1375
00:54:16,389 --> 00:54:20,279
if we're done with the Hubble hanging

1376
00:54:18,369 --> 00:54:22,539
out part of it I want to I'm sorry the

1377
00:54:20,280 --> 00:54:25,210
Twitter nobody's nobody's left in

1378
00:54:22,539 --> 00:54:26,858
comments and questions then I am I am I

1379
00:54:25,210 --> 00:54:30,389
have another question of course but we

1380
00:54:26,858 --> 00:54:33,789
note I'm sorry Kara out of time yes

1381
00:54:30,389 --> 00:54:38,199
absolutely all the time you get one of

1382
00:54:33,789 --> 00:54:42,519
yours you want to use it right now in

1383
00:54:38,199 --> 00:54:46,269
question I get oh my this is my 2016

1384
00:54:42,519 --> 00:54:48,369
question if we saw this a cluster very

1385
00:54:46,269 --> 00:54:53,409
similar to this one but at a closer

1386
00:54:48,369 --> 00:54:56,559
redshift how would it be different hello

1387
00:54:53,409 --> 00:54:59,259
I house do this this cluster you know as

1388
00:54:56,559 --> 00:55:01,329
it evolved oh I see this exact cluster

1389
00:54:59,260 --> 00:55:03,850
as it evolves through totality so one

1390
00:55:01,329 --> 00:55:05,259
like it right right well I like it yeah

1391
00:55:03,849 --> 00:55:06,549
we obviously can't follow this one but

1392
00:55:05,260 --> 00:55:09,190
we can find clusters that are

1393
00:55:06,550 --> 00:55:10,990
statistically consistent with evolving

1394
00:55:09,190 --> 00:55:12,789
from one into the next that we see over

1395
00:55:10,989 --> 00:55:16,358
time and as Anthony mentioned earlier

1396
00:55:12,789 --> 00:55:18,730
this cluster will grow to be you know

1397

00:55:16,358 --> 00:55:20,650
the one of the largest clusters that we

1398
00:55:18,730 --> 00:55:21,820
can see or if not the largest we can see

1399
00:55:20,650 --> 00:55:23,590
in the sky today and that's true at

1400
00:55:21,820 --> 00:55:25,330
every red shift so there are clusters

1401
00:55:23,590 --> 00:55:27,340
people have found you know at

1402
00:55:25,329 --> 00:55:29,559
intermediate red shifts that are more

1403
00:55:27,340 --> 00:55:31,600
massive than this one but I mean if you

1404
00:55:29,559 --> 00:55:33,519
if you plot the growth the expected

1405
00:55:31,599 --> 00:55:34,329
growth this cluster over time you find

1406
00:55:33,519 --> 00:55:36,340
that

1407
00:55:34,329 --> 00:55:38,319
now as this cluster reaches that epic

1408
00:55:36,340 --> 00:55:39,789
that intermediate has gotten that big

1409
00:55:38,320 --> 00:55:43,030
and in fact it's consistent with growing

1410
00:55:39,789 --> 00:55:44,619
bigger and bigger and with being this

1411
00:55:43,030 --> 00:55:46,510

cluster is like a progenitor

1412

00:55:44,619 --> 00:55:47,949
statistically of all the massive

1413

00:55:46,510 --> 00:55:50,740
clusters that we have found at all

1414

00:55:47,949 --> 00:55:54,549
different redshifts cool all right thank

1415

00:55:50,739 --> 00:55:58,719
you yeah we got my question all right

1416

00:55:54,550 --> 00:56:00,550
boat well almost I guess we'll stop

1417

00:55:58,719 --> 00:56:02,319
there i want to thank you everybody for

1418

00:56:00,550 --> 00:56:05,140
watching i want to thank my guest dr.

1419

00:56:02,320 --> 00:56:07,059
doctors mark broad when anthony gonzalez

1420

00:56:05,139 --> 00:56:09,329
and mike mcdonald aw thank you guys for

1421

00:56:07,059 --> 00:56:11,289
taking the time out to share their

1422

00:56:09,329 --> 00:56:13,539
evaluations and angle that's all this

1423

00:56:11,289 --> 00:56:14,590
five this is ben and i hope that uh well

1424

00:56:13,539 --> 00:56:16,119
let me ask you this do you have any

1425

00:56:14,590 --> 00:56:17,530
follow-up work coming down the pike on

1426
00:56:16,119 --> 00:56:19,480
this i know you're working on euclid but

1427
00:56:17,530 --> 00:56:22,840
any any other observations like this

1428
00:56:19,480 --> 00:56:25,150
coming down Oh always you know Anthony

1429
00:56:22,840 --> 00:56:26,800
mentioned his student has a follow of

1430
00:56:25,150 --> 00:56:29,079
paper on the mass of this cluster that's

1431
00:56:26,800 --> 00:56:31,180
about to be resubmitted there's a paper

1432
00:56:29,079 --> 00:56:33,039
on the star formation activity in this

1433
00:56:31,179 --> 00:56:35,349
cluster that has been submitted and work

1434
00:56:33,039 --> 00:56:37,449
we're about to resubmit it soon and hint

1435
00:56:35,349 --> 00:56:39,099
it has a lot of fun activity in terms of

1436
00:56:37,449 --> 00:56:41,649
star formation and black hole activity

1437
00:56:39,099 --> 00:56:44,289
and also we have a whole other survey

1438
00:56:41,650 --> 00:56:48,250
using a I guess not so great Observatory

1439
00:56:44,289 --> 00:56:52,360
that the wise i think the control is the

1440
00:56:48,250 --> 00:56:54,429
okay observed yeah is very interesting

1441
00:56:52,360 --> 00:56:58,510
observer right yeah why is great it's

1442
00:56:54,429 --> 00:57:00,489
what i like most importantly we've

1443
00:56:58,510 --> 00:57:03,190
worked on our acronyms since I dcs to

1444
00:57:00,489 --> 00:57:05,169
okay yes the acronym is better you'll

1445
00:57:03,190 --> 00:57:07,510
like it we come back next time with the

1446
00:57:05,170 --> 00:57:10,720
wise survey we have a program called mad

1447
00:57:07,510 --> 00:57:13,930
cowz the massive and clusters of ice

1448
00:57:10,719 --> 00:57:16,449
survey that's been done you banged I and

1449
00:57:13,929 --> 00:57:18,699
so yeah that's it that's great and uh

1450
00:57:16,449 --> 00:57:20,589
like you're finding my very massive

1451
00:57:18,699 --> 00:57:22,149
clusters mad cows that are very master

1452
00:57:20,590 --> 00:57:23,710
clusters at a distance of about 7

1453
00:57:22,150 --> 00:57:25,660
billion like you're so a little bit

1454

00:57:23,710 --> 00:57:26,980
younger sorry a little bit older in the

1455
00:57:25,659 --> 00:57:29,679
state of the universe not so far away

1456
00:57:26,980 --> 00:57:31,869
but but you know a huge range of mass

1457
00:57:29,679 --> 00:57:33,759
from you know pretty wimpy to extremely

1458
00:57:31,869 --> 00:57:35,349
massive most massive seen at that red

1459
00:57:33,760 --> 00:57:37,510
shift something like two or three times

1460
00:57:35,349 --> 00:57:40,659
the mass with this one so lots of fun

1461
00:57:37,510 --> 00:57:42,550
stuff nice good well well we hope you

1462
00:57:40,659 --> 00:57:43,750
you'll we hope you haven't scared you

1463
00:57:42,550 --> 00:57:45,910
away from our hangouts and you'll join

1464
00:57:43,750 --> 00:57:47,829
us when you get some more data to talk

1465
00:57:45,909 --> 00:57:48,139
about that be be awesome to show our

1466
00:57:47,829 --> 00:57:50,090
view

1467
00:57:48,139 --> 00:57:53,900
he's okay he has mad cows so he won't

1468
00:57:50,090 --> 00:57:58,519

know the difference I can imagine first

1469

00:57:53,900 --> 00:58:00,110

one who yes all right all right well I

1470

00:57:58,519 --> 00:58:03,380

thank you thank you guys very much and

1471

00:58:00,110 --> 00:58:07,519

uh Carol we will be back next week but

1472

00:58:03,380 --> 00:58:13,160

do we have a topic yet we do okay we do

1473

00:58:07,519 --> 00:58:18,139

we do so Eric Rona is a famous object

1474

00:58:13,159 --> 00:58:21,289

that had an outburst in 1827 or

1475

00:58:18,139 --> 00:58:23,839

something like that anyway it's kind of

1476

00:58:21,289 --> 00:58:26,389

unique it's well-loved well studied and

1477

00:58:23,840 --> 00:58:29,480

there is a group that has been studying

1478

00:58:26,389 --> 00:58:32,449

and trying to find other objects like it

1479

00:58:29,480 --> 00:58:34,579

in other galaxies so we'll find out what

1480

00:58:32,449 --> 00:58:36,919

they did up next week great so we hope

1481

00:58:34,579 --> 00:58:39,920

you guys will join us next week at this

1482

00:58:36,920 --> 00:58:41,599

Hubble channel and and on behalf of

1483
00:58:39,920 --> 00:58:42,920
carol christian and scott lewis and all

1484
00:58:41,599 --> 00:58:46,489
of our guests i want to thank you all

1485
00:58:42,920 --> 00:58:49,329
for watching and as always keep kicking

1486
00:58:46,489 --> 00:58:49,329
good you're not