
HUBBLE 25
HUBBLE
hangouts
January 14, 2016 3pm EST
Weighing an Extremely Massive, Distant Galaxy Cluster

1
00:00:19,939 --> 00:00:17,000
or back oh my gosh hello hello and

2
00:00:22,929 --> 00:00:19,949
welcome to the first Hubble hang out of

3
00:00:26,420 --> 00:00:22,939
2016 and it begins auspicious Lorraine

4
00:00:28,750 --> 00:00:26,430
initially a telephone call the instant

5
00:00:31,070 --> 00:00:28,760
we had started broadcast thats hilarious

6
00:00:33,020 --> 00:00:31,080
anyway my name is Tony Darnell and I'm

7
00:00:34,670 --> 00:00:33,030
really excited to be back doing these

8
00:00:36,620 --> 00:00:34,680
hangouts for this year we've got a lot

9
00:00:38,900 --> 00:00:36,630
of great hangouts plan for you and in

10
00:00:40,880 --> 00:00:38,910
fact today in particular we're going to

11
00:00:43,280 --> 00:00:40,890
be talking about galaxy clusters in the

12
00:00:46,130 --> 00:00:43,290
early universe because astronomers using

13
00:00:48,170 --> 00:00:46,140

three of NASA's great observatories the

14
00:00:49,850 --> 00:00:48,180
Hubble Space Telescope the Chandra x-ray

15
00:00:52,369 --> 00:00:49,860
telescope and the Spitzer Space

16
00:00:55,369 --> 00:00:52,379
Telescope along with the Keck

17
00:00:58,160 --> 00:00:55,379
Observatory in Hawaii have been looking

18
00:01:01,250 --> 00:00:58,170
at a have found one of the earliest and

19
00:01:03,529 --> 00:01:01,260
most massive galaxy clusters ever seen

20
00:01:05,390 --> 00:01:03,539
and we're going to talk about why that

21
00:01:07,640 --> 00:01:05,400
is important and we're going to put that

22
00:01:09,850 --> 00:01:07,650
in perspective for you with my with the

23
00:01:12,200 --> 00:01:09,860
help of my friends and colleagues

24
00:01:13,700 --> 00:01:12,210
joining me again this year dr. carol

25
00:01:16,399 --> 00:01:13,710
christian she's the Hubble Space

26
00:01:18,140 --> 00:01:16,409
Telescope outreach scientist and Scott

27
00:01:21,170 --> 00:01:18,150
Lewis is also here with us to help us

28
00:01:23,450 --> 00:01:21,180
just bring us back to earth and get the

29
00:01:26,060 --> 00:01:23,460
and tell us what's going on with the

30
00:01:27,770 --> 00:01:26,070
levity in this conversation yeah yeah

31
00:01:32,810 --> 00:01:27,780
yeah you might even be way out there I

32
00:01:34,399 --> 00:01:32,820
got ya the welcome back guy is a happy

33
00:01:36,319 --> 00:01:34,409
new year and all that kind of girl I

34
00:01:42,020 --> 00:01:36,329
mean it's good to be back doing these

35
00:01:43,850 --> 00:01:42,030
again um the UH the I guess usually this

36
00:01:45,289 --> 00:01:43,860
time of the the hangout we have some

37
00:01:46,429 --> 00:01:45,299
announcements but I don't really have

38
00:01:48,410 --> 00:01:46,439

any Carol do you have anything you'd

39
00:01:51,380 --> 00:01:48,420
like to point out anybody what's for

40
00:01:52,910 --> 00:01:51,390
just that James Webb telescope is doing

41
00:01:55,609 --> 00:01:52,920
really well and searching all the

42
00:01:58,870 --> 00:01:55,619
mirrors so let's come along we had a

43
00:02:03,530 --> 00:01:58,880
great american astronomical society

44
00:02:06,020 --> 00:02:03,540
meeting last week where results were

45
00:02:08,719 --> 00:02:06,030
presented in including this one right

46
00:02:11,360 --> 00:02:08,729
and that's right it was presented at the

47
00:02:13,369 --> 00:02:11,370
double-a s last week it was a lot there

48
00:02:13,820 --> 00:02:13,379
there were a lot of interesting results

49
00:02:17,720 --> 00:02:13,830
that

50
00:02:21,410 --> 00:02:17,730
came out and Hubble's doing well and

51
00:02:23,750 --> 00:02:21,420
we're off to a new cycle of proposals so

52
00:02:26,570 --> 00:02:23,760
we'll get to ask people oh are you going

53
00:02:29,870 --> 00:02:26,580
to propose for this in cycle 24 problem

54
00:02:31,400 --> 00:02:29,880
that's right now is the season it begins

55
00:02:33,980 --> 00:02:31,410
the season of asking for Hubble time

56
00:02:38,420 --> 00:02:33,990
isn't that right yeah that's right cool

57
00:02:40,160 --> 00:02:38,430
all right well uh so the so before we

58
00:02:41,360 --> 00:02:40,170
want to introduce my guest but before I

59
00:02:44,390 --> 00:02:41,370
get started I'm going to have Scott

60
00:02:45,710 --> 00:02:44,400
Lewis tell you guys how we'd like to get

61
00:02:47,210 --> 00:02:45,720
your questions and comments throughout

62
00:02:49,910 --> 00:02:47,220
the Hangout so we hope you'll engage

63
00:02:52,100 --> 00:02:49,920

with us and ask questions Scott tell

64
00:02:53,750 --> 00:02:52,110
people how they can do that alright so

65
00:02:55,010 --> 00:02:53,760
the the best and easiest way for you to

66
00:02:56,630 --> 00:02:55,020
get in touch with us while we're live

67
00:02:58,850 --> 00:02:56,640
since you're watching the streams on the

68
00:03:00,590 --> 00:02:58,860
very bottom left o be some texture that

69
00:03:03,380 --> 00:03:00,600
says that we're answering questions and

70
00:03:05,330 --> 00:03:03,390
we are it opens up to Q&A and it allows

71
00:03:07,760 --> 00:03:05,340
you to watch us and on the right hand

72
00:03:09,290 --> 00:03:07,770
side you'll have some you'll have a

73
00:03:10,760 --> 00:03:09,300
little menu in there where you can type

74
00:03:12,710 --> 00:03:10,770
in questions you can upload other

75
00:03:15,110 --> 00:03:12,720
questions too and so when we're going to

76
00:03:16,580 --> 00:03:15,120
our Q&A time we can actually select it

77
00:03:18,259 --> 00:03:16,590
and i'll actually notify you that we're

78
00:03:20,509 --> 00:03:18,269
answering those questions so that's a

79
00:03:22,880 --> 00:03:20,519
really really good way to engage with us

80
00:03:24,800 --> 00:03:22,890
while we're live broadcasting the other

81
00:03:26,570 --> 00:03:24,810
best way for you to get in touch with us

82
00:03:29,270 --> 00:03:26,580
is grover on Twitter so we are live

83
00:03:32,030 --> 00:03:29,280
tweeting right now as at Hubble

84
00:03:33,920 --> 00:03:32,040
telescope using the hashtag Hubble hang

85
00:03:35,870 --> 00:03:33,930
out so i'll be live tweeting as we're

86
00:03:38,180 --> 00:03:35,880
going on so if you have any questions or

87
00:03:39,860 --> 00:03:38,190
interesting insights I please use that

88
00:03:41,960 --> 00:03:39,870

hashtag and I'll be going back and forth

89
00:03:45,380 --> 00:03:41,970
with their i also have an event open on

90
00:03:46,820 --> 00:03:45,390
facebook and and we can check the

91
00:03:48,259 --> 00:03:46,830
regular YouTube comments as well so

92
00:03:49,370 --> 00:03:48,269
we'll be checking all over the place for

93
00:03:52,040 --> 00:03:49,380
any of the comments you have but the

94
00:03:53,990 --> 00:03:52,050
best way is using the Q&A app or using

95
00:03:56,240 --> 00:03:54,000
Twitter that's how we'll get in touch

96
00:03:57,110 --> 00:03:56,250
with you Oh some thank you so we look

97
00:03:59,240 --> 00:03:57,120
forward to your comments and questions

98
00:04:00,890 --> 00:03:59,250
and we'll read them as we go along or

99
00:04:02,930 --> 00:04:00,900
we'll have some time on set aside at the

100
00:04:04,640 --> 00:04:02,940
end to also read them out so we look

101
00:04:08,180 --> 00:04:04,650
forward to that so let me get to today's

102
00:04:10,160 --> 00:04:08,190
hangout as I said three of NASA's great

103
00:04:11,810 --> 00:04:10,170
observers how many are there Carol how

104
00:04:15,470 --> 00:04:11,820
many great observatories are there any

105
00:04:19,759 --> 00:04:15,480
way I'd other more than 3 billions and

106
00:04:22,010 --> 00:04:19,769
billions now after all right you know

107
00:04:25,219 --> 00:04:22,020
because nowadays the NASA has set these

108
00:04:27,590 --> 00:04:25,229
aside specifically as a yes the

109
00:04:31,730 --> 00:04:27,600
gamma-ray observatory was a grade of

110
00:04:34,730 --> 00:04:31,740
ritory Oh bit Spitzer which is infrared

111
00:04:37,610 --> 00:04:34,740
Hubble which is UV optical infrared and

112
00:04:40,670 --> 00:04:37,620
Chandra which is the x-ray Observatory

113
00:04:43,880 --> 00:04:40,680

so the bar be good they're not great or

114
00:04:47,390 --> 00:04:43,890
they swell are they danamon turns yeah

115
00:04:52,850 --> 00:04:47,400
pretty good you know awesome but yeah

116
00:04:58,220 --> 00:04:52,860
yeah they're just not great okay so well

117
00:05:01,930 --> 00:04:58,230
good so colleagues out there yeah yeah

118
00:05:06,500 --> 00:05:01,940
mom it's 2016 and work grumpy okay hey

119
00:05:07,730 --> 00:05:06,510
NASA Colton gray right okay so so a lot

120
00:05:09,080 --> 00:05:07,740
of a lot of wavelengths a lot of

121
00:05:10,910 --> 00:05:09,090
eyeballs were brought to bear on this

122
00:05:12,080 --> 00:05:10,920
particular set of observations so let's

123
00:05:14,930 --> 00:05:12,090
get to them but let me introduce our

124
00:05:17,270 --> 00:05:14,940
guests joining me is the the lead author

125
00:05:20,210 --> 00:05:17,280
on the on the paper dr. mark broad when

126
00:05:22,400 --> 00:05:20,220
he is a US and is an assistant professor

127
00:05:24,370 --> 00:05:22,410
at MIT he's also a member of the

128
00:05:28,790 --> 00:05:24,380
Cavalier for astrophysics and space

129
00:05:31,210 --> 00:05:28,800
research also dr. Anthony Gonzales he's

130
00:05:33,920 --> 00:05:31,220
a professor at the University of Florida

131
00:05:37,070 --> 00:05:33,930
very near where I'm at my where my home

132
00:05:40,070 --> 00:05:37,080
is actually also dr. Mike McDonald from

133
00:05:41,990 --> 00:05:40,080
from oh wait a minute did I get I got a

134
00:05:44,810 --> 00:05:42,000
backwards in my fraud when is university

135
00:05:46,640 --> 00:05:44,820
of missouri at kansas sorry about that I

136
00:05:48,440 --> 00:05:46,650
apologize he's at the university of

137
00:05:50,450 --> 00:05:48,450
missouri at kansas it's mike mcdonald

138
00:05:52,940 --> 00:05:50,460

who's from MIT an assistant professor a

139
00:05:54,200 --> 00:05:52,950
member or and a member of the MIT my

140
00:05:57,080 --> 00:05:54,210
teas carefully Center for Astrophysics

141
00:05:58,850 --> 00:05:57,090
based research here to talk about all

142
00:06:00,800 --> 00:05:58,860
these things so welcome to our hangout

143
00:06:02,920 --> 00:06:00,810
guys I'm glad we didn't scare you off

144
00:06:06,020 --> 00:06:02,930
and after we got through all of the

145
00:06:07,490 --> 00:06:06,030
initial browser difficulties we're back

146
00:06:09,200 --> 00:06:07,500
on track so let's talk about this a

147
00:06:13,310 --> 00:06:09,210
let's talk about this mark I'm going to

148
00:06:15,560 --> 00:06:13,320
start with you so you guys obviously got

149
00:06:19,970 --> 00:06:15,570
a lot of telescope time here to do this

150
00:06:21,890 --> 00:06:19,980
but the the you you guys have found not

151
00:06:27,350 --> 00:06:21,900
just found but you've characterized and

152
00:06:29,660 --> 00:06:27,360
measured the mass of one of the largest

153
00:06:32,570 --> 00:06:29,670
galaxy clusters in the early universe

154
00:06:33,950 --> 00:06:32,580
now astronomers you know it takes

155
00:06:35,750 --> 00:06:33,960
hundreds of millions of years for

156
00:06:38,240 --> 00:06:35,760
galaxies to form but even longer for

157
00:06:39,650 --> 00:06:38,250
galaxy clusters to form so I want to

158
00:06:40,999 --> 00:06:39,660
talk a little bit about your work and

159
00:06:42,140 --> 00:06:41,009
what you're doing and

160
00:06:45,679 --> 00:06:42,150
which are going to be presenting to us

161
00:06:47,600 --> 00:06:45,689
today okay thanks Tony yeah this this is

162
00:06:49,249 --> 00:06:47,610
a really exciting cluster that needed

163
00:06:51,679 --> 00:06:49,259

all of NASA's great observatories as

164
00:06:53,959 --> 00:06:51,689
well as some some awesome facilities on

165
00:06:56,420 --> 00:06:53,969
the ground in order to to both find and

166
00:06:59,209 --> 00:06:56,430
characterize we actually found it with

167
00:07:00,739 --> 00:06:59,219
Spitzer in 2012 and as Carol mentioned

168
00:07:03,200 --> 00:07:00,749
Spitzer's an infrared telescope that

169
00:07:04,879 --> 00:07:03,210
lets us see galaxies you know pretty

170
00:07:06,920 --> 00:07:04,889
massive galaxies all the way out in the

171
00:07:09,200 --> 00:07:06,930
universe unlike an optical they don't

172
00:07:11,239 --> 00:07:09,210
really fade so we can find them and you

173
00:07:13,459 --> 00:07:11,249
just God has a copy or Scott has an

174
00:07:14,689 --> 00:07:13,469
image of the 2012 cluster and while

175
00:07:17,899 --> 00:07:14,699
you're talking if he can pull that up

176
00:07:20,749 --> 00:07:17,909
that'd be great okay and so we actually

177
00:07:22,850 --> 00:07:20,759
found this cluster with Spitzer and we

178
00:07:25,159 --> 00:07:22,860
used Hubble back then not just to get

179
00:07:26,510 --> 00:07:25,169
pretty pictures but also to measure the

180
00:07:28,639 --> 00:07:26,520
distance to the cluster Hubble was

181
00:07:30,469 --> 00:07:28,649
actually the key facility in getting

182
00:07:33,219 --> 00:07:30,479
what we call a spectroscopic redshift

183
00:07:35,959 --> 00:07:33,229
although we also used Keck the 10-meter

184
00:07:38,299 --> 00:07:35,969
diameter mirror in Hawaii to help

185
00:07:39,889 --> 00:07:38,309
without that also together we were able

186
00:07:42,260 --> 00:07:39,899
to confirm that the distance is about 10

187
00:07:44,420 --> 00:07:42,270
billion light years away then we turned

188
00:07:46,249 --> 00:07:44,430

our attention to a radio telescope on

189
00:07:48,589 --> 00:07:46,259
the ground that no longer is in

190
00:07:50,510 --> 00:07:48,599
operation sadly but it was called karma

191
00:07:52,989 --> 00:07:50,520
and it allowed us to measure a first

192
00:07:55,219 --> 00:07:52,999
estimate of the mass of the cluster

193
00:07:56,709 --> 00:07:55,229
basically the way that works is if you

194
00:07:58,999 --> 00:07:56,719
look at the Cosmic Microwave Background

195
00:08:00,799 --> 00:07:59,009
when there's a cluster in the way it

196
00:08:02,209 --> 00:08:00,809
looks different the cluster gas affects

197
00:08:04,399 --> 00:08:02,219
the light coming from the cosmic

198
00:08:06,619 --> 00:08:04,409
microwave background and from how much

199
00:08:08,239 --> 00:08:06,629
the spectrum changes we can measure the

200
00:08:10,279 --> 00:08:08,249
mass of the cluster and we did that and

201
00:08:12,139 --> 00:08:10,289
got a mass of something like four

202
00:08:16,059 --> 00:08:12,149
hundred trillion times the mass of our

203
00:08:18,409 --> 00:08:16,069
Sun truly with a tea with a tea yeah Wow

204
00:08:19,730 --> 00:08:18,419
okay now let me make sure I understood

205
00:08:21,110 --> 00:08:19,740
what you just said so you said you

206
00:08:24,139 --> 00:08:21,120
looked at this with karma and radio

207
00:08:25,969 --> 00:08:24,149
waves rant based on the amount of

208
00:08:27,799 --> 00:08:25,979
distortion in the Cosmic Microwave

209
00:08:29,689 --> 00:08:27,809
Background in that wavelength you were

210
00:08:33,379 --> 00:08:29,699
able to get an idea how massive it was

211
00:08:34,459 --> 00:08:33,389
that's right yeah the basically the the

212
00:08:37,009 --> 00:08:34,469
photons from the Cosmic Microwave

213
00:08:38,930 --> 00:08:37,019

Background hit are they scatter they hit

214
00:08:41,629 --> 00:08:38,940
the electrons in the cluster and they

215
00:08:43,639 --> 00:08:41,639
change what the CMB looks like in fact

216
00:08:45,319 --> 00:08:43,649
at you the same be kind of disappears a

217
00:08:46,670 --> 00:08:45,329
little bit at the right if you look in

218
00:08:49,250 --> 00:08:46,680
the right frequency so you're kind of

219
00:08:51,199 --> 00:08:49,260
looking for holes in the sky and the

220
00:08:53,780 --> 00:08:51,209
deeper the whole the greater the mass of

221
00:08:54,680 --> 00:08:53,790
the cluster so those observations back

222
00:08:58,130 --> 00:08:54,690
in 2012

223
00:09:00,050 --> 00:08:58,140
kind of set the stage then for knowing

224
00:09:02,600 --> 00:09:00,060
that this was something very massive and

225
00:09:05,510 --> 00:09:02,610
very very far away correct yeah exactly

226
00:09:08,000 --> 00:09:05,520
and and the logical thing to do next was

227
00:09:09,950 --> 00:09:08,010
to try and get Shandra time shaundra's

228
00:09:11,900 --> 00:09:09,960
the premier facility for studying galaxy

229
00:09:14,390 --> 00:09:11,910
clusters in the x-ray and why was that

230
00:09:16,520 --> 00:09:14,400
why was that the logical next step why

231
00:09:19,730 --> 00:09:16,530
did you go from from radio all the way

232
00:09:22,310 --> 00:09:19,740
to x-ray it is a long way to go that's

233
00:09:24,910 --> 00:09:22,320
right as far as you can go but the

234
00:09:26,960 --> 00:09:24,920
reason is because the Chandra is the

235
00:09:29,210 --> 00:09:26,970
facility that's best able to

236
00:09:31,630 --> 00:09:29,220
characterize galaxy clusters all aspects

237
00:09:33,800 --> 00:09:31,640
of galaxy clusters and so that's when

238
00:09:35,900 --> 00:09:33,810

professor McDonald got involved I

239
00:09:37,550 --> 00:09:35,910
actually wrote the proposal but he did a

240
00:09:40,880 --> 00:09:37,560
lot of the analysis on the extra David

241
00:09:42,440 --> 00:09:40,890
he can speak to that okay Michael so you

242
00:09:43,790 --> 00:09:42,450
want to talk a little bit about some of

243
00:09:45,670 --> 00:09:43,800
the some of the x-ray data that you took

244
00:09:48,860 --> 00:09:45,680
from this image or from this cluster

245
00:09:51,770 --> 00:09:48,870
sure so the the x-ray data it gets a

246
00:09:53,480 --> 00:09:51,780
sense of not only how massive the

247
00:09:55,220 --> 00:09:53,490
cluster is but how that mass is

248
00:09:58,460 --> 00:09:55,230
distributed and sort of where the bulk

249
00:10:00,790 --> 00:09:58,470
of the matter is in the cluster because

250
00:10:04,520 --> 00:10:00,800
the bulk of the matter is in a very hot

251
00:10:07,460 --> 00:10:04,530
diffuse gas phase which is bright x-ray

252
00:10:10,040 --> 00:10:07,470
so Scott has scott has something very

253
00:10:11,780 --> 00:10:10,050
fuzzy and blue up is that what you're

254
00:10:15,620 --> 00:10:11,790
talking about that is exactly what I'm

255
00:10:18,260 --> 00:10:15,630
talking about yeah so this is an x-ray

256
00:10:21,050 --> 00:10:18,270
image of the cluster after we've hit the

257
00:10:23,720 --> 00:10:21,060
enhance button a few times to sort of

258
00:10:25,820 --> 00:10:23,730
improve their data quality but what

259
00:10:28,430 --> 00:10:25,830
you're seeing there is sort of a diffuse

260
00:10:30,830 --> 00:10:28,440
component that's you know a million

261
00:10:33,610 --> 00:10:30,840
light years across and then there's

262
00:10:36,830 --> 00:10:33,620
three peaks two of those Peaks are

263
00:10:39,410 --> 00:10:36,840

active actively creating black holes and

264
00:10:41,930 --> 00:10:39,420
the center of the three peaks the center

265
00:10:45,110 --> 00:10:41,940
is it's just the densest part of the ha

266
00:10:47,870 --> 00:10:45,120
Ozma ok so wait every bright spot we see

267
00:10:49,870 --> 00:10:47,880
here the really bright spot is a is a

268
00:10:54,020 --> 00:10:49,880
supermassive black hole in the galaxy

269
00:10:55,520 --> 00:10:54,030
burning so every every spot that we see

270
00:10:57,560 --> 00:10:55,530
here bright spot we see here in this

271
00:11:00,380 --> 00:10:57,570
image that's they the center of a galaxy

272
00:11:02,480 --> 00:11:00,390
or supermassive black hole right so all

273
00:11:05,300 --> 00:11:02,490
the peaks are either the center of the

274
00:11:08,470 --> 00:11:05,310
galaxy or a clump of galaxies but the

275
00:11:10,780 --> 00:11:08,480
diffuse stuff extends over the full

276
00:11:14,350 --> 00:11:10,790
for volume so the cluster the cluster

277
00:11:17,019 --> 00:11:14,360
galaxies are basically in a hot bath at

278
00:11:21,100 --> 00:11:17,029
this path is who's admitting in the next

279
00:11:22,810 --> 00:11:21,110
ways so this gas is by nature of the

280
00:11:26,110 --> 00:11:22,820
fact you're seeing in an x rays is

281
00:11:28,810 --> 00:11:26,120
extremely hot right or at least

282
00:11:30,930 --> 00:11:28,820
energetic correctness and its affiliates

283
00:11:35,439 --> 00:11:30,940
of degrees or millions of degrees thirty

284
00:11:37,269 --> 00:11:35,449
and does do all galaxy clusters have

285
00:11:39,730 --> 00:11:37,279
this kind of characters to gas I mean

286
00:11:40,840 --> 00:11:39,740
are they or is it just is this one I'm

287
00:11:44,319 --> 00:11:40,850
trying to I'm trying to get a sense of

288
00:11:46,120 --> 00:11:44,329

it is this special too early galaxy

289
00:11:48,280 --> 00:11:46,130
clusters or do all galaxy clusters know

290
00:11:50,920 --> 00:11:48,290
so so in fact the temperature of the gas

291
00:11:52,870 --> 00:11:50,930
tells us something about the mass or it

292
00:11:56,439 --> 00:11:52,880
tells us a lot about the mass so as you

293
00:11:58,600 --> 00:11:56,449
compressed gas it gets hotter and so the

294
00:12:00,910 --> 00:11:58,610
more mass you have that's pushing the

295
00:12:03,639 --> 00:12:00,920
cluster down and compressing it in the

296
00:12:05,110 --> 00:12:03,649
center the hotter the gas will be so by

297
00:12:08,860 --> 00:12:05,120
measuring the temperature of these

298
00:12:10,629 --> 00:12:08,870
x-rays we get a sense of how much matter

299
00:12:12,730 --> 00:12:10,639
is is sort of pulling in on the cluster

300
00:12:15,040 --> 00:12:12,740
that gives us a estimate of the total

301
00:12:18,610 --> 00:12:15,050
mass which is much more accurate than

302
00:12:20,410 --> 00:12:18,620
the radio s okay so that's why it was

303
00:12:22,059 --> 00:12:20,420
the next logical step to go from Radio

304
00:12:25,449 --> 00:12:22,069
to x-rays to get a bit more accurate

305
00:12:28,480 --> 00:12:25,459
mass then right okay alright so these

306
00:12:32,280 --> 00:12:28,490
also you have a question so why why do

307
00:12:35,590 --> 00:12:32,290
these galaxies clusters have like a

308
00:12:39,610 --> 00:12:35,600
regular mass that we can see presumably

309
00:12:41,470 --> 00:12:39,620
there's dark matter and then it has this

310
00:12:45,879 --> 00:12:41,480
hot gas what's the relationship between

311
00:12:48,280 --> 00:12:45,889
the hot gas and the galaxy galaxies we

312
00:12:50,439 --> 00:12:48,290
see which will we'll see later on and

313
00:12:54,400 --> 00:12:50,449

images that were taken by Hubble and

314
00:12:58,150 --> 00:12:54,410
Spitzer so most of this hot gas was

315
00:13:00,129 --> 00:12:58,160
probably once in galaxies and it's been

316
00:13:02,379 --> 00:13:00,139
either stripped as the galaxies fall

317
00:13:05,350 --> 00:13:02,389
into the cluster or it's been expelled

318
00:13:08,470 --> 00:13:05,360
by things like supernova or active

319
00:13:11,949 --> 00:13:08,480
galaxies so this is the cluster kind of

320
00:13:14,470 --> 00:13:11,959
all shares all of this gas okay end it

321
00:13:18,269 --> 00:13:14,480
but it was probably once a part of the

322
00:13:20,290 --> 00:13:18,279
galaxies that were in the cluster okay

323
00:13:23,070 --> 00:13:20,300
so I just want to comment real quickly

324
00:13:25,720 --> 00:13:23,080
on a something Andrew planet

325
00:13:28,570 --> 00:13:25,730
put on the Q&A app about having problems

326
00:13:31,210 --> 00:13:28,580
with the streaming it sometimes helps if

327
00:13:32,680 --> 00:13:31,220
you just refresh the browser window or

328
00:13:35,170 --> 00:13:32,690
close in the browser window and getting

329
00:13:36,520 --> 00:13:35,180
back to it again sometimes that helps

330
00:13:37,750 --> 00:13:36,530
but that's really your only course of

331
00:13:40,090 --> 00:13:37,760
action I'm sorry you guys are having

332
00:13:42,540 --> 00:13:40,100
trouble while watching the stream

333
00:13:46,390 --> 00:13:42,550
hopefully it'll sort itself out soon

334
00:13:48,130 --> 00:13:46,400
okay so so Anthony I want to get you

335
00:13:51,220 --> 00:13:48,140
involved here a little bit and want to

336
00:13:53,410 --> 00:13:51,230
ask you about the give us a sense of the

337
00:13:55,180 --> 00:13:53,420
timeline here we've already you've

338
00:13:57,460 --> 00:13:55,190

already told us the punchline that this

339
00:14:01,180 --> 00:13:57,470
thing is worth this thing weighs 45

340
00:14:02,680 --> 00:14:01,190
hundred trillion Suns so it's very very

341
00:14:05,170 --> 00:14:02,690
very massive in fact it's the most

342
00:14:08,680 --> 00:14:05,180
massive I think the press release states

343
00:14:11,800 --> 00:14:08,690
a galaxy cluster of this period in the

344
00:14:14,130 --> 00:14:11,810
in the history of the universe but give

345
00:14:16,690 --> 00:14:14,140
us a sense of the timeline so we

346
00:14:19,180 --> 00:14:16,700
presumably we have stars followed by

347
00:14:20,680 --> 00:14:19,190
galaxies followed by clusters of

348
00:14:24,450 --> 00:14:20,690
galaxies right can you give us a sense

349
00:14:26,380 --> 00:14:24,460
of just how long that might take sure so

350
00:14:27,700 --> 00:14:26,390
when you're building a structure in the

351
00:14:29,200 --> 00:14:27,710
universe the smallest things are

352
00:14:32,830 --> 00:14:29,210
building up first so you form the first

353
00:14:34,630 --> 00:14:32,840
stars very early on as soon as matter

354
00:14:37,270 --> 00:14:34,640
starts having a chance to collapse down

355
00:14:39,160 --> 00:14:37,280
enough to that you get structures class

356
00:14:41,470 --> 00:14:39,170
structures and you keep building up

357
00:14:42,910 --> 00:14:41,480
larger and larger things so you get

358
00:14:45,100 --> 00:14:42,920
galaxies forming within the first

359
00:14:47,500 --> 00:14:45,110
billion years after the big bang and

360
00:14:49,630 --> 00:14:47,510
then first billionaire as we're going

361
00:14:51,880 --> 00:14:49,640
with yes within the first billion years

362
00:14:53,230 --> 00:14:51,890
day the first there are these galaxies

363
00:14:55,810 --> 00:14:53,240

we've seen are actually even a bit

364
00:14:56,950 --> 00:14:55,820
further back than that but then you have

365
00:14:59,200 --> 00:14:56,960
to wait while you're building up these

366
00:15:01,950 --> 00:14:59,210
larger and larger structures these

367
00:15:04,360 --> 00:15:01,960
galaxy clusters have as much mass as a

368
00:15:07,360 --> 00:15:04,370
thousand galaxies aside from Milky Way

369
00:15:09,460 --> 00:15:07,370
more or less so and so it's only when

370
00:15:11,500 --> 00:15:09,470
you only you only expect to get its arms

371
00:15:13,210 --> 00:15:11,510
as long as when you're approaching a

372
00:15:16,180 --> 00:15:13,220
little under a mile under happening

373
00:15:19,540 --> 00:15:16,190
already so yes wait another five or six

374
00:15:22,990 --> 00:15:19,550
islands and audio we go but your your

375
00:15:27,310 --> 00:15:23,000
audio just but yeah when my I am yeah

376
00:15:29,470 --> 00:15:27,320
unfortunately it's yet maybe mmm sounds

377
00:15:31,330 --> 00:15:29,480
like you're part cyborg Anthony yeah

378
00:15:32,860 --> 00:15:31,340
yeah I get a lot of things got a lot of

379
00:15:34,450 --> 00:15:32,870
noise in the Indy audio but now you're

380
00:15:35,190 --> 00:15:34,460
better go so I'm sorry go ahead and

381
00:15:37,170 --> 00:15:35,200
continue

382
00:15:39,420 --> 00:15:37,180
oh sure I was just saying that it takes

383
00:15:41,100 --> 00:15:39,430
much longer before galaxy clusters have

384
00:15:42,420 --> 00:15:41,110
time to assemble in form because there's

385
00:15:45,270 --> 00:15:42,430
so much more massive than individual

386
00:15:46,560 --> 00:15:45,280
galaxies and so you don't expect to

387
00:15:47,850 --> 00:15:46,570
start getting galaxy clusters that's

388
00:15:49,650 --> 00:15:47,860

massive until the universe is

389
00:15:52,260 --> 00:15:49,660
approaching roughly half its current age

390
00:15:54,470 --> 00:15:52,270
so when it's getting to be more like six

391
00:15:57,180 --> 00:15:54,480
billion years or seven billion years old

392
00:15:58,740 --> 00:15:57,190
so that's the time skills you formed

393
00:16:00,990 --> 00:15:58,750
start forming the first star is very

394
00:16:02,130 --> 00:16:01,000
quickly the galaxies a bit after that

395
00:16:05,460 --> 00:16:02,140
and then you have to wait a while before

396
00:16:06,750 --> 00:16:05,470
you start seeing these and so at the

397
00:16:09,030 --> 00:16:06,760
distance we're looking at for this

398
00:16:11,060 --> 00:16:09,040
cluster you really at the era where

399
00:16:14,460 --> 00:16:11,070
you're starting to see the very first

400
00:16:17,130 --> 00:16:14,470
cluster is formed so we're really this

401
00:16:18,810 --> 00:16:17,140
is kind of the burthen very early days

402
00:16:22,110 --> 00:16:18,820
or toddler days as it were for cluster

403
00:16:24,930 --> 00:16:22,120
formation ok so I'm sorry I'm going to

404
00:16:26,640 --> 00:16:24,940
comment again on the people having

405
00:16:28,350 --> 00:16:26,650
trouble seeing this dream Scott is there

406
00:16:30,470 --> 00:16:28,360
a way you could post the youtube link on

407
00:16:32,490 --> 00:16:30,480
the comments maybe that will help people

408
00:16:34,590 --> 00:16:32,500
maybe if they go straight to YouTube

409
00:16:36,900 --> 00:16:34,600
they might be able to see it better ok

410
00:16:40,890 --> 00:16:36,910
so don't another bad out there all right

411
00:16:43,410 --> 00:16:40,900
thank you so the so I guess the the

412
00:16:46,980 --> 00:16:43,420
surprise here then with this particular

413
00:16:49,560 --> 00:16:46,990

one is that we is that you saw so you

414
00:16:52,230 --> 00:16:49,570
saw this this particular galaxy cluster

415
00:16:54,120 --> 00:16:52,240
when it was you said universe was was

416
00:16:56,370 --> 00:16:54,130
his 10 billion light years away so the

417
00:16:58,110 --> 00:16:56,380
universe is 13.8 billion years old so

418
00:16:59,970 --> 00:16:58,120
this is about when the universe was

419
00:17:03,630 --> 00:16:59,980
roughly three point eight to four

420
00:17:07,260 --> 00:17:03,640
billion years old correct right so and

421
00:17:09,030 --> 00:17:07,270
how is point the survey that we actually

422
00:17:11,760 --> 00:17:09,040
found this galaxy cluster in was fairly

423
00:17:13,470 --> 00:17:11,770
small in the sky so we elected an area

424
00:17:16,020 --> 00:17:13,480
of about ten square degrees on the sky

425
00:17:18,930 --> 00:17:16,030
which the whole sky is about 42,000

426
00:17:20,579 --> 00:17:18,940
square degrees and you would not have

427
00:17:23,370 --> 00:17:20,589
necessarily expected to find something

428
00:17:26,220 --> 00:17:23,380
this extreme looking in such a small

429
00:17:27,780 --> 00:17:26,230
patch of sky you might expect to find a

430
00:17:31,590 --> 00:17:27,790
few of these across the sky but not

431
00:17:33,180 --> 00:17:31,600
within such a small area so it was a

432
00:17:36,570 --> 00:17:33,190
pleasant surprise that we found this I

433
00:17:41,790 --> 00:17:36,580
think it was fair thing to say okay so

434
00:17:43,350 --> 00:17:41,800
the so the galaxy comes so we use are

435
00:17:47,340 --> 00:17:43,360
you saying this particular cluster then

436
00:17:48,980 --> 00:17:47,350
is is small compared to other other

437
00:17:53,330 --> 00:17:48,990
known galaxy clusters that are older

438
00:17:57,500 --> 00:17:53,340

I so they believe like a small area of

439
00:17:58,880 --> 00:17:57,510
sky it's exceptionally massive it it's

440
00:18:00,650 --> 00:17:58,890
one of the most massive that you would

441
00:18:02,919 --> 00:18:00,660
expect to be out there at this distance

442
00:18:05,090 --> 00:18:02,929
away from us it will grow to something

443
00:18:07,340 --> 00:18:05,100
that will be one of the most massive

444
00:18:08,960 --> 00:18:07,350
clusters in the universe but their real

445
00:18:11,180 --> 00:18:08,970
universe by the time it gets the present

446
00:18:14,660 --> 00:18:11,190
day so it will continue to grow but it's

447
00:18:16,940 --> 00:18:14,670
a very extreme cluster I say okay so we

448
00:18:20,150 --> 00:18:16,950
got so we have so there's our rough

449
00:18:22,130 --> 00:18:20,160
there's roughly our timeline we without

450
00:18:23,960 --> 00:18:22,140
within the first billion years or so the

451
00:18:25,430 --> 00:18:23,970
first stars are the first stars go and

452
00:18:27,049 --> 00:18:25,440
when did you say the first galaxies I'm

453
00:18:28,940 --> 00:18:27,059
sorry because your audio was messed up

454
00:18:30,770 --> 00:18:28,950
then when were the first galaxies came

455
00:18:32,720 --> 00:18:30,780
along a rut for galaxies are within the

456
00:18:35,540 --> 00:18:32,730
first billion years the first stirred in

457
00:18:37,100 --> 00:18:35,550
the first boner yes saying okay you you

458
00:18:39,230 --> 00:18:37,110
form the first stars fairly quickly

459
00:18:40,700 --> 00:18:39,240
after a matter starts having crime to

460
00:18:42,950 --> 00:18:40,710
collapse and you form start forming

461
00:18:45,169 --> 00:18:42,960
galaxies the first galaxies within the

462
00:18:46,850 --> 00:18:45,179
first billion years as well okay so from

463
00:18:49,100 --> 00:18:46,860

what I know about the first stars and

464
00:18:51,169 --> 00:18:49,110
galaxies and what I've learned talking

465
00:18:52,880 --> 00:18:51,179
to people working on things like jwst

466
00:18:54,890 --> 00:18:52,890
and things like this these first stars

467
00:18:57,020 --> 00:18:54,900
and by definition the first galaxies

468
00:18:59,570 --> 00:18:57,030
were pretty strange beasts right i mean

469
00:19:01,280 --> 00:18:59,580
these galaxies that were made up of

470
00:19:03,290 --> 00:19:01,290
stars that were very hot very they

471
00:19:05,510 --> 00:19:03,300
burned out very quickly they died in

472
00:19:08,780 --> 00:19:05,520
core collapse supernovae and they're

473
00:19:10,340 --> 00:19:08,790
very strange massive hot stars and so

474
00:19:12,740 --> 00:19:10,350
bright presumably the galaxies would be

475
00:19:16,490 --> 00:19:12,750
like that is that what the galaxies are

476
00:19:19,180 --> 00:19:16,500
like in this particular cluster are they

477
00:19:22,190 --> 00:19:19,190
they have stars that are reminiscent or

478
00:19:24,530 --> 00:19:22,200
indicative of early stars let me ask let

479
00:19:26,390 --> 00:19:24,540
me ask mark that question no these

480
00:19:28,520 --> 00:19:26,400
you're speaking about a much earlier

481
00:19:31,010 --> 00:19:28,530
time in the universe when stars are

482
00:19:33,290 --> 00:19:31,020
forming from gas that is relatively

483
00:19:35,120 --> 00:19:33,300
pristine also by the time the four

484
00:19:37,250 --> 00:19:35,130
billion years hits for this galaxy

485
00:19:40,280 --> 00:19:37,260
cluster it's we've gone through several

486
00:19:43,040 --> 00:19:40,290
generations well yeah at least one and

487
00:19:44,930 --> 00:19:43,050
and so the the galaxies the stars in

488
00:19:47,390 --> 00:19:44,940

these galaxies are pretty you know

489
00:19:48,650 --> 00:19:47,400
typical stars and the start you know the

490
00:19:50,990 --> 00:19:48,660
star formation activity that's going on

491
00:19:53,299 --> 00:19:51,000
is substantial but it's not appreciably

492
00:19:55,940 --> 00:19:53,309
different than then you know then what's

493
00:20:00,950 --> 00:19:55,950
happening in the local universe okay

494
00:20:01,580 --> 00:20:00,960
that's a very high okay so so the okay

495
00:20:07,970 --> 00:20:01,590
so

496
00:20:11,419 --> 00:20:07,980
Scott's already shown the x-ray the

497
00:20:14,060 --> 00:20:11,429
x-ray version but there's also a sort of

498
00:20:15,169 --> 00:20:14,070
a composite of with Hubble and the

499
00:20:16,970 --> 00:20:15,179
different wavelengths that we're up

500
00:20:18,409 --> 00:20:16,980
there and while Scott if you could put

501
00:20:19,669 --> 00:20:18,419
that up I think it was the press release

502
00:20:22,130 --> 00:20:19,679
image that's what I'm is the one I'm

503
00:20:25,070 --> 00:20:22,140
referring to and then I want to have

504
00:20:28,310 --> 00:20:25,080
maybe Mike remark talk a little bit

505
00:20:29,960 --> 00:20:28,320
about that image here it is so what so

506
00:20:32,210 --> 00:20:29,970
this is what were you guys released last

507
00:20:33,830 --> 00:20:32,220
week correct yeah that's right this was

508
00:20:36,200 --> 00:20:33,840
the press release image that the

509
00:20:38,810 --> 00:20:36,210
accompanied the actual press release and

510
00:20:41,840 --> 00:20:38,820
it's it's really a beautiful image I

511
00:20:45,019 --> 00:20:41,850
think you can see a lot of massive

512
00:20:46,580 --> 00:20:45,029
galaxies the ones that are redder or red

513
00:20:48,380 --> 00:20:46,590

redness here basically indicates a lot

514
00:20:51,169 --> 00:20:48,390
of stellar mass that's the Spitzer data

515
00:20:52,970 --> 00:20:51,179
coming in and you see you know the

516
00:20:54,769 --> 00:20:52,980
gravitational arc to the sort of

517
00:20:57,830 --> 00:20:54,779
straight north of the middle of the

518
00:21:02,570 --> 00:20:57,840
cluster there's a very thin arc of light

519
00:21:05,630 --> 00:21:02,580
which which is the image of a distant

520
00:21:08,060 --> 00:21:05,640
galaxies whose light is being bent by

521
00:21:10,220 --> 00:21:08,070
the you know by the mass of this cluster

522
00:21:13,130 --> 00:21:10,230
a Scott could you use your pointer to

523
00:21:16,539 --> 00:21:13,140
kind of outline that for us please can

524
00:21:22,669 --> 00:21:16,549
you there ya know a little bit lower

525
00:21:24,200 --> 00:21:22,679
yeah there you go okay it's right center

526
00:21:25,909 --> 00:21:24,210
of the image now where he's got is his

527
00:21:28,039 --> 00:21:25,919
cursor yeah just to the left of the

528
00:21:32,240 --> 00:21:28,049
cursor that's right so that is that

529
00:21:33,919 --> 00:21:32,250
smudge is a galaxy that's a distant

530
00:21:36,560 --> 00:21:33,929
galaxies whose light is being distorted

531
00:21:39,830 --> 00:21:36,570
as it passes through the bent space-time

532
00:21:43,070 --> 00:21:39,840
but of the cluster and in fact that that

533
00:21:46,100 --> 00:21:43,080
arc provided us with another independent

534
00:21:48,830 --> 00:21:46,110
estimate of the mass which which was the

535
00:21:51,760 --> 00:21:48,840
subject of a paper that Anthony put out

536
00:21:56,029 --> 00:21:51,770
in 2012 you can speak to that Anthony

537
00:21:57,980 --> 00:21:56,039
sure so if you have us when you see

538
00:22:00,820 --> 00:21:57,990

something that's elongated like that's

539
00:22:03,110 --> 00:22:00,830
called a strong gravitational arc and

540
00:22:04,669 --> 00:22:03,120
just like a magnifying glass will

541
00:22:06,440 --> 00:22:04,679
distort light coming through it the mass

542
00:22:08,210 --> 00:22:06,450
of that cluster is bending the light

543
00:22:11,270 --> 00:22:08,220
from the background galaxies as it comes

544
00:22:13,250 --> 00:22:11,280
towards us and you can use the distance

545
00:22:15,139 --> 00:22:13,260
but the shape of that arc you can figure

546
00:22:15,450 --> 00:22:15,149
out where the center of it is and you

547
00:22:17,460 --> 00:22:15,460
can

548
00:22:20,789 --> 00:22:17,470
use that distortion and how large an

549
00:22:22,649 --> 00:22:20,799
area is enclosed by that circle to get

550
00:22:23,970 --> 00:22:22,659
an estimate for how much matter is

551
00:22:26,880 --> 00:22:23,980
enclosed and that includes the dark

552
00:22:30,330 --> 00:22:26,890
matter and the x-ray gas and the

553
00:22:31,830 --> 00:22:30,340
galaxies and then you can based on what

554
00:22:33,960 --> 00:22:31,840
you think the shape of a galaxy cluster

555
00:22:36,450 --> 00:22:33,970
should look like get an estimate for

556
00:22:38,610 --> 00:22:36,460
what the total mass is as well and when

557
00:22:40,019 --> 00:22:38,620
you do that you get a value that's very

558
00:22:42,330 --> 00:22:40,029
consistent with what we're now seeing

559
00:22:44,789 --> 00:22:42,340
with the x-ray okay I guess we chose me

560
00:22:46,919 --> 00:22:44,799
oh go ahead I'm just goes like this

561
00:22:48,930 --> 00:22:46,929
reminds me of what you would see in the

562
00:22:50,430 --> 00:22:48,940
frontier field survey where they're

563
00:22:51,779 --> 00:22:50,440

looking at all these galaxy clusters

564
00:22:54,360 --> 00:22:51,789
that are seeing smudges all over the

565
00:22:56,159 --> 00:22:54,370
place and they use they have models what

566
00:22:59,610 --> 00:22:56,169
they're calling lensing models for all

567
00:23:03,120 --> 00:22:59,620
of galaxy clusters you do that with this

568
00:23:04,680 --> 00:23:03,130
or is this one smudge not enough it

569
00:23:06,630 --> 00:23:04,690
seems to me like this one cleansed

570
00:23:09,180 --> 00:23:06,640
Galaxy isn't enough to make a model of

571
00:23:10,680 --> 00:23:09,190
the whole thing and right you to carol's

572
00:23:12,180 --> 00:23:10,690
point about dark matter what does this

573
00:23:14,789 --> 00:23:12,190
tell you about the distribution of dark

574
00:23:17,970 --> 00:23:14,799
matter in this cluster writes a very

575
00:23:19,769 --> 00:23:17,980
good question so first the frontier

576
00:23:21,899 --> 00:23:19,779
fields data is phenomenal with all the

577
00:23:23,820 --> 00:23:21,909
multiple different images of different

578
00:23:25,200 --> 00:23:23,830
galaxies there we are not at a stage

579
00:23:27,269 --> 00:23:25,210
where we can do anything like that right

580
00:23:30,090 --> 00:23:27,279
now we can just do a very crude estimate

581
00:23:32,490 --> 00:23:30,100
based on where that arc is of how much

582
00:23:34,560 --> 00:23:32,500
matter should be enclosed with inside of

583
00:23:35,580 --> 00:23:34,570
it so we're not close to trying to do

584
00:23:38,159 --> 00:23:35,590
something like they're doing with the

585
00:23:42,149 --> 00:23:38,169
frontier fields but you can get a first

586
00:23:44,789 --> 00:23:42,159
order estimate and what it also what

587
00:23:45,810 --> 00:23:44,799
else is interesting about it is a number

588
00:23:47,880 --> 00:23:45,820

of different people have made

589
00:23:49,620 --> 00:23:47,890
predictions for how many such

590
00:23:51,389 --> 00:23:49,630
gravitational arcs your you should be

591
00:23:53,600 --> 00:23:51,399
finding behind galaxy clusters at

592
00:23:56,279 --> 00:23:53,610
different distances away from us and

593
00:23:58,320 --> 00:23:56,289
generally for something this far away

594
00:24:01,110 --> 00:23:58,330
you would not have expected to find any

595
00:24:03,090 --> 00:24:01,120
arcs at all and if you looked already

596
00:24:06,240 --> 00:24:03,100
inspires that's really interesting so

597
00:24:08,490 --> 00:24:06,250
you're saying that the further away a

598
00:24:10,409 --> 00:24:08,500
galaxy cluster is the fewer are it

599
00:24:12,810 --> 00:24:10,419
there's a relation between distance and

600
00:24:14,490 --> 00:24:12,820
how many are you should see yeah so at

601
00:24:16,260 --> 00:24:14,500
some point the expectation is that you

602
00:24:18,990 --> 00:24:16,270
just start running out of background

603
00:24:20,820 --> 00:24:19,000
galaxies that are at proverbs sure that

604
00:24:22,529 --> 00:24:20,830
makes perfect sense yeah that does make

605
00:24:24,240 --> 00:24:22,539
sense so there's not that many earlier

606
00:24:28,139 --> 00:24:24,250
galaxies that can be detected by these

607
00:24:29,310 --> 00:24:28,149
telescopes right and so predictions if

608
00:24:31,379 --> 00:24:29,320
you look at before we found

609
00:24:35,009 --> 00:24:31,389
sorry that you really were not expecting

610
00:24:36,899 --> 00:24:35,019
to find one and that's means not

611
00:24:39,810 --> 00:24:36,909
expecting to find one behind any galaxy

612
00:24:41,399 --> 00:24:39,820
cluster over the entire sky so that

613
00:24:43,049 --> 00:24:41,409

starts telling you that there's

614
00:24:46,289 --> 00:24:43,059
something wrong with those expectations

615
00:24:48,539 --> 00:24:46,299
and still working on trying to get a

616
00:24:50,909 --> 00:24:48,549
handle on what exactly that is but one

617
00:24:52,470 --> 00:24:50,919
plausible candidate is if the dark

618
00:24:55,169 --> 00:24:52,480
matter in this cluster is more

619
00:24:56,909 --> 00:24:55,179
concentrated towards the center then you

620
00:24:59,430 --> 00:24:56,919
expect for the standard profile the

621
00:25:01,769 --> 00:24:59,440
galaxy cluster that can help you in

622
00:25:03,899 --> 00:25:01,779
terms of increasing the probability that

623
00:25:08,009 --> 00:25:03,909
some galaxy behind it will get magnified

624
00:25:10,440 --> 00:25:08,019
in this way so okay that's the first

625
00:25:13,169 --> 00:25:10,450
here so I had a question you talked

626
00:25:15,899 --> 00:25:13,179
about early on you all were talking

627
00:25:18,749 --> 00:25:15,909
about there's the radio data you had a

628
00:25:21,450 --> 00:25:18,759
radio JT had a hole that suggested that

629
00:25:24,060 --> 00:25:21,460
the microwave background was disturbed

630
00:25:27,450 --> 00:25:24,070
and there was a mass there and then you

631
00:25:30,990 --> 00:25:27,460
have the x-ray data and then you have

632
00:25:35,100 --> 00:25:31,000
the lensing phenomenon now receiving the

633
00:25:36,840 --> 00:25:35,110
optical do all those masses agree yeah

634
00:25:39,149 --> 00:25:36,850
in fact they do that was that was the

635
00:25:41,909 --> 00:25:39,159
main result of the paper that came out

636
00:25:44,220 --> 00:25:41,919
this year right it is pretty awesome

637
00:25:45,899 --> 00:25:44,230
because there are assumptions to go into

638
00:25:47,850 --> 00:25:45,909

all of those who are and they're

639
00:25:49,230 --> 00:25:47,860
different there's fewer assumptions in

640
00:25:51,210 --> 00:25:49,240
the lensing but there's still some

641
00:25:53,940 --> 00:25:51,220
there's definitely assumptions on the

642
00:25:56,039 --> 00:25:53,950
state and maturity of the gas and the

643
00:25:58,169 --> 00:25:56,049
how relax the dynamics is the cluster

644
00:26:00,720 --> 00:25:58,179
that comes into play for both the x-ray

645
00:26:02,369 --> 00:26:00,730
and for the radio data and they're all

646
00:26:03,960 --> 00:26:02,379
different that's right they all you know

647
00:26:06,060 --> 00:26:03,970
there there are different physics and

648
00:26:07,830 --> 00:26:06,070
different assumptions and and they yet

649
00:26:09,960 --> 00:26:07,840
the mass is all agree perfectly

650
00:26:12,539 --> 00:26:09,970
basically within the errors and that's

651
00:26:14,369 --> 00:26:12,549
astonishing and this is why one of the

652
00:26:16,379 --> 00:26:14,379
main conclusions is that this cluster

653
00:26:18,659 --> 00:26:16,389
seems to be relatively advanced and

654
00:26:21,749 --> 00:26:18,669
mature for its age you know it's not

655
00:26:23,960 --> 00:26:21,759
shocking to find a galaxy cluster at

656
00:26:26,759 --> 00:26:23,970
redshifts like this handfuls are known

657
00:26:28,619 --> 00:26:26,769
but mostly they look like train wrecks

658
00:26:30,060 --> 00:26:28,629
they're still forming you know they look

659
00:26:31,740 --> 00:26:30,070
like you expect them to look at that age

660
00:26:33,659 --> 00:26:31,750
where they will only look mature at a

661
00:26:35,789 --> 00:26:33,669
much later time but this one looks

662
00:26:37,919 --> 00:26:35,799
mature in place 10 billion light years

663
00:26:40,320 --> 00:26:37,929

away and you know and a lot of the

664
00:26:41,639 --> 00:26:40,330
evidence for that is that the masses are

665
00:26:42,899 --> 00:26:41,649
all the same from these different

666
00:26:44,399 --> 00:26:42,909
measurements

667
00:26:46,320 --> 00:26:44,409
you know that there's that there's the

668
00:26:48,960 --> 00:26:46,330
existence of a cool core in the cluster

669
00:26:51,060 --> 00:26:48,970
which might can speak more to but that's

670
00:26:52,830 --> 00:26:51,070
a property of an evolved cluster we

671
00:26:54,180 --> 00:26:52,840
don't usually see that in the early

672
00:26:55,979 --> 00:26:54,190
universe we see it today much more

673
00:26:57,989 --> 00:26:55,989
frequently so there's a lot of evidence

674
00:26:59,430 --> 00:26:57,999
pointing to the fact that this is an

675
00:27:01,469 --> 00:26:59,440
involved cluster at such an early time

676
00:27:04,379 --> 00:27:01,479
and the significance of that is that

677
00:27:07,289 --> 00:27:04,389
basically it's a signpost for one of the

678
00:27:08,909 --> 00:27:07,299
earliest very dense you know parts of

679
00:27:11,580 --> 00:27:08,919
the early universe it had to get a head

680
00:27:13,889 --> 00:27:11,590
start early to be finished so early and

681
00:27:16,649 --> 00:27:13,899
so this was really a very dense region

682
00:27:19,080 --> 00:27:16,659
in the very early universe so you've all

683
00:27:21,269 --> 00:27:19,090
seen that sort of cosmic web view of the

684
00:27:22,619 --> 00:27:21,279
universe with all these galaxies dancing

685
00:27:23,729 --> 00:27:22,629
around each other and these long thin

686
00:27:26,849 --> 00:27:23,739
thread so you're saying that it's

687
00:27:29,070 --> 00:27:26,859
possible this galaxy cluster was

688
00:27:31,229 --> 00:27:29,080

probably in a more dense region early in

689
00:27:33,060 --> 00:27:31,239
the universe's history that allowed it

690
00:27:35,190 --> 00:27:33,070
to get this mature correct exactly

691
00:27:37,560 --> 00:27:35,200
exactly it's a very extreme peak in the

692
00:27:40,139 --> 00:27:37,570
early density distribution and you know

693
00:27:42,089 --> 00:27:40,149
in 2012 we asked her cells if it was if

694
00:27:44,460 --> 00:27:42,099
it in fact it was allowed by modern

695
00:27:45,960 --> 00:27:44,470
cosmic by our theory should there be

696
00:27:48,330 --> 00:27:45,970
something this massive so early because

697
00:27:50,310 --> 00:27:48,340
it wasn't obvious we did the calculation

698
00:27:52,649 --> 00:27:50,320
and in fact it's okay there are a few

699
00:27:54,930 --> 00:27:52,659
all scythes that we reverse it you told

700
00:27:56,789 --> 00:27:54,940
right yeah it's actually okay there's a

701
00:27:59,700 --> 00:27:56,799
handful you know a dozen or so all sky

702
00:28:01,919 --> 00:27:59,710
we found one in a tiny tiny fraction of

703
00:28:03,930 --> 00:28:01,929
the sky which is what was strange and

704
00:28:05,609 --> 00:28:03,940
why we were so lucky we all we had way

705
00:28:08,279 --> 00:28:05,619
less than one percent chance of finding

706
00:28:10,349 --> 00:28:08,289
it in that area but we did okay all

707
00:28:12,479 --> 00:28:10,359
right so yeah let's go back to this cool

708
00:28:14,460 --> 00:28:12,489
core that you were just mentioning marca

709
00:28:17,339 --> 00:28:14,470
Mike do you want to comment a little but

710
00:28:20,879 --> 00:28:17,349
what do they mean by that is a cool cool

711
00:28:23,700 --> 00:28:20,889
for sure um let me just quickly sort of

712
00:28:26,099 --> 00:28:23,710
throw in the analogy I like to sort of

713
00:28:28,139 --> 00:28:26,109

put this resulting contents of analogies

714
00:28:30,210 --> 00:28:28,149
yeah so sorry I mean you can think of a

715
00:28:32,849 --> 00:28:30,220
galaxy cluster as like a city right of

716
00:28:36,930 --> 00:28:32,859
the galaxies of the people right and so

717
00:28:38,820 --> 00:28:36,940
as time goes by in human history cities

718
00:28:40,919 --> 00:28:38,830
become bigger you know that it go from

719
00:28:43,710 --> 00:28:40,929
villages 2 tallis the cities to drop

720
00:28:46,409 --> 00:28:43,720
traffic snorts I mean yeah right yeah so

721
00:28:48,539 --> 00:28:46,419
this is that I mean in my mind kind of

722
00:28:52,820 --> 00:28:48,549
like finding Rome you know we're finding

723
00:28:55,200 --> 00:28:52,830
one of these really advanced older

724
00:28:56,460 --> 00:28:55,210
civilizations oh no that is a good

725
00:28:58,590 --> 00:28:56,470
analogy so

726
00:29:00,419 --> 00:28:58,600
so so we found a civilization of

727
00:29:03,510 --> 00:29:00,429
galaxies that's that's probably

728
00:29:05,460 --> 00:29:03,520
benchmarking the era that it it's it's

729
00:29:11,039 --> 00:29:05,470
observed that it's the most advanced

730
00:29:14,130 --> 00:29:11,049
civilization at that innocence okay so

731
00:29:16,289 --> 00:29:14,140
that boy my simple well that begs the

732
00:29:19,620 --> 00:29:16,299
question so I guess my next thing is

733
00:29:23,399 --> 00:29:19,630
that you know you found Rome any chance

734
00:29:25,110 --> 00:29:23,409
any chance of finding a ancient Egyptian

735
00:29:26,549 --> 00:29:25,120
stuff i mean you know they were pretty

736
00:29:29,159 --> 00:29:26,559
advanced to so what do you think the

737
00:29:30,870 --> 00:29:29,169
chances are of maybe finding something

738
00:29:32,610 --> 00:29:30,880

any earlier do you think this is a

739
00:29:34,080 --> 00:29:32,620
horror limit not let anyone have you

740
00:29:35,779 --> 00:29:34,090
comment on that well i think i think

741
00:29:39,000 --> 00:29:35,789
what Mark was saying is that this is

742
00:29:40,680 --> 00:29:39,010
this is about that massive as you expect

743
00:29:42,930 --> 00:29:40,690
the universe to produce a cluster at

744
00:29:45,390 --> 00:29:42,940
this right shift at this distance so as

745
00:29:48,600 --> 00:29:45,400
I said about 10 billion light years this

746
00:29:49,890 --> 00:29:48,610
is about as good or as mature a galaxy

747
00:29:51,840 --> 00:29:49,900
clusters you're ever going to see you

748
00:29:54,539 --> 00:29:51,850
won't anything earlier is going to be

749
00:29:56,880 --> 00:29:54,549
like he said more disheveled less less

750
00:30:01,169 --> 00:29:56,890
organized the more of a mess but these

751
00:30:04,200 --> 00:30:01,179
are in like me a lot yeah it out loud

752
00:30:07,649 --> 00:30:04,210
but yeah you are thinking it in 2016

753
00:30:10,830 --> 00:30:07,659
they seek the truth yes well I glad

754
00:30:14,820 --> 00:30:10,840
that's a good resolution I'll help you a

755
00:30:16,080 --> 00:30:14,830
help you keep usually mind why don't

756
00:30:18,450 --> 00:30:16,090
your those we can name it after you

757
00:30:20,669 --> 00:30:18,460
perfect it's i'm done with let the IE

758
00:30:22,200 --> 00:30:20,679
you know we'll get it set well it's

759
00:30:25,279 --> 00:30:22,210
better than the name that the that

760
00:30:28,590 --> 00:30:25,289
you've given this thing we never see SJ

761
00:30:30,899 --> 00:30:28,600
1426 I mean Scott Lewis cluster I'd be

762
00:30:34,110 --> 00:30:30,909
much willing to come I sorry that's not

763
00:30:37,610 --> 00:30:34,120

their fault I'm okay with that too they

764
00:30:40,200 --> 00:30:37,620
do not mislead of Scott Lewis cluster

765
00:30:45,270 --> 00:30:40,210
supermassive and not as the shell that

766
00:30:51,360 --> 00:30:45,280
was as it was a few just just messed all

767
00:30:53,430 --> 00:30:51,370
up with Dark Matters ok so astral girl 1

768
00:30:54,419 --> 00:30:53,440
USA is asking a good question out that

769
00:30:56,909 --> 00:30:54,429
kind of goes along with the

770
00:30:59,520 --> 00:30:56,919
gravitational lensing i can't select it

771
00:31:01,080 --> 00:30:59,530
so if maybe Elena or someone who has the

772
00:31:03,990 --> 00:31:01,090
ability to do that can maybe click on

773
00:31:05,430 --> 00:31:04,000
her comment she's asking you may have

774
00:31:06,539 --> 00:31:05,440
covered this already i missed quite a

775
00:31:08,669 --> 00:31:06,549
bit fooling around trying to get the

776
00:31:09,340 --> 00:31:08,679
video to work but is there a difference

777
00:31:11,610 --> 00:31:09,350
in what

778
00:31:13,630 --> 00:31:11,620
causes an Einstein cross and

779
00:31:15,789 --> 00:31:13,640
gravitational arcing like what we just

780
00:31:18,370 --> 00:31:15,799
saw in that one galaxy that you should

781
00:31:19,659 --> 00:31:18,380
have in this image and she also adds I

782
00:31:23,590 --> 00:31:19,669
have to say this is a very interesting

783
00:31:25,150 --> 00:31:23,600
session well thank you astral one USA so

784
00:31:27,580 --> 00:31:25,160
let's talk about that and maybe this is

785
00:31:30,610 --> 00:31:27,590
a good one for you Anthony gravitational

786
00:31:33,909 --> 00:31:30,620
lensing arcing Einstein crosses we've

787
00:31:36,520 --> 00:31:33,919
seen a supernova recently in an Einstein

788
00:31:38,950 --> 00:31:36,530

cross so what is there this is the same

789
00:31:41,020 --> 00:31:38,960
physics at work here yes indeed in both

790
00:31:43,480 --> 00:31:41,030
cases it is just the bending of light by

791
00:31:45,340 --> 00:31:43,490
gravity as predicted by Einstein the

792
00:31:48,220 --> 00:31:45,350
main difference is just the geometry of

793
00:31:50,500 --> 00:31:48,230
exactly how the background galaxy or the

794
00:31:52,539 --> 00:31:50,510
background quasar is lined up with the

795
00:31:55,840 --> 00:31:52,549
foreground matter that's doing the

796
00:31:57,960 --> 00:31:55,850
lensing so at a fundamental physical

797
00:32:00,460 --> 00:31:57,970
level though it's it's identical physics

798
00:32:02,890 --> 00:32:00,470
okay good that's good question asker

799
00:32:04,539 --> 00:32:02,900
girl1 thank you Andrew Hamilton Einstein

800
00:32:06,669 --> 00:32:04,549
cross by the way yes we talked about

801
00:32:09,820 --> 00:32:06,679
that's the supernova ref stall i believe

802
00:32:12,430 --> 00:32:09,830
it was or something yes okay Andrew

803
00:32:14,289 --> 00:32:12,440
planet is asking would massive galaxies

804
00:32:18,070 --> 00:32:14,299
have been more prone to form right after

805
00:32:19,600 --> 00:32:18,080
the Big Bang having them there having

806
00:32:22,230 --> 00:32:19,610
been far more of a preponderant

807
00:32:24,730 --> 00:32:22,240
preponderance of material available to

808
00:32:27,580 --> 00:32:24,740
gravitationally mutually attract to

809
00:32:28,930 --> 00:32:27,590
itself the last part confused me but I'm

810
00:32:31,180 --> 00:32:28,940
gonna go back to the beginning would the

811
00:32:33,399 --> 00:32:31,190
massive galaxies have been more prone to

812
00:32:35,680 --> 00:32:33,409
form right after the Big Bang well I'll

813
00:32:37,419 --> 00:32:35,690

take that generically it's true the

814
00:32:39,100 --> 00:32:37,429
universe was denser because it was all

815
00:32:40,659 --> 00:32:39,110
the materials closer together and that

816
00:32:42,399 --> 00:32:40,669
is a plus if you're trying to form

817
00:32:45,190 --> 00:32:42,409
galaxies but it was also a lot hotter

818
00:32:47,020 --> 00:32:45,200
and you can't make gas collapse if it's

819
00:32:48,970 --> 00:32:47,030
hot so the universe has to expand and

820
00:32:51,490 --> 00:32:48,980
cool to a point where you can actually

821
00:32:53,289 --> 00:32:51,500
have gravitational collapse so it has to

822
00:32:55,180 --> 00:32:53,299
happen a bit after the Big Bang so on

823
00:32:56,620 --> 00:32:55,190
the one hand the universe is smaller but

824
00:32:59,049 --> 00:32:56,630
on the other hand it's also very hot and

825
00:33:01,600 --> 00:32:59,059
it's hard to get things to to sort of

826
00:33:04,270 --> 00:33:01,610
coalesce right right collapsing down

827
00:33:06,070 --> 00:33:04,280
means you have to have cold gas if it's

828
00:33:07,360 --> 00:33:06,080
hot temperature is basically the same

829
00:33:09,070 --> 00:33:07,370
thing as the velocity of the gas

830
00:33:10,330 --> 00:33:09,080
particles and if it's hot they're moving

831
00:33:13,149 --> 00:33:10,340
very fast and they can't come close

832
00:33:14,590 --> 00:33:13,159
together but the corollary to that if I

833
00:33:16,810 --> 00:33:14,600
understood the second part of the

834
00:33:19,299 --> 00:33:16,820
question is you're more likely to form

835
00:33:20,710 --> 00:33:19,309
very massive galaxies earlier where you

836
00:33:22,899 --> 00:33:20,720
have the densest locations in the

837
00:33:23,200 --> 00:33:22,909
universe which would be sites like where

838
00:33:25,180 --> 00:33:23,210

you're

839
00:33:26,799 --> 00:33:25,190
he's mask right so that's dense thats

840
00:33:28,539 --> 00:33:26,809
dark matter density which doesn't get

841
00:33:30,789 --> 00:33:28,549
care about the temperature as much as

842
00:33:33,100 --> 00:33:30,799
the gas dose good alright thank you

843
00:33:34,899 --> 00:33:33,110
andrea was a good question um alright so

844
00:33:38,139 --> 00:33:34,909
we want to I want to ask you briefly

845
00:33:39,669 --> 00:33:38,149
about with the radio detection you said

846
00:33:43,330 --> 00:33:39,679
that you all of these different methods

847
00:33:45,190 --> 00:33:43,340
have sort of gone in in hand in hand

848
00:33:47,470 --> 00:33:45,200
between the gravitational lensing of the

849
00:33:51,279 --> 00:33:47,480
galaxy that the art gravitational arc

850
00:33:52,750 --> 00:33:51,289
the temperature of the x-ray gas and you

851
00:33:54,460 --> 00:33:52,760
said you initially got an initial

852
00:33:57,760 --> 00:33:54,470
estimate of the mass for using radio

853
00:34:01,060 --> 00:33:57,770
data is it something Alma can do I mean

854
00:34:02,740 --> 00:34:01,070
I'm just wonder it that's that is that a

855
00:34:05,620 --> 00:34:02,750
wavelength that can give you any more

856
00:34:07,779 --> 00:34:05,630
information or is it well necessary it's

857
00:34:09,550 --> 00:34:07,789
always necessary we would be where we're

858
00:34:10,869 --> 00:34:09,560
lacking in radio facilities right now

859
00:34:13,270 --> 00:34:10,879
that can make this kind of measurement

860
00:34:14,470 --> 00:34:13,280
actually all night at you all know

861
00:34:17,440 --> 00:34:14,480
watches that went out what all you

862
00:34:19,210 --> 00:34:17,450
mentioned would only do just so all well

863
00:34:21,220 --> 00:34:19,220

ok let me just say Alma is a radio

864
00:34:22,810 --> 00:34:21,230
interferon interfer metric array it's a

865
00:34:24,879 --> 00:34:22,820
bunch of dishes in the mountains of

866
00:34:27,550 --> 00:34:24,889
chili and when you use them all together

867
00:34:31,720 --> 00:34:27,560
you can gather you can sort of

868
00:34:33,700 --> 00:34:31,730
approximate the the resolution of a huge

869
00:34:35,109 --> 00:34:33,710
dish as big as the the largest linear

870
00:34:37,000 --> 00:34:35,119
extent between you know the largest

871
00:34:39,639 --> 00:34:37,010
separation between any of those two

872
00:34:41,770 --> 00:34:39,649
small dishes that's great for resolution

873
00:34:42,820 --> 00:34:41,780
the that's actually a bad thing though

874
00:34:45,490 --> 00:34:42,830
if you're trying to make this

875
00:34:47,800 --> 00:34:45,500
measurement use a solution is a bad

876
00:34:51,490 --> 00:34:47,810
thing yeah because you end up we're

877
00:34:53,680 --> 00:34:51,500
looking at if you if you think about the

878
00:34:56,260 --> 00:34:53,690
x-ray image and maybe we can call that

879
00:34:58,690 --> 00:34:56,270
up again the blue fuzzy image the the

880
00:35:00,790 --> 00:34:58,700
galaxy cluster is not a point it's it's

881
00:35:03,310 --> 00:35:00,800
actually a very big area it's a big

882
00:35:05,470 --> 00:35:03,320
extended area of light and if you're

883
00:35:07,900 --> 00:35:05,480
using an interferometric array a bunch

884
00:35:09,220 --> 00:35:07,910
of small dishes you actually are it's

885
00:35:11,770 --> 00:35:09,230
very good at detecting the point sources

886
00:35:13,450 --> 00:35:11,780
but it resolves it resolves out the

887
00:35:16,060 --> 00:35:13,460
light you you want to sort of not lose

888
00:35:17,530 --> 00:35:16,070

that light if you had a very big single

889
00:35:19,750 --> 00:35:17,540
dish in the radio that wouldn't happen

890
00:35:22,450 --> 00:35:19,760
and that would be fabulous for that kind

891
00:35:24,849 --> 00:35:22,460
of analysis but Alma is not great

892
00:35:28,120 --> 00:35:24,859
actually for measuring things like the

893
00:35:29,890 --> 00:35:28,130
the the effect of the CMB spectral

894
00:35:31,750 --> 00:35:29,900
distortion because it's a very large

895
00:35:33,609 --> 00:35:31,760
scale distortion and being so high

896
00:35:35,770 --> 00:35:33,619
resolution you actually can't see it

897
00:35:36,940 --> 00:35:35,780
basically the idea is you do a you

898
00:35:39,220 --> 00:35:36,950
subtract effect

899
00:35:40,480 --> 00:35:39,230
you subtract what's around it's locally

900
00:35:41,680 --> 00:35:40,490
around the object that you're looking at

901
00:35:43,030 --> 00:35:41,690
and if it's all the same brightness

902
00:35:44,560 --> 00:35:43,040
where you're looking in the background

903
00:35:47,890 --> 00:35:44,570
around it then it subtracts away

904
00:35:49,660 --> 00:35:47,900
entirely you get zero so so that's why

905
00:35:51,970 --> 00:35:49,670
Alma's not the perfect instrument for

906
00:35:55,750 --> 00:35:51,980
that kind of okay all right Oh Scott

907
00:35:59,020 --> 00:35:55,760
head up so here's the IR that Spitzer

908
00:36:01,960 --> 00:35:59,030
right right okay and then you said you

909
00:36:04,599 --> 00:36:01,970
want to Chandra yeah yeah this is the IR

910
00:36:06,069 --> 00:36:04,609
on now and you see a few of the galaxies

911
00:36:07,660 --> 00:36:06,079
so they're shaundra and if you ignore

912
00:36:10,000 --> 00:36:07,670
the point so you look at the big blue

913
00:36:12,609 --> 00:36:10,010

fuzzy region in the middle that's the

914
00:36:14,920 --> 00:36:12,619
sort of the extent of the hot gas in the

915
00:36:18,730 --> 00:36:14,930
cluster it's a very big extended region

916
00:36:21,490 --> 00:36:18,740
sort of 30 arc seconds on the side okay

917
00:36:23,260 --> 00:36:21,500
so well while we're on trays then let me

918
00:36:25,599 --> 00:36:23,270
ask you this and resolution doesn't

919
00:36:28,240 --> 00:36:25,609
matter or at least it's not as is as

920
00:36:31,150 --> 00:36:28,250
critical as it might be an optical image

921
00:36:33,099 --> 00:36:31,160
but what about new star is that

922
00:36:34,569 --> 00:36:33,109
something that can give you I mean it's

923
00:36:37,390 --> 00:36:34,579
a slightly different energy level I know

924
00:36:39,609 --> 00:36:37,400
that but it have you thought about maybe

925
00:36:42,280 --> 00:36:39,619
what do you think new Tsar might show if

926
00:36:44,109 --> 00:36:42,290
well I'll toss this one to Mike but

927
00:36:45,640 --> 00:36:44,119
generically it's just too high energy

928
00:36:48,940 --> 00:36:45,650
but Mike probably can get some color on

929
00:36:51,130 --> 00:36:48,950
that right I'll also add a little the

930
00:36:54,160 --> 00:36:51,140
easy answer for the Alma question is

931
00:36:58,710 --> 00:36:54,170
that this targets in the north well

932
00:37:01,059 --> 00:36:58,720
there we actually you're gonna say that

933
00:37:03,250 --> 00:37:01,069
this was in the north right yeah we

934
00:37:04,720 --> 00:37:03,260
actually can we actually can it's doable

935
00:37:08,650 --> 00:37:04,730
but you can see it right on the horizon

936
00:37:11,380 --> 00:37:08,660
yeah you guys ground-based telescopes

937
00:37:13,359 --> 00:37:11,390
yes so with with regard did you say

938
00:37:15,490 --> 00:37:13,369

Fermi which tells before you know I was

939
00:37:18,700 --> 00:37:15,500
I was wondering about new store start

940
00:37:20,880 --> 00:37:18,710
right yeah so we so if there was another

941
00:37:25,059 --> 00:37:20,890
process going on that wasn't thermal

942
00:37:26,349 --> 00:37:25,069
you'd expect new star to pick it up we

943
00:37:29,319 --> 00:37:26,359
have no reason to believe that's the

944
00:37:33,069 --> 00:37:29,329
case here so so all of our thermal

945
00:37:34,480 --> 00:37:33,079
emission is captured by a Chandra ok

946
00:37:36,460 --> 00:37:34,490
that's a good end so you're saying that

947
00:37:39,160 --> 00:37:36,470
what Chandra is looking at is thermal

948
00:37:40,990 --> 00:37:39,170
emission in x-rays right what else is

949
00:37:42,550 --> 00:37:41,000
there i mean it's some kind of what

950
00:37:45,760 --> 00:37:42,560
other kind of x-ray emission would there

951
00:37:47,589 --> 00:37:45,770
be then so accretion disks shop

952
00:37:49,430 --> 00:37:47,599
accelerating shop celebrating

953
00:37:51,589 --> 00:37:49,440
accelerating charged particles maybe

954
00:37:54,500 --> 00:37:51,599
Thank kind of thing yeah so very very

955
00:37:57,079 --> 00:37:54,510
energetic Austin sees but I mean we

956
00:38:00,109 --> 00:37:57,089
struggle to measure that those types of

957
00:38:04,030 --> 00:38:00,119
things in nearby clusters so this is not

958
00:38:06,230 --> 00:38:04,040
a test fit for brand new star I think

959
00:38:08,450 --> 00:38:06,240
okay well no that's good to know I mean

960
00:38:10,940 --> 00:38:08,460
I I just learned about new star died

961
00:38:12,410 --> 00:38:10,950
about a year ago and it was pretty

962
00:38:14,510 --> 00:38:12,420
amazing some of the stuff I've seen come

963
00:38:16,099 --> 00:38:14,520

out of there they would I think they

964
00:38:17,540 --> 00:38:16,109
just looked at the Andromeda galaxy with

965
00:38:18,980 --> 00:38:17,550
it recently if i'm not mistaken so

966
00:38:23,089 --> 00:38:18,990
here's a good question from Craig

967
00:38:25,430 --> 00:38:23,099
kranthi ugh oh gosh good good hot am I'm

968
00:38:29,420 --> 00:38:25,440
sorry if I screwed that up but he's

969
00:38:32,329 --> 00:38:29,430
asking is big is does this galaxy

970
00:38:35,660 --> 00:38:32,339
cluster have any net rotation or is

971
00:38:41,089 --> 00:38:35,670
there any overall motion of the galaxy

972
00:38:43,069 --> 00:38:41,099
cluster itself ah almost certainly any

973
00:38:47,599 --> 00:38:43,079
other are you yeah are you able to

974
00:38:49,460 --> 00:38:47,609
measure it we only have detailed sort of

975
00:38:52,550 --> 00:38:49,470
dynamical information for a handful of

976
00:38:55,670 --> 00:38:52,560
the galaxies as I said using Hubble and

977
00:38:58,970 --> 00:38:55,680
keck spectroscopy most of that isn't

978
00:39:00,800 --> 00:38:58,980
even at sufficient precision to do much

979
00:39:03,140 --> 00:39:00,810
with other than know the distance from

980
00:39:06,559 --> 00:39:03,150
us to the galaxy so yeah it would take a

981
00:39:07,819 --> 00:39:06,569
pretty dedicated survey over a long

982
00:39:09,589 --> 00:39:07,829
period of time to build even start to

983
00:39:11,450 --> 00:39:09,599
answer that question yeah i think the

984
00:39:14,450 --> 00:39:11,460
echo what Mike was saying a second ago

985
00:39:16,579 --> 00:39:14,460
this is hard to do even locally right so

986
00:39:18,140 --> 00:39:16,589
it's a bit out of the realm for right

987
00:39:21,740 --> 00:39:18,150
now for this movie so you're saying

988
00:39:23,599 --> 00:39:21,750

looking at at these galaxies clusters is

989
00:39:25,640 --> 00:39:23,609
hard to do even for closer clusters but

990
00:39:27,380 --> 00:39:25,650
trying to measure the rotation of them

991
00:39:30,440 --> 00:39:27,390
even for a little monsters is not an

992
00:39:32,450 --> 00:39:30,450
easy job okay well mark I'm glad you

993
00:39:36,410 --> 00:39:32,460
reminded me about heck I wanted to ask

994
00:39:37,309 --> 00:39:36,420
you what data you used for that from

995
00:39:40,550 --> 00:39:37,319
them and you're saying it was

996
00:39:43,849 --> 00:39:40,560
spectroscopy yeah back in 2012 we did

997
00:39:45,230 --> 00:39:43,859
some pretty heroic observations given

998
00:39:48,740 --> 00:39:45,240
the redshift of the cluster and the

999
00:39:51,440 --> 00:39:48,750
screen galaxies yeah we'd we observed

1000
00:39:53,630 --> 00:39:51,450
with the Elridge spectrograph the low

1001
00:39:55,339 --> 00:39:53,640
resolution imaging spectrograph on the

1002
00:39:58,490 --> 00:39:55,349
Keck one telescope but I think that's

1003
00:40:01,490 --> 00:39:58,500
what it was and and observed for you

1004
00:40:03,410 --> 00:40:01,500
know four or five hours normally you can

1005
00:40:05,599 --> 00:40:03,420
get the distances to

1006
00:40:07,730 --> 00:40:05,609
Buster's at more normal red ships you

1007
00:40:09,500 --> 00:40:07,740
know the clusters that are around seven

1008
00:40:12,289 --> 00:40:09,510
or eight or nine billion light-years

1009
00:40:14,030 --> 00:40:12,299
away well eight anyway in an hour and a

1010
00:40:15,920 --> 00:40:14,040
half or two but this was pretty heroic

1011
00:40:17,750 --> 00:40:15,930
because of the distance and it was a

1012
00:40:20,690 --> 00:40:17,760
difficult redshift range to do from the

1013
00:40:23,210 --> 00:40:20,700

ground we only ended up actually only

1014
00:40:27,470 --> 00:40:23,220
getting as I recall one spectroscopic

1015
00:40:28,910 --> 00:40:27,480
member ha from from we targeted many all

1016
00:40:31,250 --> 00:40:28,920
at the same time in parallel but we only

1017
00:40:33,650 --> 00:40:31,260
got a redshift for one of them and it's

1018
00:40:35,120 --> 00:40:33,660
Hubble actually from space that was much

1019
00:40:37,609 --> 00:40:35,130
better able to give us the distance we

1020
00:40:40,099 --> 00:40:37,619
got six or seven pretty quickly from

1021
00:40:43,760 --> 00:40:40,109
from observations with the the grizzin

1022
00:40:45,920 --> 00:40:43,770
from the infrared camera okay well now

1023
00:40:47,839 --> 00:40:45,930
it's time for the grand question the

1024
00:40:50,510 --> 00:40:47,849
bloody scale questions that I love to

1025
00:40:52,870 --> 00:40:50,520
ask so let me these observations in this

1026
00:40:58,880 --> 00:40:52,880
study of this particular galaxy cluster

1027
00:41:01,069 --> 00:40:58,890
was it has it it has it disproven or

1028
00:41:03,829 --> 00:41:01,079
lent support to any of the current

1029
00:41:05,150 --> 00:41:03,839
theories of gravity of how galaxies form

1030
00:41:06,859 --> 00:41:05,160
in the early universe and more

1031
00:41:09,620 --> 00:41:06,869
importantly galaxy clusters in other

1032
00:41:12,200 --> 00:41:09,630
words observations we have more theories

1033
00:41:14,180 --> 00:41:12,210
than observations usually have any have

1034
00:41:15,859 --> 00:41:14,190
any come under fire as a result of what

1035
00:41:18,559 --> 00:41:15,869
you found or have you supported any

1036
00:41:21,440 --> 00:41:18,569
theories um generically everything makes

1037
00:41:23,660 --> 00:41:21,450
sense with one big exception the the

1038
00:41:25,549 --> 00:41:23,670

mass of the cluster is high but it does

1039
00:41:27,680 --> 00:41:25,559
it's not unusual it's not surprising

1040
00:41:28,880 --> 00:41:27,690
that you would find it you know it's

1041
00:41:31,280 --> 00:41:28,890
surprising that we found it in such a

1042
00:41:33,650 --> 00:41:31,290
small area so when we're able to conduct

1043
00:41:35,299 --> 00:41:33,660
a full Sky Survey to the same depth we

1044
00:41:37,099 --> 00:41:35,309
should find the remaining handful that

1045
00:41:39,079 --> 00:41:37,109
we expect there to be if we find many

1046
00:41:40,280 --> 00:41:39,089
many more than that then that would be a

1047
00:41:43,370 --> 00:41:40,290
problem but right now there's no

1048
00:41:46,039 --> 00:41:43,380
indication of a problem on that side the

1049
00:41:48,109 --> 00:41:46,049
on in terms of the the gas properties of

1050
00:41:50,870 --> 00:41:48,119
the cluster it's it's pretty advanced

1051
00:41:54,020 --> 00:41:50,880
but you know it doesn't you know it

1052
00:41:55,910 --> 00:41:54,030
doesn't make its not worrisome in any

1053
00:41:57,500 --> 00:41:55,920
way the problem there is hard to predict

1054
00:41:59,930 --> 00:41:57,510
what you expect to see because you need

1055
00:42:02,150 --> 00:41:59,940
very advanced simulations that that are

1056
00:42:04,010 --> 00:42:02,160
right now not up to the task actually of

1057
00:42:05,930 --> 00:42:04,020
making a prediction that we could go

1058
00:42:07,819 --> 00:42:05,940
test in terms of the gas inside of

1059
00:42:10,220 --> 00:42:07,829
clusters at high redshift though the one

1060
00:42:11,599 --> 00:42:10,230
case that's still rather puzzling is the

1061
00:42:15,260 --> 00:42:11,609
one Anthony brought up about the arc

1062
00:42:17,260 --> 00:42:15,270
because you know we really tried to to

1063
00:42:19,720 --> 00:42:17,270

break that you know we do we tried to

1064
00:42:21,040 --> 00:42:19,730
to test our measurement you know or

1065
00:42:23,650 --> 00:42:21,050
rather the prediction that there should

1066
00:42:26,950 --> 00:42:23,660
be none robustly none all sky we tried

1067
00:42:29,290 --> 00:42:26,960
to every which way that we can make it

1068
00:42:30,910 --> 00:42:29,300
less severe of a contradiction but no

1069
00:42:33,130 --> 00:42:30,920
matter what we did it's really just not

1070
00:42:36,070 --> 00:42:33,140
you don't expect any and and the fact

1071
00:42:40,510 --> 00:42:36,080
that we see one is still a surprise it

1072
00:42:42,840 --> 00:42:40,520
is possible that that very cigar like

1073
00:42:44,800 --> 00:42:42,850
yeah like a cigar in the sky

1074
00:42:46,690 --> 00:42:44,810
distribution of dark matter all along

1075
00:42:51,070 --> 00:42:46,700
the line of sight might help alleviate

1076
00:42:52,930 --> 00:42:51,080
that somewhat but but I mind personnel

1077
00:42:54,880 --> 00:42:52,940
still a little confused by for them but

1078
00:42:57,130 --> 00:42:54,890
if that was the case you'd have an extra

1079
00:42:58,690 --> 00:42:57,140
problem because in that case the

1080
00:43:00,070 --> 00:42:58,700
different masses that we get Fred the

1081
00:43:03,460 --> 00:43:00,080
different techniques wouldn't agree with

1082
00:43:05,430 --> 00:43:03,470
each other yeah and very likely yeah

1083
00:43:07,690 --> 00:43:05,440
well we didn't mention before actually

1084
00:43:08,890 --> 00:43:07,700
started to say I've had a student who's

1085
00:43:10,150 --> 00:43:08,900
working on what's called weak

1086
00:43:12,040 --> 00:43:10,160
gravitational lensing were you looking

1087
00:43:14,890 --> 00:43:12,050
to deflections of all the small galaxies

1088
00:43:16,270 --> 00:43:14,900

around and her name's when we mow and

1089
00:43:18,640 --> 00:43:16,280
she's just finishing up a paper that

1090
00:43:21,640 --> 00:43:18,650
shows that that mass more or less agrees

1091
00:43:23,200 --> 00:43:21,650
with the other ones as well yeah yeah so

1092
00:43:25,060 --> 00:43:23,210
the fact that this arc was there really

1093
00:43:26,170 --> 00:43:25,070
kind of was was bothersome but if it

1094
00:43:28,030 --> 00:43:26,180
weren't there then you wouldn't have

1095
00:43:30,520 --> 00:43:28,040
these agreements among the different

1096
00:43:32,470 --> 00:43:30,530
methods on this mass so well we have one

1097
00:43:35,350 --> 00:43:32,480
less mass to throw up on the plot yeah

1098
00:43:37,210 --> 00:43:35,360
but it would be it would be less

1099
00:43:39,970 --> 00:43:37,220
surprising surprising is good surprising

1100
00:43:42,280 --> 00:43:39,980
is why we do this yes I a bothersome as

1101
00:43:46,030 --> 00:43:42,290
much as intriguing in front hey

1102
00:43:47,980 --> 00:43:46,040
bothering okay so I'd like to point out

1103
00:43:50,530 --> 00:43:47,990
also that this gravitational lensing

1104
00:43:51,990 --> 00:43:50,540
technique of measuring mass or inferring

1105
00:43:54,520 --> 00:43:52,000
mass I guess is what you're really doing

1106
00:43:57,070 --> 00:43:54,530
doesn't differentiate between the mass

1107
00:43:59,620 --> 00:43:57,080
and the stuff that we can see the normal

1108
00:44:03,700 --> 00:43:59,630
matter and dark matter does it it really

1109
00:44:06,820 --> 00:44:03,710
is all of it combined correct okay so

1110
00:44:09,370 --> 00:44:06,830
the the it does it is it helping us

1111
00:44:11,830 --> 00:44:09,380
understand the nature of dark matter in

1112
00:44:14,170 --> 00:44:11,840
the early universe at all or is it just

1113
00:44:17,160 --> 00:44:14,180

you just know it's there and so it's

1114
00:44:21,100 --> 00:44:17,170
made this a fact or its had this effect

1115
00:44:23,980 --> 00:44:21,110
it's a more oh go ahead go ahead you go

1116
00:44:25,480 --> 00:44:23,990
ahead I would say it's more along the

1117
00:44:26,980 --> 00:44:25,490
lines of you know it's there you're

1118
00:44:28,300 --> 00:44:26,990
still seeing the same evidence for dark

1119
00:44:31,059 --> 00:44:28,310
matter here that you're seeing more

1120
00:44:33,309 --> 00:44:31,069
locally there's nothing there

1121
00:44:34,870 --> 00:44:33,319
is clearly no dramatic change right

1122
00:44:36,939 --> 00:44:34,880
there's no evidence for evolution and if

1123
00:44:39,219 --> 00:44:36,949
you wanted to use clusters to study dark

1124
00:44:40,630 --> 00:44:39,229
matter which is a great thing to do you

1125
00:44:42,849 --> 00:44:40,640
would want to do it more locally where

1126
00:44:44,920 --> 00:44:42,859
you have a much better ability to study

1127
00:44:46,239 --> 00:44:44,930
them in detail okay well I guess where I

1128
00:44:47,920 --> 00:44:46,249
was heading with that is that in the

1129
00:44:50,890 --> 00:44:47,930
same way that people are trying to

1130
00:44:53,410 --> 00:44:50,900
understand the characteristics of dark

1131
00:44:55,359 --> 00:44:53,420
energy over over the history of universe

1132
00:44:58,420 --> 00:44:55,369
like was it this isn't the same

1133
00:44:59,859 --> 00:44:58,430
everywhere is it you know it was it were

1134
00:45:01,930 --> 00:44:59,869
there different amounts of it at

1135
00:45:03,519 --> 00:45:01,940
different periods and the history of the

1136
00:45:05,049 --> 00:45:03,529
universe I'm trying to figure out if

1137
00:45:06,969 --> 00:45:05,059
maybe something analogous could be

1138
00:45:08,680 --> 00:45:06,979

learned by the nature of dark matter

1139
00:45:10,539 --> 00:45:08,690
like I know the universe was smaller I

1140
00:45:13,479 --> 00:45:10,549
know that this particular galaxy cluster

1141
00:45:16,209 --> 00:45:13,489
is mature and and small for its eyes are

1142
00:45:17,859 --> 00:45:16,219
small for its mass but I just wondered

1143
00:45:19,180 --> 00:45:17,869
what that might tell us if anything

1144
00:45:21,910 --> 00:45:19,190
about dark matter and it sounds like

1145
00:45:23,859 --> 00:45:21,920
only that it's there is the ulcer from

1146
00:45:27,069 --> 00:45:23,869
the from the x-ray you can get a

1147
00:45:29,739 --> 00:45:27,079
measurement of the luminous matter as

1148
00:45:32,170 --> 00:45:29,749
well and if you remove the or if you

1149
00:45:33,519 --> 00:45:32,180
compare the luminous to dark matter the

1150
00:45:35,499 --> 00:45:33,529
Dark Matters about eighty-five percent

1151
00:45:37,509 --> 00:45:35,509
of the mass in this cluster which is a

1152
00:45:40,870 --> 00:45:37,519
bit of what it is throughout the whole

1153
00:45:43,059 --> 00:45:40,880
universe so I mean in this one case you

1154
00:45:45,699 --> 00:45:43,069
know with a data point one single data

1155
00:45:48,789 --> 00:45:45,709
point we can say that the Dark Matter

1156
00:45:51,420 --> 00:45:48,799
fraction isn't really changing ok right

1157
00:45:53,709 --> 00:45:51,430
look to me that's important I think that

1158
00:45:54,699 --> 00:45:53,719
but it sort of had to be actually

1159
00:45:56,289 --> 00:45:54,709
because you know your question about

1160
00:45:59,170 --> 00:45:56,299
Direct Energy is right there's a huge

1161
00:46:01,390 --> 00:45:59,180
search on for you know to study its its

1162
00:46:03,459 --> 00:46:01,400
nature in particular is it changing is

1163
00:46:05,829 --> 00:46:03,469

it evolving with time because if it is

1164
00:46:08,680 --> 00:46:05,839
then it's not Einstein's cosmological

1165
00:46:11,229 --> 00:46:08,690
constant it's an even weirder kind of

1166
00:46:13,539 --> 00:46:11,239
quantum field and so that's an active

1167
00:46:15,549 --> 00:46:13,549
area of research Dark Matter on the

1168
00:46:16,989 --> 00:46:15,559
other hand you know we talk about all

1169
00:46:18,519 --> 00:46:16,999
our models and whether or not these

1170
00:46:19,930 --> 00:46:18,529
observations agree with the models the

1171
00:46:21,729 --> 00:46:19,940
models are all predicated on non

1172
00:46:23,589 --> 00:46:21,739
evolving dark matter dark matter has

1173
00:46:25,449 --> 00:46:23,599
whatever properties it has in the big

1174
00:46:28,390 --> 00:46:25,459
bang as that far back it has the same

1175
00:46:29,949 --> 00:46:28,400
properties today it's a little slower

1176
00:46:32,650 --> 00:46:29,959
moving today because universe is cool

1177
00:46:34,630 --> 00:46:32,660
but it's the same basic dark matter with

1178
00:46:36,219 --> 00:46:34,640
no evolution and if you brought in the

1179
00:46:37,870 --> 00:46:36,229
ability for dark matter to evolve and

1180
00:46:39,200 --> 00:46:37,880
change then the models will get much

1181
00:46:42,440 --> 00:46:39,210
more complicated

1182
00:46:43,700 --> 00:46:42,450
so dark matter is more or less what it

1183
00:46:45,290 --> 00:46:43,710
was at the beginning of the it was the

1184
00:46:47,839 --> 00:46:45,300
amount of it was set at the beginning of

1185
00:46:49,040 --> 00:46:47,849
the universe and that's what we have to

1186
00:46:51,410 --> 00:46:49,050
work with is what you're saying right

1187
00:46:53,750 --> 00:46:51,420
and its properties and its properties so

1188
00:46:55,070 --> 00:46:53,760

whatever it is we find hopefully we'll

1189
00:46:56,990 --> 00:46:55,080
find out at one point but it doesn't

1190
00:46:59,480 --> 00:46:57,000
seem to change all that much I guess I

1191
00:47:01,040 --> 00:46:59,490
was I guess it would be really freaky if

1192
00:47:03,410 --> 00:47:01,050
it wasn't conserved right i mean if you

1193
00:47:04,970 --> 00:47:03,420
suddenly went from Dark Matter more of

1194
00:47:06,859 --> 00:47:04,980
it in the early universe than later it

1195
00:47:09,380 --> 00:47:06,869
would probably be a real real problems

1196
00:47:11,390 --> 00:47:09,390
what we're going to animal you can

1197
00:47:12,650 --> 00:47:11,400
imagine doing that if it was going from

1198
00:47:15,579 --> 00:47:12,660
dark matter to turning into something

1199
00:47:18,020 --> 00:47:15,589
else other types of particles however

1200
00:47:19,970 --> 00:47:18,030
given all the other observations we have

1201
00:47:23,060 --> 00:47:19,980
from the Cosmic Microwave Background for

1202
00:47:25,550 --> 00:47:23,070
instance and that really constrains that

1203
00:47:26,599 --> 00:47:25,560
you can't have much changing okay all

1204
00:47:27,950 --> 00:47:26,609
right well I'd love to talk about that

1205
00:47:29,780 --> 00:47:27,960
at some point but I think it's a little

1206
00:47:33,349 --> 00:47:29,790
beyond what we're doing here so okay

1207
00:47:36,740 --> 00:47:33,359
well um so let me turn to Scott have you

1208
00:47:38,120 --> 00:47:36,750
noticed anything on the Twitterverse or

1209
00:47:41,240 --> 00:47:38,130
any other of the channels I'm only

1210
00:47:42,859 --> 00:47:41,250
looking at the at the q no no everything

1211
00:47:45,290 --> 00:47:42,869
on twitter has actually been pretty much

1212
00:47:48,980 --> 00:47:45,300
answered overall we were on air which is

1213
00:47:50,780 --> 00:47:48,990

always good um besides that I'm not

1214
00:47:53,540 --> 00:47:50,790
saying anything over on google+ and

1215
00:47:55,520 --> 00:47:53,550
facebook let me just check if you

1216
00:47:57,530 --> 00:47:55,530
there's a youtube comments real quick

1217
00:47:58,790 --> 00:47:57,540
you know everything's been great there's

1218
00:48:00,890 --> 00:47:58,800
been a lot of really good activity as

1219
00:48:03,500 --> 00:48:00,900
far as engagement on Twitter so thank

1220
00:48:06,950 --> 00:48:03,510
you guys for for tweeting with us as

1221
00:48:09,500 --> 00:48:06,960
we're going on I I guess I had a couple

1222
00:48:15,109 --> 00:48:09,510
questions and one is that so there's

1223
00:48:17,930 --> 00:48:15,119
this cluster and you somewhat said that

1224
00:48:20,839 --> 00:48:17,940
it's a little bit unusual but not hugely

1225
00:48:25,630 --> 00:48:20,849
unusual but is there anything in this

1226
00:48:29,599 --> 00:48:25,640
cluster that suggests a merging or

1227
00:48:32,089 --> 00:48:29,609
hierarchical galaxy formation or

1228
00:48:36,680 --> 00:48:32,099
anything like that any hints of what

1229
00:48:39,349 --> 00:48:36,690
went on before is this a tracer of any

1230
00:48:43,130 --> 00:48:39,359
of those mechanisms for creating

1231
00:48:48,430 --> 00:48:43,140
galaxies and then galaxy clusters yeah

1232
00:48:51,260 --> 00:48:48,440
I'll take that one so in the x-ray a map

1233
00:48:53,090 --> 00:48:51,270
if you have the composite image I'd be a

1234
00:48:57,110 --> 00:48:53,100
good one to show

1235
00:48:59,930 --> 00:48:57,120
the x-ray gas is sort of offset from the

1236
00:49:03,880 --> 00:48:59,940
center of the cluster and so if you

1237
00:49:06,410 --> 00:49:03,890
imagine the cluster of the clusters this

1238
00:49:08,840 --> 00:49:06,420

don't matter potential it's full of hot

1239
00:49:11,270 --> 00:49:08,850
gas and if it's disturb the gas it's

1240
00:49:13,850 --> 00:49:11,280
going to splash around in that dark

1241
00:49:16,100 --> 00:49:13,860
matter world just like glass of wine in

1242
00:49:18,740 --> 00:49:16,110
the glass and so we're seeing that the

1243
00:49:20,210 --> 00:49:18,750
gas is sort of sloshing from the center

1244
00:49:22,490 --> 00:49:20,220
of the cluster and eventually it'll sort

1245
00:49:24,830 --> 00:49:22,500
of fall back in towards the center but

1246
00:49:26,600 --> 00:49:24,840
that's sort of a signature that that

1247
00:49:29,360 --> 00:49:26,610
it's been knocked around a little bit or

1248
00:49:33,080 --> 00:49:29,370
that it's had a bit of a violent past so

1249
00:49:34,550 --> 00:49:33,090
to speak okay well I want to go back to

1250
00:49:37,370 --> 00:49:34,560
something I heard I think it was Mark

1251
00:49:41,030 --> 00:49:37,380
say about it if we could get an all-sky

1252
00:49:43,100 --> 00:49:41,040
survey of the same depth yeah is there

1253
00:49:45,860 --> 00:49:43,110
what could get work where could we go to

1254
00:49:50,420 --> 00:49:45,870
get one of those well funny you should

1255
00:49:52,190 --> 00:49:50,430
ask none of us are actually working on

1256
00:49:53,930 --> 00:49:52,200
that right now there's a there's a

1257
00:49:57,050 --> 00:49:53,940
mission called Euclid that is being

1258
00:49:58,970 --> 00:49:57,060
built in Europe and it's designed

1259
00:50:00,800 --> 00:49:58,980
actually to measure dark energy that's

1260
00:50:04,900 --> 00:50:00,810
the prime mission Euclid is of course

1261
00:50:07,820 --> 00:50:04,910
the famous geometry Greek professor and

1262
00:50:10,520 --> 00:50:07,830
and it's all about the geometry

1263
00:50:13,160 --> 00:50:10,530

basically is is the key question in dark

1264
00:50:15,890 --> 00:50:13,170
energy you know what is the nature of

1265
00:50:18,290 --> 00:50:15,900
space-time itself but a side effect of

1266
00:50:19,880 --> 00:50:18,300
that survey is that it you know will be

1267
00:50:22,370 --> 00:50:19,890
able to do an amazing cluster search

1268
00:50:24,410 --> 00:50:22,380
with it it's going to image basically

1269
00:50:25,880 --> 00:50:24,420
the whole extra galactic sky that

1270
00:50:27,020 --> 00:50:25,890
doesn't you know that does the part of

1271
00:50:28,880 --> 00:50:27,030
the guy that doesn't have our galaxy

1272
00:50:30,740 --> 00:50:28,890
blocking it so the whole rest of the sky

1273
00:50:32,840 --> 00:50:30,750
which is a milky way band that you see

1274
00:50:35,180 --> 00:50:32,850
in a really dark sky or at least yeah

1275
00:50:39,140 --> 00:50:35,190
it's gonna look not there everywhere

1276
00:50:41,690 --> 00:50:39,150
else and and it's going to take very

1277
00:50:43,400 --> 00:50:41,700
deep high-resolution images almost

1278
00:50:45,590 --> 00:50:43,410
Hubble how about half the resolution of

1279
00:50:49,130 --> 00:50:45,600
public because it's half the size and

1280
00:50:51,050 --> 00:50:49,140
have the linear size and from those data

1281
00:50:53,870 --> 00:50:51,060
we will be able to find galaxy clusters

1282
00:50:56,210 --> 00:50:53,880
to this red shift and even further if

1283
00:50:59,450 --> 00:50:56,220
they should exist in fact that's where

1284
00:51:01,400 --> 00:50:59,460
that Anthony and I are working on we're

1285
00:51:04,880 --> 00:51:01,410
part of the NASA contribution to that

1286
00:51:06,170 --> 00:51:04,890
the NASA science team and it's a like I

1287
00:51:06,890 --> 00:51:06,180
said a majority European mission but

1288
00:51:09,060 --> 00:51:06,900

we're

1289
00:51:10,860 --> 00:51:09,070
working on the cluster the galaxy

1290
00:51:13,230 --> 00:51:10,870
cluster part among other parts so that's

1291
00:51:15,930 --> 00:51:13,240
supposed to launch in 2020 or maybe 20

1292
00:51:17,400 --> 00:51:15,940
21 more realistically and the next few

1293
00:51:19,410 --> 00:51:17,410
years after that we will have amazing

1294
00:51:22,290 --> 00:51:19,420
data that should allow us to find the

1295
00:51:25,950 --> 00:51:22,300
rest of these all the friends of I dcs

1296
00:51:29,520 --> 00:51:25,960
1426 the entire sky minus the plane of

1297
00:51:31,890 --> 00:51:29,530
the galaxy about half this yeah wow

1298
00:51:33,150 --> 00:51:31,900
that's going to be a man net and so 2021

1299
00:51:35,400 --> 00:51:33,160
excellent well you're gonna have to come

1300
00:51:37,080 --> 00:51:35,410
back way before then and tell us how

1301
00:51:39,300 --> 00:51:37,090
things are going because I that sounds

1302
00:51:41,010 --> 00:51:39,310
like an amazing serve and it's going to

1303
00:51:43,950 --> 00:51:41,020
be a survey telescope right meaning that

1304
00:51:45,420 --> 00:51:43,960
it's gonna just systematically look at

1305
00:51:47,280 --> 00:51:45,430
the entire sky instead of people

1306
00:51:48,960 --> 00:51:47,290
applying for time and looking at that's

1307
00:51:50,760 --> 00:51:48,970
right yeah that's right it's a pure it's

1308
00:51:52,290 --> 00:51:50,770
a pure mission it's going to carry out

1309
00:51:54,390 --> 00:51:52,300
its mission like the plunk did for

1310
00:51:56,640 --> 00:51:54,400
instance and and all the data will be

1311
00:51:58,680 --> 00:51:56,650
there for people to exploit you know on

1312
00:52:00,570 --> 00:51:58,690
the US side more directly w first of

1313
00:52:02,850 --> 00:52:00,580

course we had the news of the ee s is

1314
00:52:04,460 --> 00:52:02,860
really officially it happen which is

1315
00:52:06,630 --> 00:52:04,470
awesome and double first is a good

1316
00:52:08,160 --> 00:52:06,640
complementary telescope it's going to go

1317
00:52:09,660 --> 00:52:08,170
for a small double size so it's going to

1318
00:52:11,820 --> 00:52:09,670
be higher resolution it's going to go

1319
00:52:14,970 --> 00:52:11,830
deeper in a smaller area of the sky and

1320
00:52:16,800 --> 00:52:14,980
so it will allow us to find either you

1321
00:52:18,990 --> 00:52:16,810
know the the little brothers of this the

1322
00:52:20,820 --> 00:52:19,000
small clusters that are groups of

1323
00:52:23,100 --> 00:52:20,830
clusters that are forming even you know

1324
00:52:25,200 --> 00:52:23,110
in the very early universe you know

1325
00:52:26,460 --> 00:52:25,210
above above red shifted to and maybe

1326
00:52:28,230 --> 00:52:26,470
even a little higher so that'll be

1327
00:52:30,240 --> 00:52:28,240
working together we'll see the full

1328
00:52:31,620 --> 00:52:30,250
picture of growth I was about to ask you

1329
00:52:33,810 --> 00:52:31,630
about W first because that is a

1330
00:52:34,860 --> 00:52:33,820
compliment it is also a survey telescope

1331
00:52:36,570 --> 00:52:34,870
and it's an important distinction

1332
00:52:38,310 --> 00:52:36,580
because when you think about the first

1333
00:52:39,570 --> 00:52:38,320
stars first galaxies first galaxies

1334
00:52:41,760 --> 00:52:39,580
clusters that you're talking about

1335
00:52:43,530 --> 00:52:41,770
understanding these survey telescopes

1336
00:52:45,780 --> 00:52:43,540
are going to give you more than say even

1337
00:52:47,760 --> 00:52:45,790
though jwst and telescopes like it might

1338
00:52:50,730 --> 00:52:47,770

be able to see these things it's not a

1339
00:52:53,040 --> 00:52:50,740
survey it's not the survey telescopes we

1340
00:52:54,840 --> 00:52:53,050
can't systematically look at all the

1341
00:52:56,010 --> 00:52:54,850
areas of the sky like we're talking

1342
00:52:59,250 --> 00:52:56,020
about here and that's important

1343
00:53:01,140 --> 00:52:59,260
distinction so great w first is I guess

1344
00:53:04,020 --> 00:53:01,150
go and I guess it'll be launched

1345
00:53:05,880 --> 00:53:04,030
sometime next decade but yeah this will

1346
00:53:07,590 --> 00:53:05,890
but Euclid's going to be coming up much

1347
00:53:11,580 --> 00:53:07,600
sooner so that sounds really exciting

1348
00:53:13,170 --> 00:53:11,590
okay Andrew planet is asking does all

1349
00:53:15,750 --> 00:53:13,180
the new work on dark matter and dark

1350
00:53:17,730 --> 00:53:15,760
energy and tail mentally conceiving of a

1351
00:53:20,400 --> 00:53:17,740
universe much larger than we originally

1352
00:53:20,730 --> 00:53:20,410
thought in terms of different scales of

1353
00:53:22,530 --> 00:53:20,740
the end

1354
00:53:25,530 --> 00:53:22,540
in other words does this have any effect

1355
00:53:30,090 --> 00:53:25,540
on what we perceive is the size of our

1356
00:53:35,100 --> 00:53:30,100
universe I'll let you take the kids I'm

1357
00:53:43,580 --> 00:53:35,110
hearing crickets our mind is expanding

1358
00:53:45,840 --> 00:53:43,590
right now I'd say no okay well thank you

1359
00:53:47,850 --> 00:53:45,850
it's tree it's true that the nature of

1360
00:53:50,160 --> 00:53:47,860
dark matter how much there is etc would

1361
00:53:51,930 --> 00:53:50,170
affect the evolution of the universe how

1362
00:53:54,060 --> 00:53:51,940
big it gets as a function of time but

1363
00:53:55,680 --> 00:53:54,070

this doesn't change any of what we

1364
00:53:58,770 --> 00:53:55,690
understood before about dark matter so

1365
00:54:02,250 --> 00:53:58,780
this discovery itself has has no no

1366
00:54:03,750 --> 00:54:02,260
impact on on that aspect of theory okay

1367
00:54:05,910 --> 00:54:03,760
well thank you for answering thank you

1368
00:54:08,460 --> 00:54:05,920
for stumping us Andrew as you usually do

1369
00:54:09,810 --> 00:54:08,470
on these hangouts so we a lot a lot of

1370
00:54:11,460 --> 00:54:09,820
our regular viewers I have some some

1371
00:54:16,380 --> 00:54:11,470
pretty amazing questions and sometimes I

1372
00:54:18,359 --> 00:54:16,390
just go I don't know ok well the I guess

1373
00:54:20,270 --> 00:54:18,369
if we're done with the Hubble hanging

1374
00:54:22,530 --> 00:54:20,280
out part of it I want to I'm sorry the

1375
00:54:25,200 --> 00:54:22,540
Twitter nobody's nobody's left in

1376
00:54:26,849 --> 00:54:25,210
comments and questions then I am I am I

1377
00:54:30,380 --> 00:54:26,859
have another question of course but we

1378
00:54:33,780 --> 00:54:30,390
note I'm sorry Kara out of time yes

1379
00:54:38,190 --> 00:54:33,790
absolutely all the time you get one of

1380
00:54:42,510 --> 00:54:38,200
yours you want to use it right now in

1381
00:54:46,260 --> 00:54:42,520
question I get oh my this is my 2016

1382
00:54:48,359 --> 00:54:46,270
question if we saw this a cluster very

1383
00:54:53,400 --> 00:54:48,369
similar to this one but at a closer

1384
00:54:56,550 --> 00:54:53,410
redshift how would it be different hello

1385
00:54:59,250 --> 00:54:56,560
I house do this this cluster you know as

1386
00:55:01,320 --> 00:54:59,260
it evolved oh I see this exact cluster

1387
00:55:03,840 --> 00:55:01,330
as it evolves through totality so one

1388
00:55:05,250 --> 00:55:03,850

like it right right well I like it yeah

1389
00:55:06,540 --> 00:55:05,260
we obviously can't follow this one but

1390
00:55:09,180 --> 00:55:06,550
we can find clusters that are

1391
00:55:10,980 --> 00:55:09,190
statistically consistent with evolving

1392
00:55:12,780 --> 00:55:10,990
from one into the next that we see over

1393
00:55:16,349 --> 00:55:12,790
time and as Anthony mentioned earlier

1394
00:55:18,720 --> 00:55:16,359
this cluster will grow to be you know

1395
00:55:20,640 --> 00:55:18,730
the one of the largest clusters that we

1396
00:55:21,810 --> 00:55:20,650
can see or if not the largest we can see

1397
00:55:23,580 --> 00:55:21,820
in the sky today and that's true at

1398
00:55:25,320 --> 00:55:23,590
every red shift so there are clusters

1399
00:55:27,330 --> 00:55:25,330
people have found you know at

1400
00:55:29,550 --> 00:55:27,340
intermediate red shifts that are more

1401
00:55:31,590 --> 00:55:29,560
massive than this one but I mean if you

1402
00:55:33,510 --> 00:55:31,600
if you plot the growth the expected

1403
00:55:34,320 --> 00:55:33,520
growth this cluster over time you find

1404
00:55:39,780 --> 00:55:34,330
that

1405
00:55:43,020 --> 00:55:39,790
and in fact it's consistent with growing

1406
00:55:44,610 --> 00:55:43,030
bigger and bigger and with being this

1407
00:55:46,500 --> 00:55:44,620
cluster is like a progenitor

1408
00:55:47,940 --> 00:55:46,510
statistically of all the massive

1409
00:55:50,730 --> 00:55:47,950
clusters that we have found at all

1410
00:55:54,540 --> 00:55:50,740
different redshifts cool all right thank

1411
00:55:58,710 --> 00:55:54,550
you yeah we got my question all right

1412
00:56:00,540 --> 00:55:58,720
boat well almost I guess we'll stop

1413
00:56:02,310 --> 00:56:00,550

there i want to thank you everybody for

1414
00:56:05,130 --> 00:56:02,320
watching i want to thank my guest dr.

1415
00:56:07,050 --> 00:56:05,140
doctors mark broad when anthony gonzalez

1416
00:56:09,320 --> 00:56:07,060
and mike mcdonald aw thank you guys for

1417
00:56:11,280 --> 00:56:09,330
taking the time out to share their

1418
00:56:13,530 --> 00:56:11,290
evaluations and angle that's all this

1419
00:56:14,580 --> 00:56:13,540
five this is ben and i hope that uh well

1420
00:56:16,110 --> 00:56:14,590
let me ask you this do you have any

1421
00:56:17,520 --> 00:56:16,120
follow-up work coming down the pike on

1422
00:56:19,470 --> 00:56:17,530
this i know you're working on euclid but

1423
00:56:22,830 --> 00:56:19,480
any any other observations like this

1424
00:56:25,140 --> 00:56:22,840
coming down Oh always you know Anthony

1425
00:56:26,790 --> 00:56:25,150
mentioned his student has a follow of

1426
00:56:29,070 --> 00:56:26,800
paper on the mass of this cluster that's

1427
00:56:31,170 --> 00:56:29,080
about to be resubmitted there's a paper

1428
00:56:33,030 --> 00:56:31,180
on the star formation activity in this

1429
00:56:35,340 --> 00:56:33,040
cluster that has been submitted and work

1430
00:56:37,440 --> 00:56:35,350
we're about to resubmit it soon and hint

1431
00:56:39,090 --> 00:56:37,450
it has a lot of fun activity in terms of

1432
00:56:41,640 --> 00:56:39,100
star formation and black hole activity

1433
00:56:44,280 --> 00:56:41,650
and also we have a whole other survey

1434
00:56:48,240 --> 00:56:44,290
using a I guess not so great Observatory

1435
00:56:52,350 --> 00:56:48,250
that the wise i think the control is the

1436
00:56:54,420 --> 00:56:52,360
okay observed yeah is very interesting

1437
00:56:58,500 --> 00:56:54,430
observer right yeah why is great it's

1438
00:57:00,480 --> 00:56:58,510

what i like most importantly we've

1439
00:57:03,180 --> 00:57:00,490
worked on our acronyms since I dcs to

1440
00:57:05,160 --> 00:57:03,190
okay yes the acronym is better you'll

1441
00:57:07,500 --> 00:57:05,170
like it we come back next time with the

1442
00:57:10,710 --> 00:57:07,510
wise survey we have a program called mad

1443
00:57:13,920 --> 00:57:10,720
cowz the massive and clusters of ice

1444
00:57:16,440 --> 00:57:13,930
survey that's been done you banged I and

1445
00:57:18,690 --> 00:57:16,450
so yeah that's it that's great and uh

1446
00:57:20,580 --> 00:57:18,700
like you're finding my very massive

1447
00:57:22,140 --> 00:57:20,590
clusters mad cows that are very master

1448
00:57:23,700 --> 00:57:22,150
clusters at a distance of about 7

1449
00:57:25,650 --> 00:57:23,710
billion like you're so a little bit

1450
00:57:26,970 --> 00:57:25,660
younger sorry a little bit older in the

1451
00:57:29,670 --> 00:57:26,980
state of the universe not so far away

1452
00:57:31,860 --> 00:57:29,680
but but you know a huge range of mass

1453
00:57:33,750 --> 00:57:31,870
from you know pretty wimpy to extremely

1454
00:57:35,340 --> 00:57:33,760
massive most massive seen at that red

1455
00:57:37,500 --> 00:57:35,350
shift something like two or three times

1456
00:57:40,650 --> 00:57:37,510
the mass with this one so lots of fun

1457
00:57:42,540 --> 00:57:40,660
stuff nice good well well we hope you

1458
00:57:43,740 --> 00:57:42,550
you'll we hope you haven't scared you

1459
00:57:45,900 --> 00:57:43,750
away from our hangouts and you'll join

1460
00:57:47,820 --> 00:57:45,910
us when you get some more data to talk

1461
00:57:48,130 --> 00:57:47,830
about that be be awesome to show our

1462
00:57:50,080 --> 00:57:48,140
view

1463
00:57:53,890 --> 00:57:50,090

he's okay he has mad cows so he won't

1464
00:57:58,510 --> 00:57:53,900
know the difference I can imagine first

1465
00:58:00,100 --> 00:57:58,520
one who yes all right all right well I

1466
00:58:03,370 --> 00:58:00,110
thank you thank you guys very much and

1467
00:58:07,510 --> 00:58:03,380
uh Carol we will be back next week but

1468
00:58:13,150 --> 00:58:07,520
do we have a topic yet we do okay we do

1469
00:58:18,130 --> 00:58:13,160
we do so Eric Rona is a famous object

1470
00:58:21,280 --> 00:58:18,140
that had an outburst in 1827 or

1471
00:58:23,830 --> 00:58:21,290
something like that anyway it's kind of

1472
00:58:26,380 --> 00:58:23,840
unique it's well-loved well studied and

1473
00:58:29,470 --> 00:58:26,390
there is a group that has been studying

1474
00:58:32,440 --> 00:58:29,480
and trying to find other objects like it

1475
00:58:34,570 --> 00:58:32,450
in other galaxies so we'll find out what

1476
00:58:36,910 --> 00:58:34,580
they did up next week great so we hope

1477
00:58:39,910 --> 00:58:36,920
you guys will join us next week at this

1478
00:58:41,590 --> 00:58:39,920
Hubble channel and and on behalf of

1479
00:58:42,910 --> 00:58:41,600
carol christian and scott lewis and all

1480
00:58:46,480 --> 00:58:42,920
of our guests i want to thank you all