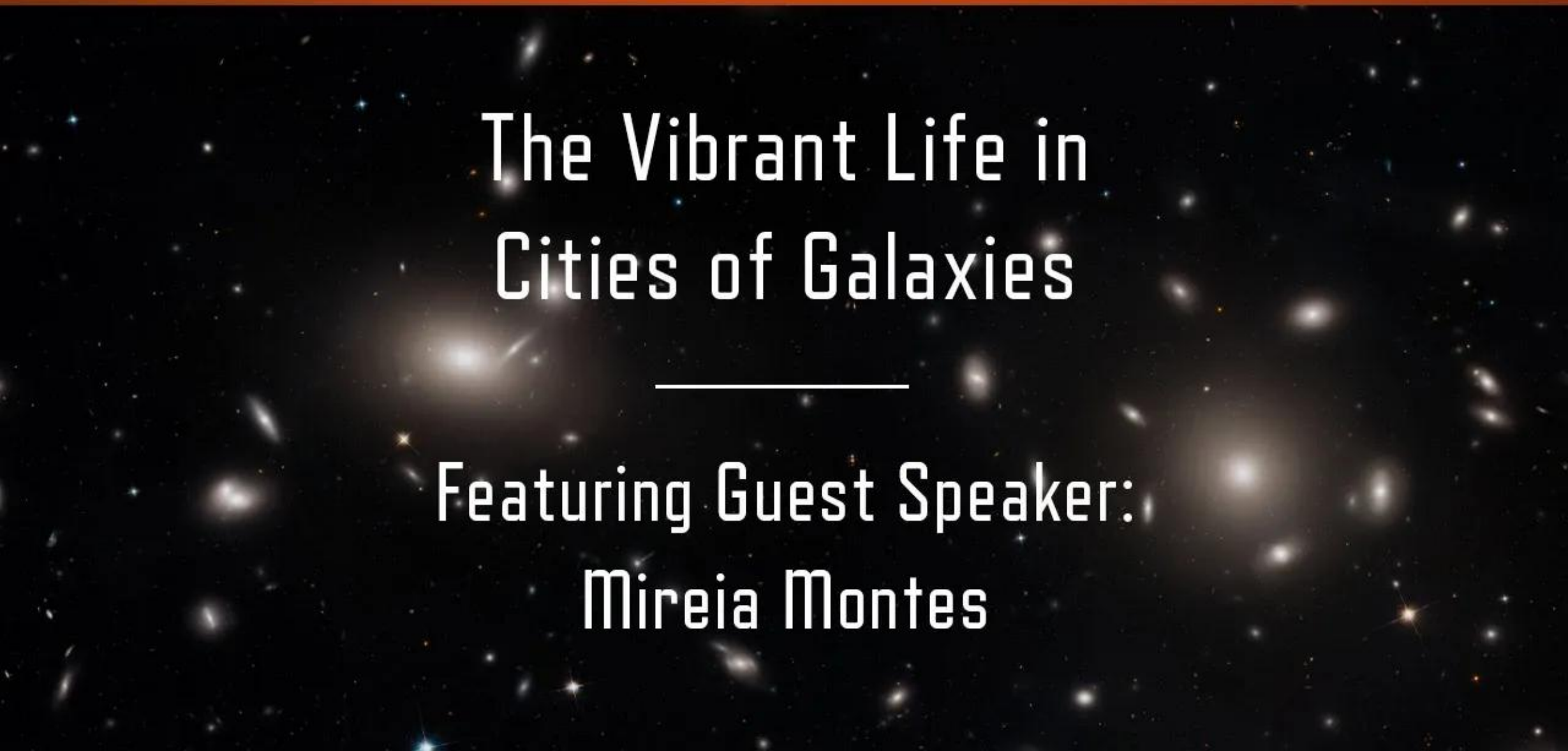
PUBLIC LECTURE SERIES



The Vibrant Life in Cities of Galaxies

Featuring Guest Speaker: Mireia Montes

1
00:00:04,390 --> 00:00:03,030
welcome to the space telescope public

2
00:00:07,349 --> 00:00:04,400
lecture series

3
00:00:10,709 --> 00:00:07,359
tonight's presentation the vibrant life

4
00:00:14,150 --> 00:00:10,719
in cities of galaxies by maria montes of

5
00:00:16,310 --> 00:00:14,160
the space telescope science institute

6
00:00:19,830 --> 00:00:16,320
i'm your host dr frank summers of the

7
00:00:22,550 --> 00:00:19,840
office of public outreach here at stsci

8
00:00:25,269 --> 00:00:22,560
i want to thank our amazing tech team

9
00:00:27,349 --> 00:00:25,279
thomas marufu and grant justice for

10
00:00:29,109 --> 00:00:27,359
doing this recording and streaming it

11
00:00:31,349 --> 00:00:29,119
live to youtube

12
00:00:33,190 --> 00:00:31,359
we also remind you that our space

13
00:00:37,670 --> 00:00:33,200

telescope public lecture series will

14
00:00:41,110 --> 00:00:37,680
remain online only until further notice

15
00:00:43,190 --> 00:00:41,120
our upcoming lectures in february we

16
00:00:46,869 --> 00:00:43,200
have from the front lines of the

17
00:00:48,709 --> 00:00:46,879
exoplanet revolution our peter roy also

18
00:00:51,350 --> 00:00:48,719
of the space telescope science institute

19
00:00:53,670 --> 00:00:51,360
will be talking about planets around

20
00:00:55,670 --> 00:00:53,680
other stars and really it is a

21
00:00:59,430 --> 00:00:55,680
revolution that has happened over the

22
00:01:02,069 --> 00:00:59,440
last 20 25 years in march

23
00:01:04,469 --> 00:01:02,079
hubble from space and integral field

24
00:01:07,350 --> 00:01:04,479
spectroscopy from the ground

25
00:01:10,710 --> 00:01:07,360
seeing both the forests and the trees a

26
00:01:12,710 --> 00:01:10,720
great i'd talk title i'm sure he's going

27
00:01:15,429 --> 00:01:12,720
to follow through that shows the

28
00:01:17,350 --> 00:01:15,439
advantages of space-based observation as

29
00:01:19,990 --> 00:01:17,360
well as the advantages of ground-based

30
00:01:22,550 --> 00:01:20,000
observation and how they work together

31
00:01:25,190 --> 00:01:22,560
that's mark sarzi from the arma

32
00:01:29,109 --> 00:01:25,200
observatory and planetarium

33
00:01:32,630 --> 00:01:29,119
and in april a really cool talk for you

34
00:01:34,469 --> 00:01:32,640
neutrino astronomy with ice cube had you

35
00:01:36,710 --> 00:01:34,479
ever think you could do astronomy using

36
00:01:38,230 --> 00:01:36,720
neutrinos do you even know what

37
00:01:40,069 --> 00:01:38,240
neutrinos are

38
00:01:42,550 --> 00:01:40,079

well pay attention because marco

39
00:01:45,429 --> 00:01:42,560
santander from the university of alabama

40
00:01:48,389 --> 00:01:45,439
will be talking about that in april

41
00:01:54,149 --> 00:01:48,399
to keep up with all of our talks you can

42
00:01:59,670 --> 00:01:57,670
public hyphen lectures and this

43
00:02:01,749 --> 00:01:59,680
the web page that you will find

44
00:02:04,709 --> 00:02:01,759
on the left hand side you can see our

45
00:02:08,710 --> 00:02:04,719
webcasts uh both on our youtube playlist

46
00:02:11,190 --> 00:02:08,720
as well as our sdsci webcast archive

47
00:02:12,630 --> 00:02:11,200
and on the right is that wonderful

48
00:02:14,630 --> 00:02:12,640
little box where you can enter your

49
00:02:16,949 --> 00:02:14,640
email address and subscribe to our

50
00:02:19,910 --> 00:02:16,959
lecture announcements and you'll get two

51
00:02:22,309 --> 00:02:19,920
maybe three emails a month

52
00:02:24,309 --> 00:02:22,319
also on our website we have a list of

53
00:02:26,710 --> 00:02:24,319
all the upcoming lectures

54
00:02:28,949 --> 00:02:26,720
and if you click on each lecture for

55
00:02:32,470 --> 00:02:28,959
more information you find the

56
00:02:34,710 --> 00:02:32,480
description uh the the speaker as well

57
00:02:36,390 --> 00:02:34,720
as after it's been recorded the link to

58
00:02:40,390 --> 00:02:36,400
the stsci webcast

59
00:02:44,949 --> 00:02:43,110
to sign up for our email

60
00:02:45,910 --> 00:02:44,959
well as i already said sign up at the

61
00:02:47,670 --> 00:02:45,920
website

62
00:02:49,910 --> 00:02:47,680
but if you don't want to have email if

63
00:02:51,990 --> 00:02:49,920

you want to use it by youtube you can

64
00:02:53,589 --> 00:02:52,000
subscribe to our youtube channel

65
00:02:55,509 --> 00:02:53,599
youtube.com

66
00:02:58,229 --> 00:02:55,519
hubble space telescope that's all one

67
00:03:00,229 --> 00:02:58,239
word hubble space telescope and as a

68
00:03:02,949 --> 00:03:00,239
subscriber you will get notices of new

69
00:03:05,750 --> 00:03:02,959
videos as well as reminders of live

70
00:03:07,750 --> 00:03:05,760
events finally if you have comments or

71
00:03:12,390 --> 00:03:07,760
questions you can send them to our email

72
00:03:15,670 --> 00:03:12,400
address public lecture stsci.edu

73
00:03:18,229 --> 00:03:15,680
you can also reach us via social media

74
00:03:20,390 --> 00:03:18,239
we have social media channels for the

75
00:03:22,470 --> 00:03:20,400
hubble space telescope for the web space

76
00:03:24,710 --> 00:03:22,480
telescope and for our institute the

77
00:03:27,589 --> 00:03:24,720
space telescope science institute so

78
00:03:28,869 --> 00:03:27,599
facebook twitter youtube and instagram

79
00:03:31,350 --> 00:03:28,879
available there

80
00:03:33,589 --> 00:03:31,360
i myself do a tiny tiny bit of social

81
00:03:37,509 --> 00:03:33,599
media you can find me on facebook and

82
00:03:39,910 --> 00:03:37,519
twitter as dr frank summers

83
00:03:42,309 --> 00:03:39,920
and now our news from the universe for

84
00:03:44,070 --> 00:03:42,319
january 2022

85
00:03:47,430 --> 00:03:44,080
and this is a special presentation

86
00:03:49,589 --> 00:03:47,440
because really there's only one story to

87
00:03:51,509 --> 00:03:49,599
tell you right now okay this is what's

88
00:03:53,910 --> 00:03:51,519

really consuming our time

89
00:03:56,550 --> 00:03:53,920
the james webb space telescope has

90
00:03:58,630 --> 00:03:56,560
launched okay and if you were here last

91
00:03:59,910 --> 00:03:58,640
month you heard all about the james webb

92
00:04:01,589 --> 00:03:59,920
space telescope so i don't need to tell

93
00:04:03,509 --> 00:04:01,599
you too much i just want to remind you

94
00:04:06,309 --> 00:04:03,519
what it looks like this is the

95
00:04:08,149 --> 00:04:06,319
web space telescope in its fully

96
00:04:10,710 --> 00:04:08,159
deployed configuration

97
00:04:13,589 --> 00:04:10,720
but it's not quite there yet

98
00:04:15,509 --> 00:04:13,599
and we've been waiting a really really

99
00:04:16,949 --> 00:04:15,519
long time for it and i wanted to just

100
00:04:19,749 --> 00:04:16,959
give you a

101
00:04:21,349 --> 00:04:19,759
feeling for just how anticipated this

102
00:04:22,310 --> 00:04:21,359
launch was

103
00:04:23,110 --> 00:04:22,320
so

104
00:04:25,350 --> 00:04:23,120
the

105
00:04:27,870 --> 00:04:25,360
timeline of selected events that's just

106
00:04:30,870 --> 00:04:27,880
i cribbed from wikipedia right

107
00:04:33,350 --> 00:04:30,880
1996 what was then called the next

108
00:04:35,430 --> 00:04:33,360
generation space telescope was initiated

109
00:04:38,310 --> 00:04:35,440
now actually the first discussion

110
00:04:40,070 --> 00:04:38,320
started in about 1994 that's a symposium

111
00:04:42,070 --> 00:04:40,080
to say all right what are we going to do

112
00:04:43,909 --> 00:04:42,080
after hubble hubble's you know was

113
00:04:46,629 --> 00:04:43,919

working and doing great stuff but what

114
00:04:49,430 --> 00:04:46,639
are we going to do next so in the 19 mid

115
00:04:52,230 --> 00:04:49,440
1990s is when all that started uh and

116
00:04:53,990 --> 00:04:52,240
then in 2002 it got renamed to the james

117
00:04:56,870 --> 00:04:54,000
webb space telescope

118
00:04:59,510 --> 00:04:56,880
in 2003 the prime contract was awarded

119
00:05:02,070 --> 00:04:59,520
so we're talking you know 18 years ago

120
00:05:03,590 --> 00:05:02,080
when the prime contracts just started

121
00:05:05,430 --> 00:05:03,600
for this telescope

122
00:05:07,830 --> 00:05:05,440
uh takes a while to do all this stuff

123
00:05:09,909 --> 00:05:07,840
the mission critical design review pass

124
00:05:11,830 --> 00:05:09,919
in 2010

125
00:05:13,350 --> 00:05:11,840
and then a really crazy thing happened

126
00:05:15,670 --> 00:05:13,360
in 2011

127
00:05:17,590 --> 00:05:15,680
um something happened in a congressional

128
00:05:19,830 --> 00:05:17,600
staffer's office they zeroed out the

129
00:05:21,830 --> 00:05:19,840
jwst budget right and it was threatened

130
00:05:24,150 --> 00:05:21,840
with cancellation but we survived that

131
00:05:27,749 --> 00:05:24,160
that was a that was quite a tense summer

132
00:05:29,830 --> 00:05:27,759
uh at here at the sdsci in 2011.

133
00:05:32,710 --> 00:05:29,840
and then we'll look towards launch but

134
00:05:34,629 --> 00:05:32,720
uh that starts in about 2015

135
00:05:36,870 --> 00:05:34,639
uh where the contract for the launcher

136
00:05:39,110 --> 00:05:36,880
with a launch date of october 2018 and

137
00:05:42,230 --> 00:05:39,120
we all really were focused on october

138
00:05:44,310 --> 00:05:42,240

2018. um we meanwhile they completed the

139
00:05:45,749 --> 00:05:44,320
jrst construction on all the instruments

140
00:05:47,590 --> 00:05:45,759
and all the mirrors and everything and

141
00:05:50,230 --> 00:05:47,600
they started into the serious testing

142
00:05:52,550 --> 00:05:50,240
phase and testing is extremely important

143
00:05:55,029 --> 00:05:52,560
for this telescope because unlike hubble

144
00:05:57,510 --> 00:05:55,039
we can't go up and repair it okay so

145
00:05:59,990 --> 00:05:57,520
it's in a really complex telescope and

146
00:06:02,390 --> 00:06:00,000
we got to get it right the first time so

147
00:06:05,510 --> 00:06:02,400
testing is absolutely crucial

148
00:06:07,830 --> 00:06:05,520
um and and that's what we found out with

149
00:06:10,950 --> 00:06:07,840
that needed further testing so in march

150
00:06:13,830 --> 00:06:10,960
of 2018 it got delayed to may 2020

151
00:06:16,029 --> 00:06:13,840
um and then in june of 2018 it got

152
00:06:18,629 --> 00:06:16,039
delayed a little bit further to march

153
00:06:20,230 --> 00:06:18,639
2021 on the recommendation of an

154
00:06:21,990 --> 00:06:20,240
independent review board that really

155
00:06:23,270 --> 00:06:22,000
wanted to make sure everything was gonna

156
00:06:26,230 --> 00:06:23,280
go right

157
00:06:29,350 --> 00:06:26,240
okay so then you get the pandemic

158
00:06:31,189 --> 00:06:29,360
happening okay and in july 2020 we had

159
00:06:33,430 --> 00:06:31,199
to postpone it again because the

160
00:06:35,350 --> 00:06:33,440
pandemic impact as well as some

161
00:06:38,309 --> 00:06:35,360
technical challenges so that became

162
00:06:41,029 --> 00:06:38,319
halloween of 2021 that was our target

163
00:06:43,510 --> 00:06:41,039

date um and then in june they had some

164
00:06:45,350 --> 00:06:43,520
problems with the ariane 5 and they said

165
00:06:46,550 --> 00:06:45,360
well due to things we got to test out

166
00:06:48,550 --> 00:06:46,560
and make sure everything is going to go

167
00:06:51,350 --> 00:06:48,560
great with the launch rocket so it

168
00:06:53,110 --> 00:06:51,360
pushed it back to november um and then

169
00:06:55,270 --> 00:06:53,120
in september the launch got postponed a

170
00:06:56,629 --> 00:06:55,280
little bit more to at a set date of

171
00:07:00,230 --> 00:06:56,639
december 18th we're going to go

172
00:07:01,990 --> 00:07:00,240
mid-december okay um and then there was

173
00:07:03,430 --> 00:07:02,000
additional testing was required and

174
00:07:05,430 --> 00:07:03,440
again you've got to get the testing

175
00:07:07,189 --> 00:07:05,440
you've got to get it right so no earlier

176
00:07:08,710 --> 00:07:07,199
than december 22nd

177
00:07:10,469 --> 00:07:08,720
and then there was an electrical fault

178
00:07:11,670 --> 00:07:10,479
that said okay no earlier than december

179
00:07:13,589 --> 00:07:11,680
24th

180
00:07:15,350 --> 00:07:13,599
and finally one of the things you always

181
00:07:17,189 --> 00:07:15,360
expect it launches is that there's

182
00:07:19,270 --> 00:07:17,199
weather and so that pushed it to

183
00:07:20,629 --> 00:07:19,280
december 25th

184
00:07:22,710 --> 00:07:20,639
and then

185
00:07:25,350 --> 00:07:22,720
on december 25th

186
00:07:28,550 --> 00:07:25,360
from kuru in french guiana this is the

187
00:07:31,909 --> 00:07:28,560
spaceport with the ariane 5 rocket

188
00:07:34,430 --> 00:07:31,919

we got to watch exactly on time

189
00:07:39,189 --> 00:07:34,440
we got to watch this

190
00:07:44,150 --> 00:07:41,350
decollege liftoff from a tropical

191
00:07:46,469 --> 00:07:44,160
rainforest to the edge of time itself

192
00:07:48,650 --> 00:07:46,479
james webb begins a voyage back to the

193
00:07:52,629 --> 00:07:48,660
birth of the universe

194
00:07:56,469 --> 00:07:52,639
[Music]

195
00:07:58,790 --> 00:07:56,479
so astronomers got their holiday present

196
00:08:01,270 --> 00:07:58,800
uh here's one of the shots that were put

197
00:08:03,749 --> 00:08:01,280
was posted to our slack channels uh

198
00:08:06,469 --> 00:08:03,759
amazing stuff we were just so excited we

199
00:08:08,869 --> 00:08:06,479
were following it um it was 7 20 in the

200
00:08:11,990 --> 00:08:08,879
morning on christmas day

201
00:08:14,150 --> 00:08:12,000
um and this shot i captures a very

202
00:08:15,909 --> 00:08:14,160
special moment because the rocket puts

203
00:08:18,469 --> 00:08:15,919
it up and then at some point the

204
00:08:21,110 --> 00:08:18,479
telescope separates from the rocket

205
00:08:23,990 --> 00:08:21,120
this captures it 27 minutes in and of

206
00:08:26,070 --> 00:08:24,000
course that is just a

207
00:08:28,070 --> 00:08:26,080
a visualization of it okay because we

208
00:08:30,550 --> 00:08:28,080
don't have a camera flying along with it

209
00:08:32,790 --> 00:08:30,560
to track it but

210
00:08:34,230 --> 00:08:32,800
on the top stage of the rocket there was

211
00:08:36,550 --> 00:08:34,240
a webcam

212
00:08:38,630 --> 00:08:36,560
and in a f and a few minutes later you

213
00:08:41,190 --> 00:08:38,640

know fit about 15-20 minutes later they

214
00:08:43,269 --> 00:08:41,200
actually got the cat footage from that

215
00:08:45,269 --> 00:08:43,279
separation all right so this this

216
00:08:47,430 --> 00:08:45,279
footage from the separation is actually

217
00:08:49,990 --> 00:08:47,440
kind of um rough because it's real it's

218
00:08:51,990 --> 00:08:50,000
real data okay and there's there's blips

219
00:08:53,590 --> 00:08:52,000
all through it it's not clean um and the

220
00:08:56,310 --> 00:08:53,600
other thing to look out for is at the

221
00:09:00,310 --> 00:08:56,320
very end the extension out

222
00:09:02,790 --> 00:09:00,320
of the sunshield not the the solar array

223
00:09:04,870 --> 00:09:02,800
because web is a solar powered telescope

224
00:09:07,910 --> 00:09:04,880
so the first thing it needs to do is get

225
00:09:10,310 --> 00:09:07,920
power from the sun so this was really

226
00:09:14,100 --> 00:09:10,320
cool to watch this is just very stirring

227
00:09:51,990 --> 00:09:14,110
to those of us at st

228
00:09:56,470 --> 00:09:54,310
the james webb space telescope amidst

229
00:09:57,430 --> 00:09:56,480
applause here in the mission control

230
00:09:59,750 --> 00:09:57,440
center

231
00:10:02,870 --> 00:09:59,760
now taking its first steps in pursuit of

232
00:10:05,590 --> 00:10:02,880
cosmological discovery

233
00:10:08,150 --> 00:10:05,600
yeah that was quite the moment

234
00:10:11,350 --> 00:10:08,160
um so you know

235
00:10:13,509 --> 00:10:11,360
jbst is going out to its orbit around

236
00:10:15,829 --> 00:10:13,519
the second lagrangian point okay which

237
00:10:18,310 --> 00:10:15,839
is a semi-stable point and usually it's

238
00:10:20,630 --> 00:10:18,320

just show you we show you a diagram like

239
00:10:23,350 --> 00:10:20,640
this but look in the lower right corner

240
00:10:25,509 --> 00:10:23,360
it says the diagram is not to scale so i

241
00:10:27,910 --> 00:10:25,519
thought i would show you a

242
00:10:28,949 --> 00:10:27,920
diagram that actually is to scale and so

243
00:10:31,030 --> 00:10:28,959
this is

244
00:10:33,030 --> 00:10:31,040
one of the possible orbits okay

245
00:10:35,030 --> 00:10:33,040
actually the orbit does depend upon the

246
00:10:37,430 --> 00:10:35,040
launch date so the exact orbit this

247
00:10:39,670 --> 00:10:37,440
isn't the exact orbit but it's it's an

248
00:10:41,829 --> 00:10:39,680
example a good example of it and you can

249
00:10:44,069 --> 00:10:41,839
see that it's not going out to the l2

250
00:10:45,750 --> 00:10:44,079
point and sitting at the l2 point okay

251
00:10:47,670 --> 00:10:45,760
it's a semi-stable gravitational

252
00:10:51,269 --> 00:10:47,680
semi-stable point and instead it's

253
00:10:54,389 --> 00:10:51,279
orbiting around that l2 point okay it's

254
00:10:57,750 --> 00:10:54,399
a very large orbit okay

255
00:10:59,590 --> 00:10:57,760
the size of that orbit is almost

256
00:11:02,150 --> 00:10:59,600
the diameter of that orbit is almost the

257
00:11:04,630 --> 00:11:02,160
same size as the distance from earth so

258
00:11:06,630 --> 00:11:04,640
it's a really really big

259
00:11:09,910 --> 00:11:06,640
halo orbit around it

260
00:11:12,069 --> 00:11:09,920
and this is what allows it to just to to

261
00:11:13,910 --> 00:11:12,079
maintain that position and we can use a

262
00:11:16,310 --> 00:11:13,920
minimum amount of fuel for station

263
00:11:19,190 --> 00:11:16,320

keeping to keep it in that orbit

264
00:11:21,990 --> 00:11:19,200
so along the way out to the orbit it

265
00:11:24,389 --> 00:11:22,000
will be doing its deployment um as you

266
00:11:26,230 --> 00:11:24,399
saw last month from alex it has the

267
00:11:28,710 --> 00:11:26,240
origami telescope has to open up and the

268
00:11:32,150 --> 00:11:28,720
sun shields stretch out and so on and so

269
00:11:35,430 --> 00:11:32,160
forth to get out there it takes about 29

270
00:11:38,310 --> 00:11:35,440
days to get to the l2

271
00:11:41,269 --> 00:11:38,320
and insertion into the l2 orbit

272
00:11:44,310 --> 00:11:41,279
and so you may ask well where is web now

273
00:11:46,389 --> 00:11:44,320
and what stage is it at well to do to

274
00:11:48,470 --> 00:11:46,399
find that out you go to a very helpful

275
00:11:50,710 --> 00:11:48,480
website that's called

276
00:11:53,110 --> 00:11:50,720
where is web hey

277
00:11:55,670 --> 00:11:53,120
um and this was a screenshot i took from

278
00:11:58,470 --> 00:11:55,680
where is web this morning

279
00:12:00,790 --> 00:11:58,480
and at that point layers one two and

280
00:12:02,470 --> 00:12:00,800
three of the sun shield layer tensioning

281
00:12:05,110 --> 00:12:02,480
had been completed

282
00:12:07,990 --> 00:12:05,120
and about two hours later about noon

283
00:12:11,590 --> 00:12:08,000
eastern time today the sunshield

284
00:12:13,030 --> 00:12:11,600
deployment was complete yes

285
00:12:14,470 --> 00:12:13,040
that was a

286
00:12:16,470 --> 00:12:14,480
point that we had really been waiting

287
00:12:18,069 --> 00:12:16,480
for okay because you got five layers of

288
00:12:20,550 --> 00:12:18,079

sunshield you had to pull it out of the

289
00:12:23,750 --> 00:12:20,560
booms and everything just really complex

290
00:12:25,190 --> 00:12:23,760
stuff and it's working beautifully

291
00:12:27,910 --> 00:12:25,200
in nasa speak

292
00:12:28,949 --> 00:12:27,920
both the launch and the deployment are

293
00:12:29,750 --> 00:12:28,959
nominal

294
00:12:31,590 --> 00:12:29,760
which

295
00:12:34,550 --> 00:12:31,600
in nasa speak really means it's going

296
00:12:37,990 --> 00:12:34,560
perfectly it's really going well so we

297
00:12:40,470 --> 00:12:38,000
are so excited uh about this um however

298
00:12:44,710 --> 00:12:40,480
we're only 10 days into into into the

299
00:12:47,509 --> 00:12:44,720
mission um and as i said it'll on day 29

300
00:12:50,069 --> 00:12:47,519
uh will be the orbit insertion on l2 so

301
00:12:53,190 --> 00:12:50,079
if you want to follow it um if you want

302
00:12:56,069 --> 00:12:53,200
ongoing information about web

303
00:12:57,750 --> 00:12:56,079
i gave you i'll give you three web urls

304
00:12:59,750 --> 00:12:57,760
you might want to screenshot this so you

305
00:13:02,629 --> 00:12:59,760
can refer to them later

306
00:13:04,069 --> 00:13:02,639
first is this where is web site

307
00:13:05,190 --> 00:13:04,079
which gives you a lot more information

308
00:13:07,590 --> 00:13:05,200
than what i showed in that one

309
00:13:09,590 --> 00:13:07,600
screenshot it has a bunch of other other

310
00:13:11,590 --> 00:13:09,600
screens where you can really go through

311
00:13:13,829 --> 00:13:11,600
all the stages of its deployment and a

312
00:13:16,949 --> 00:13:13,839
lot more information about web

313
00:13:19,509 --> 00:13:16,959

the official nasa web blog

314
00:13:21,269 --> 00:13:19,519
has articles short articles written as

315
00:13:24,069 --> 00:13:21,279
each thing completes they tell you

316
00:13:26,550 --> 00:13:24,079
exactly what's going on it's fantastic

317
00:13:29,670 --> 00:13:26,560
and then when there are particularly

318
00:13:32,629 --> 00:13:29,680
interesting things going on um the nasa

319
00:13:36,069 --> 00:13:32,639
live will cut in like today between 9 30

320
00:13:38,150 --> 00:13:36,079
and and noon um they covered the sun

321
00:13:39,189 --> 00:13:38,160
shield tensioning okay the separation of

322
00:13:42,550 --> 00:13:39,199
the layers and tensioning of the

323
00:13:45,990 --> 00:13:42,560
sunshield they covered it live and uh it

324
00:13:47,430 --> 00:13:46,000
really was you know uh

325
00:13:48,389 --> 00:13:47,440
it was

326
00:13:51,590 --> 00:13:48,399
fantastic

327
00:13:53,829 --> 00:13:51,600
live reality tv because you know it

328
00:13:56,629 --> 00:13:53,839
really means something this is the

329
00:13:58,710 --> 00:13:56,639
deployment of the nasa's next great

330
00:14:00,230 --> 00:13:58,720
observatory so

331
00:14:02,150 --> 00:14:00,240
um

332
00:14:04,310 --> 00:14:02,160
these are the three places that i've

333
00:14:07,829 --> 00:14:04,320
been following i invite you to follow

334
00:14:10,870 --> 00:14:07,839
them and um we got a wonderful holiday

335
00:14:12,470 --> 00:14:10,880
gift for astronomy and uh next month

336
00:14:14,550 --> 00:14:12,480
i'll be hopefully be able to tell you

337
00:14:17,110 --> 00:14:14,560
that it's at ll2 and everything's going

338
00:14:20,150 --> 00:14:17,120

great

339
00:14:21,189 --> 00:14:20,160
so let's get back to our main talk

340
00:14:24,230 --> 00:14:21,199
tonight

341
00:14:26,069 --> 00:14:24,240
um it is uh maria montez

342
00:14:29,030 --> 00:14:26,079
talking about the vibrant life in cities

343
00:14:33,030 --> 00:14:29,040
of galaxies

344
00:14:35,829 --> 00:14:33,040
and maria is an stsci fellow here at the

345
00:14:38,790 --> 00:14:35,839
space telescope science institute um and

346
00:14:40,870 --> 00:14:38,800
uh she works in the wide field camera 3

347
00:14:43,189 --> 00:14:40,880
group so wide field camera 3 is an

348
00:14:46,629 --> 00:14:43,199
instrument on the hubble space telescope

349
00:14:49,350 --> 00:14:46,639
she got her phd in the canary islands at

350
00:14:51,110 --> 00:14:49,360
the instituto astrophysica de canarias

351
00:14:53,269 --> 00:14:51,120
i'm sure i butchered the pronunciation

352
00:14:57,829 --> 00:14:53,279
of that but you know i did my best

353
00:15:00,470 --> 00:14:57,839
um she did a couple postdocs one at yale

354
00:15:03,030 --> 00:15:00,480
up in connecticut and another at the

355
00:15:05,350 --> 00:15:03,040
university of new south wales in

356
00:15:07,509 --> 00:15:05,360
australia so she has been quite the

357
00:15:10,790 --> 00:15:07,519
world traveler um

358
00:15:13,430 --> 00:15:10,800
she also has her own hobbies where she

359
00:15:16,949 --> 00:15:13,440
does a particular top

360
00:15:19,750 --> 00:15:16,959
specific type of belly dancing that i

361
00:15:22,389 --> 00:15:19,760
couldn't i i i don't know anything about

362
00:15:24,710 --> 00:15:22,399
so you'll have to ask her about it but

363
00:15:27,430 --> 00:15:24,720

um she has a

364
00:15:29,509 --> 00:15:27,440
both a a great spirit and a great

365
00:15:31,749 --> 00:15:29,519
outlook on life and so ladies and

366
00:15:33,670 --> 00:15:31,759
gentlemen very proud to present maria

367
00:15:35,189 --> 00:15:33,680
montes

368
00:15:38,150 --> 00:15:35,199
thank you very much frank and thank you

369
00:15:39,269 --> 00:15:38,160
very much for this nice introduction

370
00:15:41,350 --> 00:15:39,279
um

371
00:15:43,110 --> 00:15:41,360
hello everybody it's a pleasure to be

372
00:15:44,470 --> 00:15:43,120
here it's a pleasure to

373
00:15:45,509 --> 00:15:44,480
share with you

374
00:15:48,710 --> 00:15:45,519
um

375
00:15:49,590 --> 00:15:48,720
my passion and my knowledge with you all

376
00:15:51,030 --> 00:15:49,600
so

377
00:15:54,389 --> 00:15:51,040
let's start with it

378
00:15:56,470 --> 00:15:54,399
as an astronomer my job is looking up at

379
00:15:58,710 --> 00:15:56,480
the sky so

380
00:16:00,230 --> 00:15:58,720
well maybe baltimore is not the best

381
00:16:03,030 --> 00:16:00,240
place to look at the sky

382
00:16:05,269 --> 00:16:03,040
um so let's go somewhere else somewhere

383
00:16:06,870 --> 00:16:05,279
darker and where you know you can we can

384
00:16:09,670 --> 00:16:06,880
see like

385
00:16:13,030 --> 00:16:09,680
some stars at least

386
00:16:14,470 --> 00:16:13,040
so as uh frank mentioned before i lived

387
00:16:16,550 --> 00:16:14,480
in australia for three years before

388
00:16:18,470 --> 00:16:16,560

coming to baltimore

389
00:16:20,550 --> 00:16:18,480
there i got the opportunity to observe

390
00:16:23,110 --> 00:16:20,560
here in the uh

391
00:16:25,990 --> 00:16:23,120
in this this is the anglo-australian

392
00:16:28,949 --> 00:16:26,000
telescope inside a spring observatory

393
00:16:31,189 --> 00:16:28,959
that it's located almost seven hour

394
00:16:33,110 --> 00:16:31,199
drive north from sydney where i was

395
00:16:36,710 --> 00:16:33,120
living

396
00:16:38,629 --> 00:16:36,720
so the first night uh i was i was there

397
00:16:40,470 --> 00:16:38,639
um there was a problem with the

398
00:16:42,949 --> 00:16:40,480
instrument that we were using so

399
00:16:44,310 --> 00:16:42,959
although the night was it was the the

400
00:16:46,069 --> 00:16:44,320
most perfect night that you could

401
00:16:49,110 --> 00:16:46,079
imagine it was clear there were no

402
00:16:51,829 --> 00:16:49,120
clouds it was just perfect but we were

403
00:16:54,230 --> 00:16:51,839
not able to observe anything

404
00:16:56,310 --> 00:16:54,240
so what we did is we went outside

405
00:16:58,870 --> 00:16:56,320
and the first it and this is the first

406
00:16:59,990 --> 00:16:58,880
time that i saw what you can see here in

407
00:17:02,949 --> 00:17:00,000
this image

408
00:17:05,590 --> 00:17:02,959
so this is the this lane of uh bright

409
00:17:08,390 --> 00:17:05,600
and dark patches that is our milky way

410
00:17:10,789 --> 00:17:08,400
and also the satellites of the milky way

411
00:17:12,949 --> 00:17:10,799
that are that are the magellanic clouds

412
00:17:14,789 --> 00:17:12,959
and you can see one of

413
00:17:15,909 --> 00:17:14,799

one of them here

414
00:17:17,750 --> 00:17:15,919
so those

415
00:17:19,909 --> 00:17:17,760
those satellites can only be seen from

416
00:17:22,630 --> 00:17:19,919
the southern street so i was you know i

417
00:17:23,350 --> 00:17:22,640
was really really excited

418
00:17:25,990 --> 00:17:23,360
so

419
00:17:27,590 --> 00:17:26,000
one fun fact that i want to uh tell you

420
00:17:31,029 --> 00:17:27,600
before you know like going on with my

421
00:17:32,710 --> 00:17:31,039
presentation is that as well in the

422
00:17:35,350 --> 00:17:32,720
western hemisphere we define

423
00:17:36,950 --> 00:17:35,360
constellations as you know the group

424
00:17:39,029 --> 00:17:36,960
groups of stars

425
00:17:42,390 --> 00:17:39,039
aboriginal australians look at these

426
00:17:45,190 --> 00:17:42,400
dark patches that you can see here

427
00:17:47,990 --> 00:17:45,200
and uh and saw the shape of anime anemia

428
00:17:49,430 --> 00:17:48,000
is like a large bird that they have in

429
00:17:50,710 --> 00:17:49,440
australia

430
00:17:53,110 --> 00:17:50,720
um

431
00:17:55,750 --> 00:17:53,120
so it's like that and

432
00:17:58,789 --> 00:17:55,760
once you see it you're never gonna not

433
00:18:00,630 --> 00:17:58,799
see uh not see it again so

434
00:18:03,029 --> 00:18:00,640
this immune

435
00:18:05,909 --> 00:18:03,039
and they call it the immune the sky

436
00:18:08,789 --> 00:18:05,919
so at some at a particular point of the

437
00:18:11,350 --> 00:18:08,799
year the legs of this immune the sky

438
00:18:13,669 --> 00:18:11,360

will disappear below the horizon

439
00:18:15,590 --> 00:18:13,679
and that will signal original

440
00:18:18,310 --> 00:18:15,600
australians that it was time to you know

441
00:18:21,750 --> 00:18:18,320
like hunt to look for the emu eggs that

442
00:18:23,270 --> 00:18:21,760
is was part of of their diet

443
00:18:25,430 --> 00:18:23,280
so this is

444
00:18:28,150 --> 00:18:25,440
by far one of the most clever uses of

445
00:18:29,270 --> 00:18:28,160
astronomers i have ever heard well that

446
00:18:31,270 --> 00:18:29,280
and you know like

447
00:18:33,430 --> 00:18:31,280
basically like developing technology to

448
00:18:34,630 --> 00:18:33,440
have like wi-fi and and other other

449
00:18:37,830 --> 00:18:34,640
things

450
00:18:38,710 --> 00:18:37,840
but let's go back to the to the sky

451
00:18:39,830 --> 00:18:38,720
so

452
00:18:44,789 --> 00:18:39,840
this

453
00:18:48,950 --> 00:18:44,799
and

454
00:18:51,190 --> 00:18:48,960
stars is our milky way so

455
00:18:51,909 --> 00:18:51,200
because we are inside the milky way we

456
00:18:56,549 --> 00:18:51,919
are

457
00:18:59,270 --> 00:18:56,559
see one part of it so it's very

458
00:19:01,270 --> 00:18:59,280
difficult to know how it actually looks

459
00:19:03,270 --> 00:19:01,280
like

460
00:19:05,669 --> 00:19:03,280
so one one of the things that we can

461
00:19:07,830 --> 00:19:05,679
like we can do like some sort of like a

462
00:19:12,549 --> 00:19:07,840
like a

463
00:19:15,990 --> 00:19:12,559

play here

464
00:19:18,549 --> 00:19:16,000
uh it's it's you know like if we looked

465
00:19:21,510 --> 00:19:18,559
like close to this lane we can see more

466
00:19:23,029 --> 00:19:21,520
stars than if we look like you know like

467
00:19:25,350 --> 00:19:23,039
far from this lane

468
00:19:28,070 --> 00:19:25,360
so basically this is telling us that our

469
00:19:31,110 --> 00:19:28,080
uh our galaxy has like some

470
00:19:33,430 --> 00:19:31,120
some sort of uh flat structure like like

471
00:19:36,470 --> 00:19:33,440
kind of a pancake

472
00:19:39,270 --> 00:19:36,480
and actually is this is what astronomers

473
00:19:40,230 --> 00:19:39,280
do like so um basically they count the

474
00:19:43,990 --> 00:19:40,240
stars

475
00:19:46,789 --> 00:19:44,000
they are uh they uh they calculate the

476
00:19:49,909 --> 00:19:46,799
distance to figure out um

477
00:19:51,909 --> 00:19:49,919
the shape of our galaxy

478
00:19:54,230 --> 00:19:51,919
so for example this is a map of the

479
00:19:56,230 --> 00:19:54,240
milky way by astronomer william herschel

480
00:19:59,190 --> 00:19:56,240
in 1785.

481
00:20:01,990 --> 00:19:59,200
so basically he did that um

482
00:20:03,830 --> 00:20:02,000
he looked at the stars he he estimated

483
00:20:08,390 --> 00:20:03,840
some sort of

484
00:20:11,590 --> 00:20:08,400
distance and he uh he put them on a map

485
00:20:13,669 --> 00:20:11,600
uh so yeah basically what he saw is the

486
00:20:18,070 --> 00:20:13,679
same thing is that our galaxy some sort

487
00:20:19,190 --> 00:20:18,080
of like a flat um flat disk structure

488
00:20:21,750 --> 00:20:19,200

well in

489
00:20:24,310 --> 00:20:21,760
in in herschel's map we see that we are

490
00:20:27,270 --> 00:20:24,320
located here this is this this uh very

491
00:20:28,470 --> 00:20:27,280
dark you know like darker uh

492
00:20:30,549 --> 00:20:28,480
points

493
00:20:32,549 --> 00:20:30,559
so he thought that we were located like

494
00:20:34,710 --> 00:20:32,559
some sort of in the center of

495
00:20:37,830 --> 00:20:34,720
our galaxy

496
00:20:39,830 --> 00:20:37,840
but uh fast forward to today uh with

497
00:20:41,430 --> 00:20:39,840
better instrumentation and precision we

498
00:20:43,590 --> 00:20:41,440
know that the milky way

499
00:20:45,510 --> 00:20:43,600
milky way looks uh similar to this you

500
00:20:49,110 --> 00:20:45,520
know from the from the top

501
00:20:51,350 --> 00:20:49,120
uh it's um it's a spiral galaxy uh we

502
00:20:54,390 --> 00:20:51,360
see here you know like the the spiral

503
00:20:58,390 --> 00:20:54,400
arms we are sort of like in uh in

504
00:21:05,830 --> 00:21:01,830
and our galaxy um has this very like

505
00:21:08,390 --> 00:21:05,840
fuzzy blob of of orange blob of stars in

506
00:21:10,149 --> 00:21:08,400
the center this elongated shape

507
00:21:12,950 --> 00:21:10,159
and we are not in the center of our

508
00:21:15,669 --> 00:21:12,960
galaxy but we are kind of like halfway

509
00:21:18,549 --> 00:21:16,470
so

510
00:21:20,950 --> 00:21:18,559
uh

511
00:21:22,950 --> 00:21:20,960
so we know that if we observe the

512
00:21:25,110 --> 00:21:22,960
universe we know that uh there are more

513
00:21:27,510 --> 00:21:25,120

galaxies and all you know like all these

514
00:21:28,789 --> 00:21:27,520
galaxies come in very different shapes

515
00:21:30,950 --> 00:21:28,799
so

516
00:21:33,190 --> 00:21:30,960
there are galaxies that look like like

517
00:21:35,270 --> 00:21:33,200
this one like a fuzzy blob of stars that

518
00:21:39,110 --> 00:21:35,280
are have a like a roundy roundish

519
00:21:40,789 --> 00:21:39,120
elliptical shape that is what um we call

520
00:21:43,510 --> 00:21:40,799
elliptical galaxies

521
00:21:46,310 --> 00:21:43,520
their color is like this gold yellow

522
00:21:48,950 --> 00:21:46,320
orange that indicates that the stars in

523
00:21:52,870 --> 00:21:48,960
these galaxies are old and they are

524
00:21:58,789 --> 00:21:56,950
these galaxies were formed very long ago

525
00:22:00,630 --> 00:21:58,799
in very intense you know like very short

526
00:22:02,950 --> 00:22:00,640
and intense episodes of star formation

527
00:22:05,029 --> 00:22:02,960
so kind of they form

528
00:22:08,390 --> 00:22:05,039
in like at once

529
00:22:12,710 --> 00:22:10,470
the most massive galaxies in the

530
00:22:15,350 --> 00:22:12,720
universe are typically

531
00:22:16,789 --> 00:22:15,360
of the shape elliptical galaxies

532
00:22:20,390 --> 00:22:16,799
next we have

533
00:22:22,789 --> 00:22:20,400
a spiral galaxies like our own milky way

534
00:22:25,510 --> 00:22:22,799
uh they can have more or less defined

535
00:22:26,950 --> 00:22:25,520
spiral arms uh sometimes you know like

536
00:22:29,990 --> 00:22:26,960
the

537
00:22:31,750 --> 00:22:30,000
it's more or less

538
00:22:33,990 --> 00:22:31,760

more or less dominant

539
00:22:38,470 --> 00:22:34,000
and uh sometimes they have like this

540
00:22:41,669 --> 00:22:38,480
kind of bar like structure in the middle

541
00:22:42,549 --> 00:22:41,679
those these galaxies are bluer because

542
00:22:45,029 --> 00:22:42,559
uh

543
00:22:46,390 --> 00:22:45,039
they contain more you know like more of

544
00:22:48,870 --> 00:22:46,400
younger stars

545
00:22:51,350 --> 00:22:48,880
so in this in this case you know like

546
00:22:54,230 --> 00:22:51,360
compared with the elliptical galaxies

547
00:22:56,149 --> 00:22:54,240
the star formation has occurred like uh

548
00:22:58,230 --> 00:22:56,159
longer in time

549
00:23:00,710 --> 00:22:58,240
more constant over time

550
00:23:03,909 --> 00:23:00,720
and finally we have galaxies

551
00:23:06,230 --> 00:23:03,919
with like not not a particular shape and

552
00:23:09,110 --> 00:23:06,240
that's what we call it regular galaxies

553
00:23:11,510 --> 00:23:09,120
so in comparison these galaxies are are

554
00:23:15,029 --> 00:23:11,520
less massive than the other two types

555
00:23:15,990 --> 00:23:15,039
and their stars are yeah are young and

556
00:23:18,630 --> 00:23:16,000
uh

557
00:23:21,830 --> 00:23:18,640
they they have less metals so they tend

558
00:23:23,350 --> 00:23:21,840
to be so they are bluer

559
00:23:24,549 --> 00:23:23,360
because they are less massive they tend

560
00:23:28,149 --> 00:23:24,559
to be like

561
00:23:31,990 --> 00:23:28,159
a satellite of the other two types

562
00:23:34,390 --> 00:23:32,000
so in the same way that the stars in our

563
00:23:36,950 --> 00:23:34,400

milky way they were not distributed

564
00:23:39,350 --> 00:23:36,960
evenly all over the sky galaxies are not

565
00:23:42,149 --> 00:23:39,360
distributed um evenly all over the

566
00:23:44,630 --> 00:23:42,159
universe but they like us they like to

567
00:23:46,149 --> 00:23:44,640
live in communities

568
00:23:46,870 --> 00:23:46,159
so when we are talking about you know

569
00:23:54,470 --> 00:23:46,880
like

570
00:23:55,350 --> 00:23:54,480
that was too much

571
00:23:57,750 --> 00:23:55,360
um

572
00:23:59,430 --> 00:23:57,760
very very low populated here

573
00:24:02,149 --> 00:23:59,440
um

574
00:24:04,470 --> 00:24:02,159
we are talking about a group of galaxies

575
00:24:06,470 --> 00:24:04,480
for example our milky way our own milky

576
00:24:07,750 --> 00:24:06,480
way lives in a rather small group that

577
00:24:10,710 --> 00:24:07,760
consists of

578
00:24:12,470 --> 00:24:10,720
andromeda which is our nearest spiral

579
00:24:17,510 --> 00:24:12,480
galaxy

580
00:24:20,230 --> 00:24:17,520
their satellites

581
00:24:22,549 --> 00:24:20,240
if we are talking about uh hundreds or

582
00:24:25,110 --> 00:24:22,559
even thousands of galaxies

583
00:24:26,870 --> 00:24:25,120
more like a you know like a proper city

584
00:24:29,750 --> 00:24:26,880
uh we are talking about classes of

585
00:24:32,230 --> 00:24:29,760
galaxies these are some of the biggest

586
00:24:33,430 --> 00:24:32,240
structures in the universe and they are

587
00:24:34,630 --> 00:24:33,440
like well

588
00:24:36,710 --> 00:24:34,640

of course for me

589
00:24:39,750 --> 00:24:36,720
they are very interesting but let's look

590
00:24:43,830 --> 00:24:39,760
at them and what they can tell us

591
00:24:48,310 --> 00:24:43,840
so this cluster is avail 1689 it's a

592
00:24:50,630 --> 00:24:48,320
favorite of mine what you can see here

593
00:24:53,110 --> 00:24:50,640
so let's look at this image so what can

594
00:24:55,029 --> 00:24:53,120
you see in this cluster

595
00:24:56,070 --> 00:24:55,039
what is the most striking feature that

596
00:24:57,990 --> 00:24:56,080
you can see

597
00:25:00,149 --> 00:24:58,000
in here so

598
00:25:01,269 --> 00:25:00,159
we see that most of the galaxies in the

599
00:25:02,390 --> 00:25:01,279
image look

600
00:25:07,830 --> 00:25:02,400
like

601
00:25:10,470 --> 00:25:07,840
fussy blobs

602
00:25:11,990 --> 00:25:10,480
so compared to other places in the sky

603
00:25:15,029 --> 00:25:12,000
we can see a higher number of these

604
00:25:17,190 --> 00:25:15,039
orange galaxies we can also see

605
00:25:20,149 --> 00:25:17,200
that you know like we have some big

606
00:25:21,350 --> 00:25:20,159
galaxies over here or here or here

607
00:25:22,549 --> 00:25:21,360
but

608
00:25:23,590 --> 00:25:22,559
uh

609
00:25:30,630 --> 00:25:23,600
the

610
00:25:34,630 --> 00:25:32,310
so in clusters

611
00:25:36,470 --> 00:25:34,640
while you know like while tiny galaxies

612
00:25:39,110 --> 00:25:36,480
dominating numbers there are

613
00:25:41,750 --> 00:25:39,120

simply there are more tiny galaxies

614
00:25:43,750 --> 00:25:41,760
most of the stars are in these you know

615
00:25:46,070 --> 00:25:43,760
like in this big galaxy so basically

616
00:25:47,269 --> 00:25:46,080
they dominate in light so they dominate

617
00:25:51,029 --> 00:25:47,279
in the brightness

618
00:25:55,110 --> 00:25:53,750
so if we look at the cluster of itself

619
00:25:56,630 --> 00:25:55,120
we also see

620
00:25:59,029 --> 00:25:56,640
different parts

621
00:26:00,470 --> 00:25:59,039
there's there is a higher

622
00:26:03,110 --> 00:26:00,480
a higher concentration a higher number

623
00:26:04,310 --> 00:26:03,120
of galaxies in the center

624
00:26:05,430 --> 00:26:04,320
of the cluster

625
00:26:07,269 --> 00:26:05,440
a higher

626
00:26:12,070 --> 00:26:07,279
higher density which is like

627
00:26:13,909 --> 00:26:12,080
the center of a city however if we if we

628
00:26:16,149 --> 00:26:13,919
move like away from the center we go to

629
00:26:17,510 --> 00:26:16,159
the you know the outer parts

630
00:26:19,510 --> 00:26:17,520
um

631
00:26:21,190 --> 00:26:19,520
there there are less

632
00:26:23,110 --> 00:26:21,200
there's a less you know there are less

633
00:26:25,269 --> 00:26:23,120
number of galaxies which is

634
00:26:27,269 --> 00:26:25,279
kind of like the suburbs of a city you

635
00:26:28,149 --> 00:26:27,279
know like the basically the galaxies

636
00:26:30,390 --> 00:26:28,159
there

637
00:26:31,909 --> 00:26:30,400
have more space which is you know like

638
00:26:35,110 --> 00:26:31,919

what happens if you go to the suburbs

639
00:26:39,669 --> 00:26:35,909
so

640
00:26:42,230 --> 00:26:39,679
in the in a in the center of a city

641
00:26:43,590 --> 00:26:42,240
because of the highest density of people

642
00:26:47,669 --> 00:26:43,600
you're gonna

643
00:26:49,350 --> 00:26:47,679
experience more interactions you're

644
00:26:50,789 --> 00:26:49,360
gonna talk to people

645
00:26:52,789 --> 00:26:50,799
you're gonna you know experience in

646
00:26:55,350 --> 00:26:52,799
general experience more encounters with

647
00:26:57,909 --> 00:26:55,360
with other people

648
00:26:59,190 --> 00:26:57,919
that is the same that happens uh with

649
00:27:03,909 --> 00:26:59,200
galaxies

650
00:27:06,230 --> 00:27:04,789
well

651
00:27:08,710 --> 00:27:06,240
apart from the you know like they are

652
00:27:10,070 --> 00:27:08,720
they don't talk they interact in in

653
00:27:11,350 --> 00:27:10,080
they interact with each other but in

654
00:27:15,190 --> 00:27:11,360
another way

655
00:27:16,870 --> 00:27:15,200
in this case uh the interaction that uh

656
00:27:17,909 --> 00:27:16,880
they experience is a gravitational

657
00:27:20,789 --> 00:27:17,919
interaction

658
00:27:23,029 --> 00:27:20,799
so i went two galaxies you know like uh

659
00:27:23,909 --> 00:27:23,039
pass by you know like they come very

660
00:27:25,750 --> 00:27:23,919
close

661
00:27:28,070 --> 00:27:25,760
the uh the

662
00:27:30,630 --> 00:27:28,080
you know the difference of like this

663
00:27:32,789 --> 00:27:30,640

difference of gravity think about like

664
00:27:34,630 --> 00:27:32,799
you know like you have like a chalk and

665
00:27:35,750 --> 00:27:34,640
you're like world writing in a

666
00:27:36,710 --> 00:27:35,760
blackboard

667
00:27:39,350 --> 00:27:36,720
so

668
00:27:41,590 --> 00:27:39,360
when when you you're writing you're

669
00:27:43,029 --> 00:27:41,600
you're liberating this this kind of task

670
00:27:46,389 --> 00:27:43,039
that is what

671
00:27:49,990 --> 00:27:48,389
is basically the word that you you have

672
00:27:53,190 --> 00:27:50,000
there so

673
00:27:55,269 --> 00:27:53,200
it's kind of the same with with um stars

674
00:27:56,710 --> 00:27:55,279
and galaxies so when

675
00:27:59,750 --> 00:27:56,720
they come together

676
00:28:02,470 --> 00:27:59,760
uh the stars of all these galaxies they

677
00:28:03,510 --> 00:28:02,480
they are stripped off their hosts

678
00:28:05,269 --> 00:28:03,520
and

679
00:28:07,510 --> 00:28:05,279
basically this interaction is kind of

680
00:28:09,909 --> 00:28:07,520
slowly breaking these galaxies

681
00:28:13,029 --> 00:28:09,919
so in the very center

682
00:28:15,029 --> 00:28:13,039
there there's normally a big galaxy and

683
00:28:16,470 --> 00:28:15,039
the starship from from

684
00:28:18,149 --> 00:28:16,480
from the others from the other galaxies

685
00:28:20,310 --> 00:28:18,159
that are around

686
00:28:22,789 --> 00:28:20,320
uh they

687
00:28:25,669 --> 00:28:22,799
they become deposited in that galaxy in

688
00:28:30,389 --> 00:28:25,679

the big galaxy and in its surroundings

689
00:28:32,149 --> 00:28:30,399
making this um galaxy grow over time

690
00:28:35,350 --> 00:28:32,159
so

691
00:28:38,070 --> 00:28:35,360
you know like an example this is um

692
00:28:40,710 --> 00:28:38,080
this is our nearest cluster this is the

693
00:28:42,230 --> 00:28:40,720
virgo cluster as you can see here there

694
00:28:46,230 --> 00:28:42,240
are like this

695
00:28:48,630 --> 00:28:46,240
ridges of stars this is uh tales of uh

696
00:28:51,029 --> 00:28:48,640
of stars

697
00:28:53,669 --> 00:28:51,039
and the space between the galaxies and

698
00:28:55,909 --> 00:28:53,679
the cluster it's not empty it's filled

699
00:28:57,909 --> 00:28:55,919
with all these um the stars that were

700
00:29:00,389 --> 00:28:57,919
stripped from this horse galaxy while

701
00:29:01,350 --> 00:29:00,399
they are kind of interacting with this

702
00:29:02,230 --> 00:29:01,360
uh

703
00:29:05,510 --> 00:29:02,240
bigger

704
00:29:07,990 --> 00:29:05,520
galaxy this is mh7

705
00:29:09,750 --> 00:29:08,000
so basically this big galaxy at the

706
00:29:12,549 --> 00:29:09,760
center behaves like a kind of like a

707
00:29:14,710 --> 00:29:12,559
hungry monster that will not stop eating

708
00:29:16,950 --> 00:29:14,720
till you know it liberates all the all

709
00:29:22,230 --> 00:29:16,960
the cookies or in this case it divides

710
00:29:31,350 --> 00:29:23,110
so

711
00:29:32,149 --> 00:29:31,360
these classes um is that you know like

712
00:29:38,070 --> 00:29:32,159
the

713
00:29:39,510 --> 00:29:38,080

orange

714
00:29:41,029 --> 00:29:39,520
but

715
00:29:43,990 --> 00:29:41,039
the galaxies when we look at the outer

716
00:29:46,470 --> 00:29:44,000
parts the the suburbs the galaxies are

717
00:29:48,149 --> 00:29:46,480
on average a little bit more

718
00:29:50,870 --> 00:29:48,159
they are not that yellow they are like a

719
00:29:51,830 --> 00:29:50,880
little bit more you know blue

720
00:29:54,870 --> 00:29:51,840
so

721
00:29:56,789 --> 00:29:54,880
there's like a mix of of

722
00:29:57,990 --> 00:29:56,799
colors of galaxies in in these outer

723
00:30:02,470 --> 00:29:58,000
parts

724
00:30:04,470 --> 00:30:02,480
interesting because uh this is the

725
00:30:07,190 --> 00:30:04,480
boundary between you know like the

726
00:30:11,029 --> 00:30:07,200
cluster this higher density regions of

727
00:30:13,029 --> 00:30:11,039
the cluster and the rest of the space so

728
00:30:15,510 --> 00:30:13,039
this is uh where the galaxies that are

729
00:30:17,590 --> 00:30:15,520
being eaten by the by the cluster travel

730
00:30:20,149 --> 00:30:17,600
to get to the center

731
00:30:22,389 --> 00:30:20,159
and this is where they experience this

732
00:30:23,350 --> 00:30:22,399
this change

733
00:30:26,070 --> 00:30:23,360
so

734
00:30:28,549 --> 00:30:26,080
one of the most astonishing examples of

735
00:30:30,310 --> 00:30:28,559
this you know of this process

736
00:30:35,190 --> 00:30:30,320
is

737
00:30:37,909 --> 00:30:35,200
you can see the galaxy here and you can

738
00:30:39,990 --> 00:30:37,919

see these tails of

739
00:30:42,789 --> 00:30:40,000
these very blue tails that are very very

740
00:30:48,149 --> 00:30:45,669
uh those are called jellyfish galaxies

741
00:30:51,909 --> 00:30:48,159
because they actually you know look like

742
00:30:55,590 --> 00:30:53,269
so while

743
00:30:57,269 --> 00:30:55,600
you know like in the in the

744
00:30:59,269 --> 00:30:57,279
in the interactions in the center you

745
00:31:00,870 --> 00:30:59,279
you can see you know like you can see

746
00:31:03,509 --> 00:31:00,880
what is happening you see which is the

747
00:31:06,310 --> 00:31:03,519
corporate the culprit that is destroying

748
00:31:08,630 --> 00:31:06,320
the the galaxies while they interact in

749
00:31:10,389 --> 00:31:08,640
this case there's nothing around that um

750
00:31:12,070 --> 00:31:10,399
can tell us you know

751
00:31:14,149 --> 00:31:12,080
that is creating

752
00:31:17,029 --> 00:31:14,159
these and that will

753
00:31:18,789 --> 00:31:17,039
um change like the shape of this of this

754
00:31:20,950 --> 00:31:18,799
galaxy

755
00:31:23,830 --> 00:31:20,960
and this is because we are not looking

756
00:31:27,110 --> 00:31:23,840
where we should be looking so

757
00:31:29,029 --> 00:31:27,120
the the images that we normally the that

758
00:31:31,909 --> 00:31:29,039
we normally see

759
00:31:33,430 --> 00:31:31,919
it's in the optical wavelengths is

760
00:31:36,710 --> 00:31:33,440
the wavelengths that

761
00:31:38,789 --> 00:31:36,720
your our eyes can see

762
00:31:42,070 --> 00:31:38,799
but this is like a really really tiny

763
00:31:44,789 --> 00:31:42,080

part of the electromagnetic spectrum

764
00:31:46,789 --> 00:31:44,799
uh let's see what happens if we change

765
00:31:49,590 --> 00:31:46,799
our glasses and we look in another part

766
00:31:53,190 --> 00:31:49,600
of of the of this spectrum

767
00:31:58,789 --> 00:31:53,200
if we look in for example in x-rays

768
00:32:00,710 --> 00:31:58,799
so this is our our cluster of l1689

769
00:32:02,470 --> 00:32:00,720
and this is in the indivisible this is

770
00:32:06,070 --> 00:32:02,480
the you know like what we can see you

771
00:32:09,750 --> 00:32:06,080
can see the star the stars the galaxies

772
00:32:11,190 --> 00:32:09,760
but this is how it looks when we see it

773
00:32:12,710 --> 00:32:11,200
in express

774
00:32:17,669 --> 00:32:12,720
it's looks

775
00:32:21,669 --> 00:32:19,909
so what is happening here what it's what

776
00:32:25,029 --> 00:32:21,679
is this

777
00:32:26,950 --> 00:32:25,039
so galaxy clusters are filled with

778
00:32:29,110 --> 00:32:26,960
large quantities of gas

779
00:32:32,549 --> 00:32:29,120
that is really really hot it's so hot

780
00:32:34,470 --> 00:32:32,559
that it makes emits in inequities

781
00:32:36,710 --> 00:32:34,480
and it's the interaction with this hot

782
00:32:38,470 --> 00:32:36,720
gas that is causing the tails of the of

783
00:32:40,310 --> 00:32:38,480
the star formation in the in the

784
00:32:42,710 --> 00:32:40,320
jellyfish galaxy the galaxy that was

785
00:32:44,549 --> 00:32:42,720
we've seen before

786
00:32:46,870 --> 00:32:44,559
so it's kind of having like an

787
00:32:48,310 --> 00:32:46,880
underground party scene in the city so

788
00:32:50,310 --> 00:32:48,320

you hear the music but you cannot

789
00:32:52,789 --> 00:32:50,320
actually see the people dancing

790
00:32:54,470 --> 00:32:52,799
well okay i understand that this analogy

791
00:32:55,990 --> 00:32:54,480
might be a little bit forced but you

792
00:32:57,029 --> 00:32:56,000
know like i hope that you can forgive me

793
00:32:59,350 --> 00:32:57,039
this one

794
00:33:01,110 --> 00:32:59,360
and you can kind of understand what what

795
00:33:01,830 --> 00:33:01,120
i'm saying here

796
00:33:05,190 --> 00:33:01,840
so

797
00:33:07,750 --> 00:33:05,200
galaxies have gas which is in this case

798
00:33:09,509 --> 00:33:07,760
it's called gas which is the fuel to

799
00:33:10,950 --> 00:33:09,519
form stars

800
00:33:13,029 --> 00:33:10,960
when they enter the cluster they are

801
00:33:15,430 --> 00:33:13,039
welcomed by this this hot gas of the

802
00:33:17,350 --> 00:33:15,440
glasses so imagine like you know like

803
00:33:19,430 --> 00:33:17,360
when you turn around a corner and

804
00:33:22,149 --> 00:33:19,440
there's like this strong wing that you

805
00:33:24,549 --> 00:33:22,159
know like just like hits in your face

806
00:33:27,750 --> 00:33:24,559
uh it messes your hair you know like it

807
00:33:30,870 --> 00:33:27,760
just gives you your hair you know like

808
00:33:33,269 --> 00:33:30,880
back and message of her and this is not

809
00:33:35,110 --> 00:33:33,279
not in your hair so this is what is

810
00:33:36,149 --> 00:33:35,120
happening to this galaxy so it's

811
00:33:38,230 --> 00:33:36,159
basically

812
00:33:40,710 --> 00:33:38,240
it's traveling through space it hits

813
00:33:43,669 --> 00:33:40,720

this this this gas

814
00:33:45,590 --> 00:33:43,679
and uh it has not in this case not so

815
00:33:48,310 --> 00:33:45,600
star formation

816
00:33:49,590 --> 00:33:48,320
so that's the jellyfish galaxy that we

817
00:33:51,509 --> 00:33:49,600
saw before

818
00:33:53,990 --> 00:33:51,519
and uh this

819
00:33:55,269 --> 00:33:54,000
in this case this um blue light over

820
00:33:57,029 --> 00:33:55,279
here is

821
00:33:59,750 --> 00:33:57,039
what is uh

822
00:34:03,909 --> 00:33:59,760
what we see in x-rays

823
00:34:06,230 --> 00:34:03,919
so these x-rays are they are basically

824
00:34:08,710 --> 00:34:06,240
uh the the gas that is being removed

825
00:34:11,109 --> 00:34:08,720
from the from the galaxy while it's uh

826
00:34:15,510 --> 00:34:11,119
you know um

827
00:34:16,629 --> 00:34:15,520
forming on making these these new stars

828
00:34:18,950 --> 00:34:16,639
so and

829
00:34:20,470 --> 00:34:18,960
that is why the galaxies in the inner

830
00:34:22,230 --> 00:34:20,480
parts look rather

831
00:34:23,990 --> 00:34:22,240
there is not a lot of star formation

832
00:34:24,869 --> 00:34:24,000
going on because

833
00:34:30,310 --> 00:34:24,879
the

834
00:34:31,109 --> 00:34:30,320
because this hot gas

835
00:34:33,349 --> 00:34:31,119
is

836
00:34:35,909 --> 00:34:33,359
um it's very good at removing most of

837
00:34:38,389 --> 00:34:35,919
the fuel that forms the stars

838
00:34:39,349 --> 00:34:38,399

in in galaxies

839
00:34:40,869 --> 00:34:39,359
so

840
00:34:43,669 --> 00:34:40,879
although

841
00:34:45,909 --> 00:34:43,679
this gas is not very dense it is very

842
00:34:50,470 --> 00:34:45,919
important in classes of galaxies

843
00:34:53,030 --> 00:34:50,480
in fact most of the mass in clusters

844
00:34:55,430 --> 00:34:53,040
in clusters is in this gas

845
00:34:57,270 --> 00:34:55,440
and i say mass quote-unquote because

846
00:34:59,589 --> 00:34:57,280
there's something else in clusters of

847
00:35:00,550 --> 00:34:59,599
galaxies

848
00:35:01,589 --> 00:35:00,560
okay

849
00:35:04,069 --> 00:35:01,599
let's go

850
00:35:09,030 --> 00:35:04,079
back a little bit back in time

851
00:35:10,870 --> 00:35:09,040
uh to 1933. so in 1933 this guy

852
00:35:11,829 --> 00:35:10,880
alfred zwicky you know with the nice

853
00:35:14,630 --> 00:35:11,839
picture

854
00:35:16,550 --> 00:35:14,640
was measuring the velocities of the

855
00:35:18,790 --> 00:35:16,560
galaxies in this cluster the coma

856
00:35:21,670 --> 00:35:18,800
cluster

857
00:35:23,430 --> 00:35:21,680
so he well he was measuring the you know

858
00:35:26,630 --> 00:35:23,440
like he was measuring the velocities of

859
00:35:28,790 --> 00:35:26,640
the stars um and he found that those

860
00:35:31,910 --> 00:35:28,800
velocities were too high for the cluster

861
00:35:32,790 --> 00:35:31,920
to remain like a cluster

862
00:35:34,710 --> 00:35:32,800
so

863
00:35:37,430 --> 00:35:34,720

with the observed velocities

864
00:35:39,910 --> 00:35:37,440
the galaxies would have escaped

865
00:35:42,069 --> 00:35:39,920
if the if the mass that is in there it's

866
00:35:44,470 --> 00:35:42,079
the the the mass that we see the mass in

867
00:35:46,790 --> 00:35:44,480
stars

868
00:35:48,230 --> 00:35:46,800
and that is what he wrote in his

869
00:35:49,190 --> 00:35:48,240
original paper

870
00:35:51,430 --> 00:35:49,200
um

871
00:35:53,349 --> 00:35:51,440
he wrote this and if you know you know

872
00:35:55,030 --> 00:35:53,359
like you have like the same level level

873
00:35:57,030 --> 00:35:55,040
of german that i do which is basically

874
00:35:59,109 --> 00:35:57,040
zero you might appreciate that i include

875
00:36:00,870 --> 00:35:59,119
the translation and here there are two

876
00:36:02,870 --> 00:36:00,880
things that i want to

877
00:36:05,510 --> 00:36:02,880
emphasize so i want to highlight

878
00:36:07,910 --> 00:36:05,520
this is first is the this word level

879
00:36:08,630 --> 00:36:07,920
that's it's the german word for nebula

880
00:36:12,630 --> 00:36:08,640
so

881
00:36:16,230 --> 00:36:12,640
in 1933 1933

882
00:36:18,470 --> 00:36:16,240
we're we were still calling uh

883
00:36:20,550 --> 00:36:18,480
galaxies nebula

884
00:36:22,390 --> 00:36:20,560
which is it's not very important but you

885
00:36:24,550 --> 00:36:22,400
know like i find it funny and i wanted

886
00:36:29,750 --> 00:36:24,560
to share this with you

887
00:36:35,670 --> 00:36:30,550
so

888
00:36:37,030 --> 00:36:35,680

cluster to to be together to be like a

889
00:36:39,030 --> 00:36:37,040
cluster

890
00:36:42,150 --> 00:36:39,040
uh there should be more matter than what

891
00:36:46,950 --> 00:36:44,470
so basically to explain why the cluster

892
00:36:48,630 --> 00:36:46,960
is together uh it is necessary to have

893
00:36:52,310 --> 00:36:48,640
like around like a hundred times more

894
00:36:57,349 --> 00:36:54,150
but wait uh haven't i told you that

895
00:36:59,270 --> 00:36:57,359
there's like this hot gas and that you

896
00:37:02,550 --> 00:36:59,280
know like it's you know there's more

897
00:37:04,069 --> 00:37:02,560
mass in this hot gas than mass in stars

898
00:37:05,349 --> 00:37:04,079
yes that is

899
00:37:08,550 --> 00:37:05,359
that is correct

900
00:37:11,190 --> 00:37:08,560
but uh it is um the gas is only 10 times

901
00:37:13,990 --> 00:37:11,200
the mass in in stars it still cannot

902
00:37:15,349 --> 00:37:14,000
account for all these other mass that we

903
00:37:20,230 --> 00:37:15,359
need

904
00:37:21,190 --> 00:37:20,240
and if something else is uh that is what

905
00:37:24,230 --> 00:37:21,200
we call

906
00:37:27,750 --> 00:37:24,240
dharma so

907
00:37:28,870 --> 00:37:27,760
the stars the gas and basically us

908
00:37:31,430 --> 00:37:28,880
is

909
00:37:33,910 --> 00:37:31,440
what we call you know normal normal it's

910
00:37:36,630 --> 00:37:33,920
basically normal matter which is what we

911
00:37:39,990 --> 00:37:36,640
call baronic map

912
00:37:41,589 --> 00:37:40,000
but dark matter is not burning matter we

913
00:37:44,310 --> 00:37:41,599

we don't know what it is but we know

914
00:37:46,470 --> 00:37:44,320
that it's not our you know like this

915
00:37:48,550 --> 00:37:46,480
normal matter that we are made

916
00:37:50,870 --> 00:37:48,560
of

917
00:37:52,790 --> 00:37:50,880
so

918
00:37:55,270 --> 00:37:52,800
the problem here is that we don't know

919
00:37:57,910 --> 00:37:55,280
um we don't know what it is and our

920
00:37:59,109 --> 00:37:57,920
matter is uh does not emit so we cannot

921
00:38:00,550 --> 00:37:59,119
observe

922
00:38:02,470 --> 00:38:00,560
the only way that we know that it's

923
00:38:04,550 --> 00:38:02,480
there is uh by how the things that they

924
00:38:06,630 --> 00:38:04,560
meet the galaxies

925
00:38:09,109 --> 00:38:06,640
behave

926
00:38:10,630 --> 00:38:09,119
for example the um in this case it was

927
00:38:12,230 --> 00:38:10,640
the velocity of the galaxies that

928
00:38:13,510 --> 00:38:12,240
indicate that there was more mass in the

929
00:38:16,470 --> 00:38:13,520
cluster

930
00:38:17,670 --> 00:38:16,480
than uh than you know like what we could

931
00:38:20,950 --> 00:38:17,680
see

932
00:38:24,230 --> 00:38:20,960
but there's there are other ways uh to

933
00:38:25,109 --> 00:38:24,240
you know like to kind of see this dharma

934
00:38:26,950 --> 00:38:25,119
uh

935
00:38:29,109 --> 00:38:26,960
another way is what we call

936
00:38:30,470 --> 00:38:29,119
gravitational lens

937
00:38:31,670 --> 00:38:30,480
so um

938
00:38:33,349 --> 00:38:31,680

if you have a

939
00:38:35,109 --> 00:38:33,359
huge mass

940
00:38:37,750 --> 00:38:35,119
the gravitational field that is created

941
00:38:40,550 --> 00:38:37,760
by this huge mass distorts and magnifies

942
00:38:42,550 --> 00:38:40,560
the light from the galaxies that are

943
00:38:44,710 --> 00:38:42,560
i don't have anything you know you have

944
00:38:46,950 --> 00:38:44,720
like this mass and it distorts and

945
00:38:49,589 --> 00:38:46,960
magnifies the light from the galaxies

946
00:38:52,069 --> 00:38:49,599
that are behind the cluster so we are

947
00:38:54,150 --> 00:38:52,079
here some somewhere here

948
00:38:54,950 --> 00:38:54,160
and um

949
00:38:57,190 --> 00:38:54,960
so

950
00:38:58,630 --> 00:38:57,200
um basically

951
00:39:00,310 --> 00:38:58,640
um

952
00:39:05,109 --> 00:39:00,320
this

953
00:39:08,550 --> 00:39:05,119
of mass which is our cluster it allows

954
00:39:11,030 --> 00:39:08,560
us to um to see things that are behind

955
00:39:13,190 --> 00:39:11,040
which would we could have not

956
00:39:15,349 --> 00:39:13,200
seen if there was not

957
00:39:17,750 --> 00:39:15,359
this effect happening

958
00:39:20,390 --> 00:39:17,760
so basically those the classes are

959
00:39:22,470 --> 00:39:20,400
acting as telescopes for our

960
00:39:24,150 --> 00:39:22,480
telescopes

961
00:39:27,750 --> 00:39:24,160
so we can

962
00:39:28,390 --> 00:39:27,760
see and explore the the far universe

963
00:39:30,870 --> 00:39:28,400

so

964
00:39:33,349 --> 00:39:30,880
when jus you look at an image of a

965
00:39:35,349 --> 00:39:33,359
cluster like this one you see all these

966
00:39:37,510 --> 00:39:35,359
arcs you know here

967
00:39:39,829 --> 00:39:37,520
here here here you know this image is

968
00:39:41,270 --> 00:39:39,839
amazing you have all the all the arcs

969
00:39:45,349 --> 00:39:41,280
that you can

970
00:39:47,589 --> 00:39:45,359
this is the cluster level 370 is one of

971
00:39:49,670 --> 00:39:47,599
the frontier spills plasters if you want

972
00:39:50,390 --> 00:39:49,680
to know

973
00:39:51,510 --> 00:39:50,400
so

974
00:39:54,710 --> 00:39:51,520
um

975
00:39:57,109 --> 00:39:54,720
those those arcs these things are not uh

976
00:40:00,069 --> 00:39:57,119
part of the glasses they are behind the

977
00:40:01,750 --> 00:40:00,079
cluster so and the only way that uh we

978
00:40:04,470 --> 00:40:01,760
could see it is by this effective

979
00:40:09,030 --> 00:40:07,589
so what gravitational lensing does is

980
00:40:12,390 --> 00:40:09,040
telling us

981
00:40:13,670 --> 00:40:12,400
how the matter distributes in clusters

982
00:40:15,829 --> 00:40:13,680
so

983
00:40:18,150 --> 00:40:15,839
again we have our our favorite cluster

984
00:40:20,630 --> 00:40:18,160
avail 1689

985
00:40:23,510 --> 00:40:20,640
and uh let's let's pretend that we can

986
00:40:25,990 --> 00:40:23,520
have like a way of seeing this matter

987
00:40:28,550 --> 00:40:26,000
and this is how it looks

988
00:40:29,750 --> 00:40:28,560

in you know like this blue you know

989
00:40:32,230 --> 00:40:29,760
purple light

990
00:40:34,790 --> 00:40:32,240
it's the it's how the the

991
00:40:36,710 --> 00:40:34,800
the matter of the cluster is how the

992
00:40:39,589 --> 00:40:36,720
the the total matter of the the cluster

993
00:40:41,670 --> 00:40:39,599
distributes

994
00:40:44,550 --> 00:40:41,680
so and you can you can see here that

995
00:40:47,750 --> 00:40:44,560
it's very different of the you know like

996
00:40:50,069 --> 00:40:47,760
how how the the hot gas was

997
00:40:51,109 --> 00:40:50,079
distributed

998
00:40:54,230 --> 00:40:51,119
so

999
00:40:55,750 --> 00:40:54,240
um galaxy clusters and and you know like

1000
00:40:58,710 --> 00:40:55,760
this this technique the gravitational

1001
00:41:00,870 --> 00:40:58,720
lensing has uh provided the strongest

1002
00:41:04,390 --> 00:41:00,880
evidence for the existence of this

1003
00:41:06,470 --> 00:41:04,400
mysterious uh their mother thing

1004
00:41:09,270 --> 00:41:06,480
and the evidence is given by this

1005
00:41:11,910 --> 00:41:09,280
cluster which is the the bullet cluster

1006
00:41:13,910 --> 00:41:11,920
so there are actually two clusters that

1007
00:41:16,069 --> 00:41:13,920
have collided

1008
00:41:18,309 --> 00:41:16,079
and this is not the kind of uh collision

1009
00:41:20,790 --> 00:41:18,319
that you would imagine this is you know

1010
00:41:22,870 --> 00:41:20,800
like it's a cosmic collision this is

1011
00:41:24,069 --> 00:41:22,880
very different so

1012
00:41:29,190 --> 00:41:24,079
in

1013
00:41:32,150 --> 00:41:29,200

is where the most of the mass is that is

1014
00:41:35,270 --> 00:41:32,160
given by the gravitational lensing

1015
00:41:38,470 --> 00:41:35,280
and the the pink is the the hotcast is

1016
00:41:41,349 --> 00:41:38,480
the the it's basically um the the

1017
00:41:43,990 --> 00:41:41,359
cluster in x-rays

1018
00:41:48,710 --> 00:41:46,470
so and you can see here these are the

1019
00:41:51,589 --> 00:41:48,720
the galaxies of the two clusters and you

1020
00:41:53,430 --> 00:41:51,599
can see that uh they've uh they were not

1021
00:41:55,589 --> 00:41:53,440
affected by the collision they just went

1022
00:41:58,870 --> 00:41:55,599
like passing through

1023
00:41:59,990 --> 00:41:58,880
uh but the gas has

1024
00:42:01,589 --> 00:42:00,000
is it's

1025
00:42:03,589 --> 00:42:01,599
has been affected by the collision

1026
00:42:05,510 --> 00:42:03,599
instead of like follow being here where

1027
00:42:07,190 --> 00:42:05,520
the galaxy is

1028
00:42:11,670 --> 00:42:07,200
it has

1029
00:42:14,630 --> 00:42:13,270
so um

1030
00:42:18,710 --> 00:42:14,640
that is

1031
00:42:22,390 --> 00:42:18,720
you know like this in this

1032
00:42:23,990 --> 00:42:22,400
that um there's more mass than what we

1033
00:42:27,030 --> 00:42:24,000
can see because

1034
00:42:29,670 --> 00:42:27,040
if the only mass in the cluster was the

1035
00:42:32,550 --> 00:42:29,680
the stars of the galaxies and the and

1036
00:42:37,270 --> 00:42:34,790
the the galaxies instead of being over

1037
00:42:39,510 --> 00:42:37,280
here they will have followed the gas

1038
00:42:41,430 --> 00:42:39,520

because it's where the most of the mass

1039
00:42:44,230 --> 00:42:41,440
is and it's what you know like it just

1040
00:42:45,910 --> 00:42:44,240
creates this gravitational potential

1041
00:42:48,470 --> 00:42:45,920
that is where you know like galaxies

1042
00:42:51,670 --> 00:42:48,480
like to to be

1043
00:42:53,670 --> 00:42:51,680
but instead in here you have that most

1044
00:42:56,710 --> 00:42:53,680
of the masses over here in this blue

1045
00:42:58,390 --> 00:42:56,720
part and over here in this blue part so

1046
00:43:00,630 --> 00:42:58,400
this is telling us that there's

1047
00:43:04,710 --> 00:43:00,640
something else that's um we have more

1048
00:43:06,309 --> 00:43:04,720
mass and this this mass is what

1049
00:43:08,870 --> 00:43:06,319
we call

1050
00:43:11,829 --> 00:43:09,589
so

1051
00:43:14,790 --> 00:43:11,839
we have all the all the pieces together

1052
00:43:17,190 --> 00:43:14,800
to form our uh cluster our cluster of

1053
00:43:19,670 --> 00:43:17,200
galaxies we have the hot gas we have the

1054
00:43:22,470 --> 00:43:19,680
galaxies and we have the dharma which i

1055
00:43:24,870 --> 00:43:22,480
you know like i painted it in blue so

1056
00:43:27,349 --> 00:43:24,880
you can actually see something

1057
00:43:29,109 --> 00:43:27,359
um so

1058
00:43:30,950 --> 00:43:29,119
um

1059
00:43:33,589 --> 00:43:30,960
the gas accounts for like nine percent

1060
00:43:35,030 --> 00:43:33,599
of the total mass of the of the cluster

1061
00:43:37,190 --> 00:43:35,040
well the galaxies the stars and the

1062
00:43:39,670 --> 00:43:37,200
galaxies account for like around like

1063
00:43:43,349 --> 00:43:39,680

less sometimes less and around like one

1064
00:43:46,309 --> 00:43:43,359
percent of the total mass of the cluster

1065
00:43:49,270 --> 00:43:46,319
but the dark matter which is the the

1066
00:43:51,510 --> 00:43:49,280
component that dominates its 90 percent

1067
00:43:52,550 --> 00:43:51,520
of the total mass of the glass so it's a

1068
00:43:54,870 --> 00:43:52,560
lot of

1069
00:43:57,190 --> 00:43:54,880
thermal in there

1070
00:44:01,030 --> 00:43:58,950
what are the masses that we are talking

1071
00:44:03,750 --> 00:44:01,040
about so we are talking about like 10 to

1072
00:44:05,430 --> 00:44:03,760
the 14 10 to the 15

1073
00:44:08,470 --> 00:44:05,440
solar masses which is basically 10 to

1074
00:44:11,750 --> 00:44:08,480
the 14 10 to the 15 cents which is

1075
00:44:14,390 --> 00:44:11,760
basically one a one followed by 15 zeros

1076
00:44:17,829 --> 00:44:14,400
and i'm not sure if you can

1077
00:44:20,790 --> 00:44:17,839
imagine that but i i certainly cannot

1078
00:44:22,630 --> 00:44:20,800
and if it helps it should be like around

1079
00:44:24,870 --> 00:44:22,640
like one thousand milky ways i'm not

1080
00:44:26,470 --> 00:44:24,880
sure if that helps but

1081
00:44:27,510 --> 00:44:26,480
just in case

1082
00:44:29,910 --> 00:44:27,520
so

1083
00:44:31,829 --> 00:44:29,920
with that mass with this very very high

1084
00:44:34,150 --> 00:44:31,839
mass and the fact that we've seen that

1085
00:44:35,190 --> 00:44:34,160
they are held together by you know my

1086
00:44:38,150 --> 00:44:35,200
gravity

1087
00:44:39,829 --> 00:44:38,160
makes galaxy glasses the largest uh

1088
00:44:43,510 --> 00:44:39,839

the largest structures in the universe

1089
00:44:45,109 --> 00:44:43,520
that are held together by gravity

1090
00:44:47,589 --> 00:44:45,119
but and this is very important because

1091
00:44:49,030 --> 00:44:47,599
there are structures that are larger but

1092
00:44:52,309 --> 00:44:49,040
they are not

1093
00:44:55,109 --> 00:44:52,319
together by the the

1094
00:44:57,270 --> 00:44:55,119
gravitational potential so you know they

1095
00:44:58,390 --> 00:44:57,280
are kind of less less interesting

1096
00:45:01,190 --> 00:44:58,400
just kidding

1097
00:45:05,109 --> 00:45:01,200
it's they are less interesting

1098
00:45:07,910 --> 00:45:05,119
so how do you form these structures

1099
00:45:09,589 --> 00:45:07,920
so by observing the past and the present

1100
00:45:11,349 --> 00:45:09,599
uh how they look in the past and how

1101
00:45:14,950 --> 00:45:11,359
they look now

1102
00:45:16,630 --> 00:45:14,960
we can deduce how they form

1103
00:45:18,309 --> 00:45:16,640
in the same way that you build a lego

1104
00:45:20,870 --> 00:45:18,319
toy by you know like by you know like

1105
00:45:21,750 --> 00:45:20,880
tiny bricks uh putting together tiny

1106
00:45:25,270 --> 00:45:21,760
bricks

1107
00:45:27,349 --> 00:45:25,280
clusters grow by adding small systems in

1108
00:45:29,270 --> 00:45:27,359
in this case galaxies or groups of

1109
00:45:32,630 --> 00:45:29,280
galaxies so

1110
00:45:34,470 --> 00:45:32,640
i'm gonna show you now a simulation that

1111
00:45:36,790 --> 00:45:34,480
um that's

1112
00:45:38,950 --> 00:45:36,800
that's an example of how this this um

1113
00:45:41,349 --> 00:45:38,960

this process uh how we think that this

1114
00:45:42,230 --> 00:45:41,359
process um

1115
00:45:44,710 --> 00:45:42,240
if

1116
00:45:46,069 --> 00:45:44,720
it's happening

1117
00:45:47,910 --> 00:45:46,079
and you can see like there are like

1118
00:45:49,430 --> 00:45:47,920
these two clusters and they will they

1119
00:45:51,030 --> 00:45:49,440
will you know like they will come

1120
00:45:54,230 --> 00:45:51,040
together they will merge they will

1121
00:45:57,349 --> 00:45:54,240
create like a like a very big cluster

1122
00:45:59,910 --> 00:45:57,359
um and also you will see that the the

1123
00:46:02,150 --> 00:45:59,920
galaxies uh how the galaxies in the

1124
00:46:04,230 --> 00:46:02,160
cluster they interact and they interact

1125
00:46:05,510 --> 00:46:04,240
they they lose the stars and they start

1126
00:46:08,230 --> 00:46:05,520
and

1127
00:46:10,309 --> 00:46:08,240
end up uh forming

1128
00:46:13,670 --> 00:46:10,319
and that ends up forming like a big

1129
00:46:17,430 --> 00:46:13,680
galaxy and um

1130
00:46:21,829 --> 00:46:17,440
you know like a big cluster ninja

1131
00:46:26,390 --> 00:46:24,069
that's a little bit here

1132
00:46:29,750 --> 00:46:26,400
this is um what we think that will

1133
00:46:30,710 --> 00:46:29,760
happen at the end stage of a cluster

1134
00:46:33,510 --> 00:46:30,720
having like

1135
00:46:35,990 --> 00:46:33,520
this very big galaxy sitting in the

1136
00:46:38,550 --> 00:46:36,000
center and these very like basically

1137
00:46:41,430 --> 00:46:38,560
huge clusters this is the illustrious

1138
00:46:42,950 --> 00:46:41,440

tng 50 simulation

1139
00:46:45,430 --> 00:46:42,960
just in case

1140
00:46:49,030 --> 00:46:45,440
you want to know

1141
00:46:51,190 --> 00:46:49,040
so the first stages of these classes is

1142
00:46:52,950 --> 00:46:51,200
uh basically like kind of like a baby

1143
00:46:55,430 --> 00:46:52,960
cluster uh it's what we call

1144
00:46:58,630 --> 00:46:55,440
protoclasses although i i think that i

1145
00:47:01,190 --> 00:46:58,640
like more baby clusters

1146
00:47:03,349 --> 00:47:01,200
these protoclasters all important clues

1147
00:47:04,870 --> 00:47:03,359
about the details of

1148
00:47:07,030 --> 00:47:04,880
the diesels of the growth of these

1149
00:47:08,710 --> 00:47:07,040
structures

1150
00:47:11,829 --> 00:47:08,720
as you can see here this is one example

1151
00:47:14,150 --> 00:47:11,839
of a protocluster that is being observed

1152
00:47:15,750 --> 00:47:14,160
and uh

1153
00:47:17,030 --> 00:47:15,760
you can see here that it doesn't look

1154
00:47:26,309 --> 00:47:17,040
like

1155
00:47:29,190 --> 00:47:26,319
over the place but i can assure you that

1156
00:47:32,309 --> 00:47:29,200
this is a proto cluster

1157
00:47:34,549 --> 00:47:32,319
so uh well we have had like success

1158
00:47:38,549 --> 00:47:34,559
finding these proton classes

1159
00:47:40,470 --> 00:47:38,559
uh with our new and now shiny uh

1160
00:47:42,630 --> 00:47:40,480
jwst

1161
00:47:45,349 --> 00:47:42,640
it will be possible to discover more of

1162
00:47:49,109 --> 00:47:45,359
them so you know with more um more

1163
00:47:52,470 --> 00:47:49,119

clusters uh our knowledge will be much

1164
00:47:55,670 --> 00:47:52,480
much better of what is happening in this

1165
00:47:57,190 --> 00:47:55,680
um in in the formation of clusters

1166
00:47:59,589 --> 00:47:57,200
and um

1167
00:48:01,190 --> 00:47:59,599
james webb it's especially suited uh to

1168
00:48:02,470 --> 00:48:01,200
discover uh

1169
00:48:04,390 --> 00:48:02,480
these things because they are like you

1170
00:48:07,829 --> 00:48:04,400
know like they're uh high retrieved they

1171
00:48:09,750 --> 00:48:07,839
are very far away the the light um

1172
00:48:12,790 --> 00:48:09,760
basically they are meeting in the in the

1173
00:48:14,470 --> 00:48:12,800
infrared wavelengths so um there's web

1174
00:48:16,790 --> 00:48:14,480
being a telescope that observes in the

1175
00:48:18,790 --> 00:48:16,800
infrared it's just

1176
00:48:21,510 --> 00:48:18,800
the best telescope that we can imagine

1177
00:48:23,430 --> 00:48:21,520
for this so

1178
00:48:24,790 --> 00:48:23,440
we are looking forward to

1179
00:48:32,549 --> 00:48:24,800
to

1180
00:48:34,790 --> 00:48:32,559
discover more and more uh

1181
00:48:36,230 --> 00:48:34,800
baby clusters

1182
00:48:40,710 --> 00:48:36,240
so

1183
00:48:43,190 --> 00:48:40,720
the idea that galaxy clusters are the

1184
00:48:44,950 --> 00:48:43,200
are some of the well for me is the most

1185
00:48:47,030 --> 00:48:44,960
uh fascinating objects in the universe

1186
00:48:48,390 --> 00:48:47,040
but i know that my friends will will

1187
00:48:49,670 --> 00:48:48,400
will shout at me

1188
00:48:52,630 --> 00:48:49,680

so there are some of the most

1189
00:48:55,270 --> 00:48:52,640
fascinating objects in the universe

1190
00:48:56,470 --> 00:48:55,280
and from them uh therefore by stars for

1191
00:48:58,549 --> 00:48:56,480
gas and by

1192
00:49:00,630 --> 00:48:58,559
uh dark matter

1193
00:49:05,430 --> 00:49:00,640
we can learn a lot

1194
00:49:07,910 --> 00:49:05,440
gravity about dark matter and about

1195
00:49:11,349 --> 00:49:07,920
normal matters so

1196
00:49:13,990 --> 00:49:11,359
um yeah there are like the best things

1197
00:49:16,390 --> 00:49:14,000
in the universe so thank you very much

1198
00:49:21,109 --> 00:49:16,400
uh you know like please uh ask any

1199
00:49:27,349 --> 00:49:24,230
all right thank you very much maria that

1200
00:49:28,829 --> 00:49:27,359
was a nice exploration of uh these

1201
00:49:30,549 --> 00:49:28,839
really large

1202
00:49:32,950 --> 00:49:30,559
um uh

1203
00:49:34,549 --> 00:49:32,960
entities in the universe that uh you

1204
00:49:36,630 --> 00:49:34,559
know i guess

1205
00:49:38,710 --> 00:49:36,640
since most people just uh recognize that

1206
00:49:41,030 --> 00:49:38,720
we are in the milky way galaxy if they

1207
00:49:43,349 --> 00:49:41,040
recognize we're in a galaxy

1208
00:49:45,430 --> 00:49:43,359
they really don't um they don't get much

1209
00:49:47,670 --> 00:49:45,440
exposure to these these giant clusters

1210
00:49:49,349 --> 00:49:47,680
out there do they

1211
00:49:52,549 --> 00:49:49,359
i mean we have like you know like these

1212
00:49:54,790 --> 00:49:52,559
very nice images that um

1213
00:49:56,150 --> 00:49:54,800

like the ones that i show

1214
00:49:58,390 --> 00:49:56,160
that um

1215
00:50:00,230 --> 00:49:58,400
they're like really really striking

1216
00:50:02,630 --> 00:50:00,240
right they're very fascinating in when

1217
00:50:05,349 --> 00:50:02,640
you see the images but i don't think

1218
00:50:07,670 --> 00:50:05,359
that we know a lot about the science

1219
00:50:09,589 --> 00:50:07,680
that it's going on in them

1220
00:50:11,109 --> 00:50:09,599
i think that they're you know like the

1221
00:50:13,349 --> 00:50:11,119
science the things that we can learn

1222
00:50:14,710 --> 00:50:13,359
from them are such you know like this is

1223
00:50:15,430 --> 00:50:14,720
fascinating

1224
00:50:17,270 --> 00:50:15,440
so

1225
00:50:18,150 --> 00:50:17,280
one of the questions that people have is

1226
00:50:19,670 --> 00:50:18,160
um

1227
00:50:22,630 --> 00:50:19,680
our milky way

1228
00:50:25,190 --> 00:50:22,640
is it part of a big city is it uh part

1229
00:50:27,910 --> 00:50:25,200
of the suburbs is it out in this remote

1230
00:50:29,750 --> 00:50:27,920
village on the edge of nowhere

1231
00:50:33,109 --> 00:50:29,760
what's what's the milky way status here

1232
00:50:36,630 --> 00:50:33,119
so we would i don't know like if i have

1233
00:50:39,589 --> 00:50:36,640
like the perfect analogy for for uh the

1234
00:50:42,069 --> 00:50:39,599
our milky way because um our milky way

1235
00:50:44,390 --> 00:50:42,079
lives in uh in a group of galaxies but

1236
00:50:47,349 --> 00:50:44,400
it's like a very very you know like it's

1237
00:50:49,109 --> 00:50:47,359
very small group it's a it's a

1238
00:50:50,309 --> 00:50:49,119

they call it poor group so it's

1239
00:50:52,549 --> 00:50:50,319
basically

1240
00:50:54,710 --> 00:50:52,559
the milky way the andromeda galaxy which

1241
00:50:58,549 --> 00:50:54,720
is uh another

1242
00:51:01,270 --> 00:50:58,559
big spiral galaxy and it just

1243
00:51:03,589 --> 00:51:01,280
satellites so there's not a lot of

1244
00:51:06,150 --> 00:51:03,599
galaxies in this this small group

1245
00:51:08,309 --> 00:51:06,160
okay so our milky way is like a town or

1246
00:51:09,670 --> 00:51:08,319
something like that you know me you know

1247
00:51:12,470 --> 00:51:09,680
or something yeah it's like

1248
00:51:14,790 --> 00:51:12,480
you know very tiny town

1249
00:51:17,349 --> 00:51:14,800
maybe a village all right so how far

1250
00:51:19,670 --> 00:51:17,359
away is the big city from us i mean if

1251
00:51:21,750 --> 00:51:19,680
we're uh how far uh you know are we

1252
00:51:23,030 --> 00:51:21,760
really country bumpkins and uh we need

1253
00:51:24,790 --> 00:51:23,040
how far do we have to travel to get to

1254
00:51:27,030 --> 00:51:24,800
the big city

1255
00:51:29,190 --> 00:51:27,040
we are talking about billions of like

1256
00:51:30,710 --> 00:51:29,200
years so it's

1257
00:51:34,790 --> 00:51:30,720
don't think that we can get into the

1258
00:51:39,430 --> 00:51:37,190
but i guess we would consider uh virgo

1259
00:51:41,510 --> 00:51:39,440
as sort of like the nearest big city yes

1260
00:51:44,230 --> 00:51:41,520
yes we're going to the nearest big city

1261
00:51:45,270 --> 00:51:44,240
and that's and still uh virgo it's not

1262
00:51:50,870 --> 00:51:45,280
like a

1263
00:51:53,270 --> 00:51:50,880

know the small smallest city there are

1264
00:51:54,710 --> 00:51:53,280
clusters out there you know like like

1265
00:51:56,309 --> 00:51:54,720
the one that i uh

1266
00:51:59,030 --> 00:51:56,319
have been showing

1267
00:51:59,990 --> 00:51:59,040
those those gala those galaxy glasses

1268
00:52:01,910 --> 00:52:00,000
are

1269
00:52:05,190 --> 00:52:01,920
i don't know like i don't know

1270
00:52:06,390 --> 00:52:05,200
mexico new york mexico the f uh sydney

1271
00:52:08,790 --> 00:52:06,400
you know they're

1272
00:52:10,390 --> 00:52:08,800
the biggest cities we've got right

1273
00:52:13,270 --> 00:52:10,400
yeah the frontier fields clusters are

1274
00:52:14,470 --> 00:52:13,280
always the french clusters those are the

1275
00:52:17,190 --> 00:52:14,480
biggest ones the ones that produce

1276
00:52:18,710 --> 00:52:17,200
gravitational lensing whereas some like

1277
00:52:20,870 --> 00:52:18,720
virgo you're saying that might be like a

1278
00:52:22,630 --> 00:52:20,880
baltimore or something like that yeah

1279
00:52:23,910 --> 00:52:22,640
not quite as big okay

1280
00:52:25,990 --> 00:52:23,920
great

1281
00:52:28,710 --> 00:52:26,000
all right well we had a lively chat here

1282
00:52:29,829 --> 00:52:28,720
we've been following it and um i wanted

1283
00:52:31,910 --> 00:52:29,839
to uh

1284
00:52:33,750 --> 00:52:31,920
bring on grant justice who's also been

1285
00:52:34,470 --> 00:52:33,760
following it to pull up some questions

1286
00:52:36,230 --> 00:52:34,480
so

1287
00:52:38,069 --> 00:52:36,240
grant if you come on

1288
00:52:40,790 --> 00:52:38,079

say hi to everybody grant

1289
00:52:43,030 --> 00:52:40,800
and um uh what what questions did you

1290
00:52:45,349 --> 00:52:43,040
find that were interesting sure like you

1291
00:52:47,750 --> 00:52:45,359
said we had a we had a really good chat

1292
00:52:48,790 --> 00:52:47,760
tonight and um starting off kind of from

1293
00:52:50,470 --> 00:52:48,800
the beginning

1294
00:52:52,549 --> 00:52:50,480
uh chronologically so it'll make a

1295
00:52:54,309 --> 00:52:52,559
little more sense uh

1296
00:52:57,030 --> 00:52:54,319
one of the first ones was in some of

1297
00:52:59,510 --> 00:52:57,040
your earlier uh illustrations

1298
00:53:01,270 --> 00:52:59,520
the dust that was being drawn towards

1299
00:53:04,870 --> 00:53:01,280
the galaxies

1300
00:53:07,349 --> 00:53:04,880
was that gravity creating that like the

1301
00:53:10,230 --> 00:53:07,359
trail being drawn in or was there some

1302
00:53:12,069 --> 00:53:10,240
other force acting upon it i think

1303
00:53:13,510 --> 00:53:12,079
you're talking about the jellyfish the

1304
00:53:15,270 --> 00:53:13,520
with the stuff being that's actually

1305
00:53:16,710 --> 00:53:15,280
being drawn out all right so i think

1306
00:53:18,150 --> 00:53:16,720
maybe the people might have confused

1307
00:53:19,750 --> 00:53:18,160
that is stuff being drawn in versus

1308
00:53:21,190 --> 00:53:19,760
being drawn out why don't you explain

1309
00:53:24,630 --> 00:53:21,200
that again maria

1310
00:53:26,790 --> 00:53:24,640
ah yeah so the jellyfish galaxies uh is

1311
00:53:29,510 --> 00:53:26,800
what i said it's it's kind of like it

1312
00:53:31,430 --> 00:53:29,520
encounters like this kind of wind so

1313
00:53:33,190 --> 00:53:31,440

basically all the all the gas imagine

1314
00:53:35,829 --> 00:53:33,200
that you have like i don't know like you

1315
00:53:37,430 --> 00:53:35,839
have glitter and there's like

1316
00:53:39,510 --> 00:53:37,440
i don't know like my knowledges are like

1317
00:53:41,270 --> 00:53:39,520
really really bad i'm sorry

1318
00:53:43,829 --> 00:53:41,280
you have glitter and

1319
00:53:46,790 --> 00:53:43,839
there's a lot of wind so you know like

1320
00:53:48,790 --> 00:53:46,800
all the glitter or whatever you're

1321
00:53:51,430 --> 00:53:48,800
it's just you know like being dispersed

1322
00:53:54,710 --> 00:53:51,440
like behind you right so this is what

1323
00:53:57,270 --> 00:53:54,720
happens with the cold gas that are in in

1324
00:53:59,190 --> 00:53:57,280
in these galaxies so

1325
00:54:00,390 --> 00:53:59,200
they are uh you know like

1326
00:54:02,390 --> 00:54:00,400
they are like

1327
00:54:05,190 --> 00:54:02,400
blown away the gas is blown away from

1328
00:54:07,430 --> 00:54:05,200
the galaxy just being removed away from

1329
00:54:09,990 --> 00:54:07,440
the from the galaxy

1330
00:54:11,510 --> 00:54:10,000
and in in that process is because it's

1331
00:54:12,870 --> 00:54:11,520
been disturbed and it's been you know

1332
00:54:13,910 --> 00:54:12,880
like just

1333
00:54:16,390 --> 00:54:13,920
everywhere

1334
00:54:18,870 --> 00:54:16,400
and it's forming uh these clumps of star

1335
00:54:20,710 --> 00:54:18,880
formation this these new stars

1336
00:54:22,230 --> 00:54:20,720
okay so these these galaxies are

1337
00:54:23,589 --> 00:54:22,240
actually orbiting through the ga through

1338
00:54:25,270 --> 00:54:23,599

the cluster they're moving through the

1339
00:54:27,670 --> 00:54:25,280
cluster and then this stuff is being

1340
00:54:30,069 --> 00:54:27,680
pulled out as it's moving through okay

1341
00:54:33,349 --> 00:54:30,079
yes i think that'll basically yeah

1342
00:54:35,670 --> 00:54:33,359
basically uh what is um what

1343
00:54:37,990 --> 00:54:35,680
they have found is that these tails of

1344
00:54:39,750 --> 00:54:38,000
the of the jellyfish is telling us how

1345
00:54:41,990 --> 00:54:39,760
the the galaxy is moving through space

1346
00:54:43,349 --> 00:54:42,000
right because you know like it's going

1347
00:54:46,069 --> 00:54:43,359
there and

1348
00:54:46,870 --> 00:54:46,079
the the the tails are behind you okay

1349
00:54:49,030 --> 00:54:46,880
great

1350
00:54:51,190 --> 00:54:49,040
what is it that causes the wind like

1351
00:54:53,430 --> 00:54:51,200
where is it coming from

1352
00:54:55,430 --> 00:54:53,440
so that is a very interesting question

1353
00:54:58,150 --> 00:54:55,440
and

1354
00:55:00,549 --> 00:54:58,160
because we we don't know exactly so

1355
00:55:02,710 --> 00:55:00,559
there's this hot gas that has been you

1356
00:55:05,750 --> 00:55:02,720
know like been accreted so you bring all

1357
00:55:07,109 --> 00:55:05,760
the star on the stars all the galaxies

1358
00:55:10,069 --> 00:55:07,119
inside

1359
00:55:12,870 --> 00:55:10,079
and you you bring all the gas too so you

1360
00:55:15,430 --> 00:55:12,880
know like the the thing is that

1361
00:55:19,270 --> 00:55:15,440
you you you have all these gas that it's

1362
00:55:21,750 --> 00:55:19,280
you know like floating around and um the

1363
00:55:23,349 --> 00:55:21,760

particles of the gas will will collide

1364
00:55:25,750 --> 00:55:23,359
and at some point

1365
00:55:27,910 --> 00:55:25,760
it will kind of cool down

1366
00:55:29,670 --> 00:55:27,920
but what we've seen is that it's not

1367
00:55:32,390 --> 00:55:29,680
cooling down so there's something like

1368
00:55:36,390 --> 00:55:32,400
some energy that it's just making it

1369
00:55:38,309 --> 00:55:36,400
still being hot we still don't know what

1370
00:55:41,030 --> 00:55:38,319
exactly it might be like you know like

1371
00:55:42,069 --> 00:55:41,040
uh merges merges between clusters that

1372
00:55:45,750 --> 00:55:42,079
it just like

1373
00:55:49,750 --> 00:55:45,760
uh excites the the gas might be like um

1374
00:55:51,829 --> 00:55:49,760
agns that um basically uh inject a lot

1375
00:55:55,109 --> 00:55:51,839
of energy into this gas

1376
00:55:56,230 --> 00:55:55,119
uh we are still not sure

1377
00:55:58,309 --> 00:55:56,240
exactly

1378
00:56:00,309 --> 00:55:58,319
which is the mechanism that is just you

1379
00:56:01,829 --> 00:56:00,319
know like just moving the gas

1380
00:56:03,510 --> 00:56:01,839
right because you're heating this gas up

1381
00:56:06,069 --> 00:56:03,520
to x-ray with temperatures where it

1382
00:56:07,030 --> 00:56:06,079
emits x-rays so that's that's really hot

1383
00:56:08,150 --> 00:56:07,040
so

1384
00:56:09,910 --> 00:56:08,160
yeah

1385
00:56:11,430 --> 00:56:09,920
that's a lot of energy to come in all

1386
00:56:12,789 --> 00:56:11,440
right so there's a related question to

1387
00:56:15,109 --> 00:56:12,799
that um

1388
00:56:17,030 --> 00:56:15,119

there so so one was trying to get a

1389
00:56:20,069 --> 00:56:17,040
handle on that there are stars in these

1390
00:56:22,470 --> 00:56:20,079
clusters that are not part of any galaxy

1391
00:56:24,150 --> 00:56:22,480
and how much of it how how many of these

1392
00:56:25,109 --> 00:56:24,160
are there is there any way to quantify

1393
00:56:34,309 --> 00:56:25,119
that

1394
00:56:37,030 --> 00:56:34,319
i work

1395
00:56:39,589 --> 00:56:37,040
on uh this is you know like

1396
00:56:41,670 --> 00:56:39,599
those stars there are stars in in those

1397
00:56:44,390 --> 00:56:41,680
classes that they do not belong to any

1398
00:56:47,109 --> 00:56:44,400
particular galaxy they just float around

1399
00:56:49,109 --> 00:56:47,119
and that is called was what we call

1400
00:56:50,549 --> 00:56:49,119
intra cluster light

1401
00:56:52,870 --> 00:56:50,559
and this is

1402
00:56:55,270 --> 00:56:52,880
this is actually what i work

1403
00:56:58,789 --> 00:56:55,280
on like this is my ex my my actual

1404
00:57:01,109 --> 00:56:58,799
expertise is on this uh very diffuse

1405
00:57:02,950 --> 00:57:01,119
very faint light in in classes of

1406
00:57:03,910 --> 00:57:02,960
galaxies

1407
00:57:06,069 --> 00:57:03,920
so

1408
00:57:09,109 --> 00:57:06,079
um this is

1409
00:57:13,990 --> 00:57:12,390
because it is so faint it's uh it's very

1410
00:57:16,549 --> 00:57:14,000
difficult to separate between the the

1411
00:57:18,789 --> 00:57:16,559
galaxies and this this vein light

1412
00:57:20,309 --> 00:57:18,799
because we only have

1413
00:57:21,190 --> 00:57:20,319

images

1414
00:57:23,270 --> 00:57:21,200
so

1415
00:57:25,589 --> 00:57:23,280
it is very it's kind of difficult to

1416
00:57:27,349 --> 00:57:25,599
quantify exactly um there are estimates

1417
00:57:30,390 --> 00:57:27,359
that around 20

1418
00:57:31,510 --> 00:57:30,400
of them of the mass in in the stars are

1419
00:57:35,510 --> 00:57:31,520
in this

1420
00:57:37,349 --> 00:57:35,520
uh

1421
00:57:38,829 --> 00:57:37,359
that they do not belong to any galaxy

1422
00:57:41,990 --> 00:57:38,839
they just float around

1423
00:57:44,390 --> 00:57:42,000
okay so about twenty percent

1424
00:57:47,030 --> 00:57:44,400
like around twenty percent of the

1425
00:57:48,710 --> 00:57:47,040
stellar cars stellar stellar mass right

1426
00:57:49,990 --> 00:57:48,720
yes yes that's actually

1427
00:57:51,270 --> 00:57:50,000
as an astronomer that's actually

1428
00:57:53,829 --> 00:57:51,280
surprising to me i wouldn't have

1429
00:57:55,670 --> 00:57:53,839
expected it to be that large so

1430
00:57:57,109 --> 00:57:55,680
obviously i i i need to read some of

1431
00:57:58,470 --> 00:57:57,119
your papers don't i

1432
00:58:00,950 --> 00:57:58,480
sure

1433
00:58:03,349 --> 00:58:00,960
because uh i'm i'm actually i've been

1434
00:58:05,190 --> 00:58:03,359
asked by uh nature astronomy to write a

1435
00:58:07,510 --> 00:58:05,200
review on intra cluster light so you

1436
00:58:10,470 --> 00:58:07,520
know like i can send that to

1437
00:58:13,270 --> 00:58:10,480
okay great that actually leads well into

1438
00:58:15,829 --> 00:58:13,280

the next question which is uh the chat

1439
00:58:17,829 --> 00:58:15,839
has been talking quite a bit about about

1440
00:58:20,549 --> 00:58:17,839
this as i'm sure you can imagine what

1441
00:58:21,910 --> 00:58:20,559
would be your suggested like reading for

1442
00:58:24,470 --> 00:58:21,920
someone who's a little bit more

1443
00:58:26,549 --> 00:58:24,480
interested in your talk here today and

1444
00:58:28,789 --> 00:58:26,559
especially regarding like

1445
00:58:31,190 --> 00:58:28,799
the quantity of

1446
00:58:35,990 --> 00:58:31,200
dark matter regular matter and these

1447
00:58:36,870 --> 00:58:36,000
sort of like interacting forces

1448
00:59:27,270 --> 00:58:36,880
i

1449
00:59:28,309 --> 00:59:27,280
years ago

1450
00:59:29,510 --> 00:59:28,319
so

1451
00:59:32,150 --> 00:59:29,520
all right great

1452
00:59:34,230 --> 00:59:32,160
uh let's see what else we got here okay

1453
00:59:37,109 --> 00:59:34,240
um oh actually i want to go into the

1454
00:59:40,309 --> 00:59:37,119
x-ray because um everyone was was

1455
00:59:43,190 --> 00:59:40,319
massively amazed that coma looked so or

1456
00:59:45,270 --> 00:59:43,200
1689 look so bland in x-rays

1457
00:59:47,030 --> 00:59:45,280
and one of one of our our viewers

1458
00:59:49,030 --> 00:59:47,040
speculated well maybe the x-ray

1459
00:59:51,910 --> 00:59:49,040
resolution is just really really really

1460
00:59:53,510 --> 00:59:51,920
bad um and they can't see the the

1461
00:59:55,670 --> 00:59:53,520
individual galaxies

1462
00:59:57,190 --> 00:59:55,680
uh and they wanted to they suggested

1463
00:59:59,030 --> 00:59:57,200

that as a reason why the x-ray looks so

1464
01:00:02,390 --> 00:59:59,040
bad it looks doesn't doesn't have any

1465
01:00:05,030 --> 01:00:02,400
detail so if you look back to that image

1466
01:00:07,910 --> 01:00:05,040
and and you can google it like 1689

1467
01:00:10,069 --> 01:00:07,920
x-rays you can see that uh there's like

1468
01:00:11,750 --> 01:00:10,079
a big blob and there are like two small

1469
01:00:13,270 --> 01:00:11,760
blobs that actually there are like two

1470
01:00:16,630 --> 01:00:13,280
galaxies

1471
01:00:17,349 --> 01:00:16,640
so um yeah the resolution in x-ray is

1472
01:00:23,829 --> 01:00:17,359
it's

1473
01:00:25,430 --> 01:00:23,839
good than in the in

1474
01:00:27,190 --> 01:00:25,440
you know the visible light

1475
01:00:29,270 --> 01:00:27,200
also because you know like we are

1476
01:00:31,670 --> 01:00:29,280
comparing you know like

1477
01:00:32,390 --> 01:00:31,680
um anything with hubble and hubble is

1478
01:00:33,829 --> 01:00:32,400
like

1479
01:00:35,270 --> 01:00:33,839
basically the best resolution that you

1480
01:00:36,470 --> 01:00:35,280
can get now

1481
01:00:39,190 --> 01:00:36,480
uh

1482
01:00:42,230 --> 01:00:39,200
well you know wait wait a month or so

1483
01:00:44,789 --> 01:00:42,240
and um we'll take it while we can get it

1484
01:00:47,510 --> 01:00:44,799
yeah it counts it counts

1485
01:00:49,109 --> 01:00:47,520
i mean like i i like power it's it's my

1486
01:00:50,870 --> 01:00:49,119
favorite telescope

1487
01:00:53,190 --> 01:00:50,880
so um

1488
01:00:55,109 --> 01:00:53,200

so that's it it's already a little bit

1489
01:00:57,750 --> 01:00:55,119
unfair that we are you know comparing

1490
01:00:59,270 --> 01:00:57,760
like things with you know with uh hubble

1491
01:01:00,309 --> 01:00:59,280
images

1492
01:01:03,109 --> 01:01:00,319
um

1493
01:01:05,910 --> 01:01:03,119
but yes the resolution of any trace is

1494
01:01:08,309 --> 01:01:05,920
worse but it's still it's

1495
01:01:11,589 --> 01:01:08,319
cannot explain you know like uh this

1496
01:01:14,309 --> 01:01:11,599
basically big blob there in in when we

1497
01:01:16,950 --> 01:01:14,319
see uh classes yeah and you also showed

1498
01:01:18,789 --> 01:01:16,960
the bullet cluster which has which shows

1499
01:01:21,589 --> 01:01:18,799
that the x-rays do have good resolution

1500
01:01:23,109 --> 01:01:21,599
in the bullet cluster yeah right so it

1501
01:01:25,750 --> 01:01:23,119
just means that i think it just means

1502
01:01:28,789 --> 01:01:25,760
that 1689 is so hot and so massive that

1503
01:01:29,910 --> 01:01:28,799
it's just it it seems like it's just one

1504
01:01:31,750 --> 01:01:29,920
blob

1505
01:01:34,710 --> 01:01:31,760
yes because there's just some i mean and

1506
01:01:36,950 --> 01:01:34,720
it's and it's one block it's one block

1507
01:01:39,589 --> 01:01:36,960
but it's the gas that it's just you know

1508
01:01:42,069 --> 01:01:39,599
everything a lot of things also appeared

1509
01:01:44,390 --> 01:01:42,079
as one blob in the past before we got

1510
01:01:45,670 --> 01:01:44,400
the fine instrumentation control to

1511
01:01:46,470 --> 01:01:45,680
discern

1512
01:01:49,109 --> 01:01:46,480
but

1513
01:01:50,710 --> 01:01:49,119

i'm saying in 1689 it could discern it

1514
01:01:52,150 --> 01:01:50,720
if this if the substructure was there i

1515
01:01:54,230 --> 01:01:52,160
think 16 uh

1516
01:01:57,589 --> 01:01:54,240
the telescope could have discerned it in

1517
01:02:00,549 --> 01:01:57,599
1689. all right what else you got grant

1518
01:02:02,390 --> 01:02:00,559
all right um okay so

1519
01:02:06,150 --> 01:02:02,400
what do you think will be the end of

1520
01:02:08,150 --> 01:02:06,160
these large-scale galactic structures

1521
01:02:10,309 --> 01:02:08,160
so we we

1522
01:02:12,710 --> 01:02:10,319
we see uh something that is called

1523
01:02:14,309 --> 01:02:12,720
fossil groups that basically it's like

1524
01:02:16,470 --> 01:02:14,319
you know like this huge

1525
01:02:18,470 --> 01:02:16,480
massive galaxy in the center and then

1526
01:02:20,069 --> 01:02:18,480
you have uh you have like you know like

1527
01:02:21,910 --> 01:02:20,079
this

1528
01:02:23,589 --> 01:02:21,920
not that massive you know like um

1529
01:02:26,069 --> 01:02:23,599
satellites around

1530
01:02:29,670 --> 01:02:26,079
so it seems like

1531
01:02:31,589 --> 01:02:29,680
what we want what the clusters want

1532
01:02:34,069 --> 01:02:31,599
is to um

1533
01:02:35,510 --> 01:02:34,079
to be like that right having like this

1534
01:02:38,069 --> 01:02:35,520
very massive

1535
01:02:40,630 --> 01:02:38,079
uh central galaxy

1536
01:02:42,870 --> 01:02:40,640
and maybe like a few satellites that

1537
01:02:44,069 --> 01:02:42,880
they have still not managed to to merge

1538
01:02:47,430 --> 01:02:44,079

into the

1539
01:02:51,750 --> 01:02:47,440
central galaxy

1540
01:02:54,950 --> 01:02:53,430
it's what

1541
01:02:56,630 --> 01:02:54,960
it wants it to be

1542
01:02:59,670 --> 01:02:56,640
it's uh you know like it's what the

1543
01:03:00,710 --> 01:02:59,680
gravity is telling it to be right um

1544
01:03:03,029 --> 01:03:00,720
just

1545
01:03:04,549 --> 01:03:03,039
being like kind of well not boring but

1546
01:03:07,829 --> 01:03:04,559
yeah kind of

1547
01:03:10,549 --> 01:03:07,839
less less structure than what we see now

1548
01:03:11,750 --> 01:03:10,559
also boring on a galactic scale i feel

1549
01:03:12,789 --> 01:03:11,760
like yeah

1550
01:03:14,470 --> 01:03:12,799
i mean like

1551
01:03:16,950 --> 01:03:14,480
it's not like you know like

1552
01:03:19,349 --> 01:03:16,960
the x-rays are are boring too but you

1553
01:03:21,349 --> 01:03:19,359
know it's still it's it's hot gas that

1554
01:03:23,349 --> 01:03:21,359
emits in its way which it's it's

1555
01:03:26,069 --> 01:03:23,359
mind-blowing but well while it's still

1556
01:03:27,829 --> 01:03:26,079
being boring right

1557
01:03:30,230 --> 01:03:27,839
like it's hard for explosions to be

1558
01:03:32,870 --> 01:03:30,240
boring i'm just saying

1559
01:03:35,349 --> 01:03:32,880
all right so um somebody asked this one

1560
01:03:36,950 --> 01:03:35,359
i actually asked a couple times uh in

1561
01:03:39,829 --> 01:03:36,960
other galaxies all right so you went

1562
01:03:41,910 --> 01:03:39,839
through the components that are in

1563
01:03:45,270 --> 01:03:41,920

supposedly our galaxy right

1564
01:03:47,190 --> 01:03:45,280
um do we see other components uh not

1565
01:03:49,750 --> 01:03:47,200
beyond the the the dark matter and the

1566
01:03:51,190 --> 01:03:49,760
stars and the gas um in other galaxies

1567
01:03:53,270 --> 01:03:51,200
do they have other components that we

1568
01:03:54,470 --> 01:03:53,280
don't have in our galaxy

1569
01:03:55,910 --> 01:03:54,480
uh

1570
01:04:01,510 --> 01:03:55,920
no

1571
01:04:04,069 --> 01:04:01,520
it's these parts that are forming so

1572
01:04:06,710 --> 01:04:04,079
you can have the gas cold gas

1573
01:04:08,309 --> 01:04:06,720
warm gas hot gas you have like all these

1574
01:04:10,470 --> 01:04:08,319
faces of the gas that are you know like

1575
01:04:13,029 --> 01:04:10,480
just going around

1576
01:04:14,870 --> 01:04:13,039
but basically um

1577
01:04:18,710 --> 01:04:14,880
well another thing that i have mentioned

1578
01:04:21,109 --> 01:04:18,720
but you you have seen it in the

1579
01:04:23,750 --> 01:04:21,119
when we've seen like the the basically

1580
01:04:26,950 --> 01:04:23,760
the the lane of the milky way is dust

1581
01:04:30,630 --> 01:04:26,960
that is basically um some

1582
01:04:31,829 --> 01:04:30,640
somali molecules that are um

1583
01:04:33,670 --> 01:04:31,839
kind of

1584
01:04:36,470 --> 01:04:33,680
not cold but you know like

1585
01:04:39,109 --> 01:04:36,480
they they are very opaque and they they

1586
01:04:40,950 --> 01:04:39,119
basically um

1587
01:04:43,829 --> 01:04:40,960
obstructs the light so that's why we

1588
01:04:46,150 --> 01:04:43,839

cannot see the center of our our galaxy

1589
01:04:49,589 --> 01:04:46,160
because there's all this dust that is in

1590
01:04:53,349 --> 01:04:51,029
okay remember

1591
01:04:55,190 --> 01:04:53,359
other galaxies basically have the same

1592
01:04:56,950 --> 01:04:55,200
components but maybe in different

1593
01:04:59,670 --> 01:04:56,960
proportions or something like that but

1594
01:05:01,270 --> 01:04:59,680
you know nothing uh nothing new in the

1595
01:05:02,870 --> 01:05:01,280
in the universe that we don't that we

1596
01:05:04,549 --> 01:05:02,880
don't see nearby

1597
01:05:06,150 --> 01:05:04,559
well i mean i think that with you know

1598
01:05:07,990 --> 01:05:06,160
dark matter

1599
01:05:09,270 --> 01:05:08,000
we have plenty of you know like weird

1600
01:05:11,510 --> 01:05:09,280
things too

1601
01:05:13,670 --> 01:05:11,520
there's plenty of weird things out there

1602
01:05:15,990 --> 01:05:13,680
okay grant what you got

1603
01:05:19,270 --> 01:05:16,000
all right so um

1604
01:05:22,549 --> 01:05:20,390
reading through some of the further

1605
01:05:24,630 --> 01:05:22,559
comments as we've been going through the

1606
01:05:26,390 --> 01:05:24,640
questions here yeah they yeah they do

1607
01:05:28,470 --> 01:05:26,400
this to us it's like we're trying to

1608
01:05:30,069 --> 01:05:28,480
answer and look at the camera right then

1609
01:05:32,390 --> 01:05:30,079
we have to look down yeah i feel bad

1610
01:05:36,230 --> 01:05:32,400
looking away

1611
01:05:40,789 --> 01:05:38,549
all right um

1612
01:05:43,109 --> 01:05:40,799
well here we go uh

1613
01:05:45,510 --> 01:05:43,119

entropy increasing all right this isn't

1614
01:05:48,789 --> 01:05:45,520
a bad one um if entropy increases won't

1615
01:05:51,510 --> 01:05:48,799
we end up as like eventually

1616
01:05:52,549 --> 01:05:51,520
uh homologous solution do we intend to

1617
01:05:55,829 --> 01:05:52,559
like

1618
01:05:58,870 --> 01:05:55,839
see the uh the black holes

1619
01:06:00,470 --> 01:05:58,880
make their way throughout like what

1620
01:06:02,390 --> 01:06:00,480
we just kind of spoke about a little bit

1621
01:06:04,390 --> 01:06:02,400
with the death of like super massive

1622
01:06:05,910 --> 01:06:04,400
structures but on a slightly more

1623
01:06:06,789 --> 01:06:05,920
galactic scale

1624
01:06:10,789 --> 01:06:06,799
like

1625
01:06:15,910 --> 01:06:14,069
with entropy io that is

1626
01:06:17,270 --> 01:06:15,920
that is very outside

1627
01:06:20,710 --> 01:06:17,280
what i know

1628
01:06:23,270 --> 01:06:20,720
um this is the problem we run into

1629
01:06:25,109 --> 01:06:23,280
we have such literally yeah but it's a

1630
01:06:26,470 --> 01:06:25,119
natural question right so we get we

1631
01:06:27,990 --> 01:06:26,480
build these bigger and bigger clusters

1632
01:06:29,910 --> 01:06:28,000
of galaxies what's the end what's the

1633
01:06:31,109 --> 01:06:29,920
long-term fate of the universe

1634
01:06:33,029 --> 01:06:31,119
yeah

1635
01:06:34,630 --> 01:06:33,039
i mean logical

1636
01:06:37,029 --> 01:06:34,640
what we know

1637
01:06:39,510 --> 01:06:37,039
is that it's it seems like this is this

1638
01:06:42,710 --> 01:06:39,520

thing that is that energy which

1639
01:06:44,710 --> 01:06:42,720
if we don't know what is that matter we

1640
01:06:46,470 --> 01:06:44,720
don't know like anything about darwin

1641
01:06:48,789 --> 01:06:46,480
energy which is like basically pulling

1642
01:06:51,029 --> 01:06:48,799
apart and it's what is

1643
01:06:53,430 --> 01:06:51,039
uh they were saying that it would be

1644
01:06:54,870 --> 01:06:53,440
like this uh i call it big red the big

1645
01:06:57,430 --> 01:06:54,880
red

1646
01:07:00,150 --> 01:06:57,440
it's like kind of the

1647
01:07:02,069 --> 01:07:00,160
you know like kind of like just

1648
01:07:04,309 --> 01:07:02,079
everything would be

1649
01:07:05,829 --> 01:07:04,319
dismantled you know like just right the

1650
01:07:07,190 --> 01:07:05,839
acceleration of the the expansion of the

1651
01:07:10,470 --> 01:07:07,200
universe will continue to accelerate

1652
01:07:12,710 --> 01:07:10,480
until everything just rips apart yeah i

1653
01:07:15,910 --> 01:07:12,720
don't find that satisfying as as an

1654
01:07:19,190 --> 01:07:15,920
ending it's kind of like a yeah it's

1655
01:07:21,510 --> 01:07:19,200
kind of an intergalactic anti-climactic

1656
01:07:24,789 --> 01:07:21,520
zipper like yeah it's like um guess

1657
01:07:30,630 --> 01:07:28,630
okay i can see it

1658
01:07:31,910 --> 01:07:30,640
ultimately unsatisfying i agree there

1659
01:07:34,390 --> 01:07:31,920
was a there was a really good question

1660
01:07:36,549 --> 01:07:34,400
about the bullet cluster um oh please

1661
01:07:38,710 --> 01:07:36,559
somebody noted the bullet cluster um

1662
01:07:40,309 --> 01:07:38,720
that the dark matter was separated and

1663
01:07:43,349 --> 01:07:40,319

they said well wouldn't that dark matter

1664
01:07:45,750 --> 01:07:43,359
want to be to be to get wannabe together

1665
01:07:47,750 --> 01:07:45,760
so yes that is the thing is that you

1666
01:07:49,750 --> 01:07:47,760
know like you have those clusters and

1667
01:07:52,150 --> 01:07:49,760
and

1668
01:07:53,589 --> 01:07:52,160
they they they call collided which is

1669
01:07:55,829 --> 01:07:53,599
basically the plaster

1670
01:07:58,710 --> 01:07:55,839
and but the thing is that it's it's kind

1671
01:08:00,230 --> 01:07:58,720
of like the first passage so they will

1672
01:08:02,150 --> 01:08:00,240
because of the gravity they will you

1673
01:08:04,069 --> 01:08:02,160
know like kind of like tend to

1674
01:08:07,109 --> 01:08:04,079
do this like pendulum thing until you

1675
01:08:08,789 --> 01:08:07,119
know they basically are together right

1676
01:08:10,630 --> 01:08:08,799
and matter of fact the the observations

1677
01:08:11,829 --> 01:08:10,640
of the bullet cluster are so

1678
01:08:14,069 --> 01:08:11,839
intriguing

1679
01:08:17,269 --> 01:08:14,079
because it's a non-equilibrium situation

1680
01:08:20,709 --> 01:08:17,279
right uh it hasn't relaxed

1681
01:08:23,990 --> 01:08:20,719
yes because you know like once uh

1682
01:08:25,990 --> 01:08:24,000
we don't see the effects of this well

1683
01:08:29,590 --> 01:08:26,000
one is like you know like a little bit

1684
01:08:31,749 --> 01:08:29,600
far out of this collision state the gas

1685
01:08:34,470 --> 01:08:31,759
will will tend to go through you know

1686
01:08:37,030 --> 01:08:34,480
like to the kind of

1687
01:08:38,709 --> 01:08:37,040
gravitational potentials of the two

1688
01:08:40,070 --> 01:08:38,719

um

1689
01:08:40,870 --> 01:08:40,080
okay so we gotta

1690
01:08:43,510 --> 01:08:40,880
we

1691
01:08:46,070 --> 01:08:43,520
okay

1692
01:08:47,669 --> 01:08:46,080
um how do you study the diffuse emission

1693
01:08:49,829 --> 01:08:47,679
from the intraclustric great cast

1694
01:08:51,669 --> 01:08:49,839
somebody who's who's who listened to

1695
01:08:54,390 --> 01:08:51,679
what their previous question

1696
01:08:57,189 --> 01:08:54,400
is this something that jwst will help

1697
01:08:57,199 --> 01:09:00,550
so um

1698
01:09:06,070 --> 01:09:03,430
so what what i i do it's not the gas i

1699
01:09:08,309 --> 01:09:06,080
do the the stuff which is you know

1700
01:09:09,590 --> 01:09:08,319
customer like yes to see

1701
01:09:14,550 --> 01:09:09,600
um

1702
01:09:17,349 --> 01:09:16,309
there's a lot of things in the question

1703
01:09:22,870 --> 01:09:17,359
because

1704
01:09:23,910 --> 01:09:22,880
the observations that i need are so deep

1705
01:09:28,149 --> 01:09:23,920
that

1706
01:09:31,030 --> 01:09:28,159
have been observed so there are still

1707
01:09:34,709 --> 01:09:31,040
you know clusters nearby that we haven't

1708
01:09:36,870 --> 01:09:34,719
been able to um to explore and also we

1709
01:09:39,430 --> 01:09:36,880
want to know like what happened to these

1710
01:09:41,189 --> 01:09:39,440
lights you know in clusters like you

1711
01:09:42,870 --> 01:09:41,199
know like a redshift one or you know

1712
01:09:45,990 --> 01:09:42,880
like when they were like

1713
01:09:47,749 --> 01:09:46,000

more um younger so we want to see the

1714
01:09:49,669 --> 01:09:47,759
evolution that is

1715
01:09:51,030 --> 01:09:49,679
in the in the kind of in the past is

1716
01:09:54,390 --> 01:09:51,040
where uh

1717
01:09:57,510 --> 01:09:54,400
uh web will will help me to study this

1718
01:09:59,110 --> 01:09:57,520
uh this diffuse this diffuse light

1719
01:10:01,510 --> 01:09:59,120
oh fantastic

1720
01:10:03,510 --> 01:10:01,520
um do we have do you ever do do you have

1721
01:10:06,070 --> 01:10:03,520
programs to study these uh distant

1722
01:10:08,709 --> 01:10:06,080
clusters with web yet not yet not yet

1723
01:10:12,870 --> 01:10:10,870
well we won't get the first observations

1724
01:10:15,189 --> 01:10:12,880
even just the early release observations

1725
01:10:17,030 --> 01:10:15,199
until this summer so you know we got

1726
01:10:19,750 --> 01:10:17,040
some time before we'll be able to get

1727
01:10:22,070 --> 01:10:19,760
that but you know cluster observations

1728
01:10:24,149 --> 01:10:22,080
there are uh there are services that are

1729
01:10:25,910 --> 01:10:24,159
being made you know with this early you

1730
01:10:27,510 --> 01:10:25,920
know observations so

1731
01:10:30,709 --> 01:10:27,520
maybe there's a like a cluster over

1732
01:10:33,110 --> 01:10:30,719
there that i can you know study so

1733
01:10:36,950 --> 01:10:33,120
as our resident dust expert dr lawton

1734
01:10:39,110 --> 01:10:36,960
would like to say it's uh jwst is his

1735
01:10:41,669 --> 01:10:39,120
his savior for all of the dust so

1736
01:10:43,910 --> 01:10:41,679
hopefully we'll get some more

1737
01:10:45,590 --> 01:10:43,920
some more advanced and uh through

1738
01:10:48,550 --> 01:10:45,600

imagery for you

1739
01:10:49,910 --> 01:10:48,560
all right well um i think we've told the

1740
01:10:52,070 --> 01:10:49,920
audience just about everything you

1741
01:10:52,950 --> 01:10:52,080
wanted to know about galaxy clusters and

1742
01:10:55,110 --> 01:10:52,960
more

1743
01:10:57,110 --> 01:10:55,120
um although i'm sure there's still

1744
01:10:59,350 --> 01:10:57,120
plenty more more to tell

1745
01:11:00,550 --> 01:10:59,360
thank you very much maria

1746
01:11:02,790 --> 01:11:00,560
next month

1747
01:11:05,350 --> 01:11:02,800
february 1st

1748
01:11:08,149 --> 01:11:05,360
from the front lines of the exoplanet

1749
01:11:09,030 --> 01:11:08,159
revolution uh presentation by our peter

1750
01:11:11,030 --> 01:11:09,040
roy

1751
01:11:12,950 --> 01:11:11,040
join us then thank you for joining us