

1
00:00:07,230 --> 00:00:12,039
hello everybody and welcome to news from

2
00:00:10,269 --> 00:00:14,140
Hubble and across the universe this is

3
00:00:12,039 --> 00:00:16,989
our monthly hangout where we get to meet

4
00:00:14,140 --> 00:00:19,118
with dr. Frank summers to discuss a lot

5
00:00:16,989 --> 00:00:20,498
of great new science and happenings in

6
00:00:19,118 --> 00:00:22,960
both astronomy and with the Hubble Space

7
00:00:20,498 --> 00:00:24,338
Telescope my name is Tony Darnell I work

8
00:00:22,960 --> 00:00:26,679
at the Space Telescope Science Institute

9
00:00:24,338 --> 00:00:29,079
with Frank and welcome Frank it's good

10
00:00:26,678 --> 00:00:31,088
to see you again get to see you Tony how

11
00:00:29,079 --> 00:00:33,070
how everything's in this last month we

12
00:00:31,088 --> 00:00:34,570
haven't actually talked since July now I

13
00:00:33,070 --> 00:00:36,429
know it's been it's been a while since

14
00:00:34,570 --> 00:00:38,259
we've been doing this so we got a lot to

15
00:00:36,429 --> 00:00:39,969
catch up on but before we get started

16
00:00:38,259 --> 00:00:41,289
let me remind everybody how you can

17
00:00:39,969 --> 00:00:42,820
interact with us if you want to leave

18
00:00:41,289 --> 00:00:45,189
comments or ask questions we've got the

19
00:00:42,820 --> 00:00:47,649
Google+ app we've got our the Google+

20
00:00:45,189 --> 00:00:49,780
event page we have the quip the Q&A app

21
00:00:47,649 --> 00:00:52,600
on both YouTube and Google+ and I'm

22
00:00:49,780 --> 00:00:53,980
looking at the hubble hubble hang out

23
00:00:52,600 --> 00:00:55,480
hashtag all that will probably change

24
00:00:53,979 --> 00:00:57,549
that for future shows but for right now

25
00:00:55,479 --> 00:01:00,209
if you want to leave a tweak Hubble hash

26
00:00:57,549 --> 00:01:02,819
Hubble hangout is what I'm looking at Oh

27
00:01:00,210 --> 00:01:06,460
many h's on that kills me every time

28
00:01:02,820 --> 00:01:08,560
anyway uh so this month Frank is back

29

00:01:06,459 --> 00:01:10,269
like last Frank mentioned we missed last

30
00:01:08,560 --> 00:01:13,689
month for two reasons I was on vacation

31
00:01:10,269 --> 00:01:15,549
I was one and another was we just

32
00:01:13,689 --> 00:01:18,429
couldn't get our stuff together and time

33
00:01:15,549 --> 00:01:20,950
to make it happen so we are going to we

34
00:01:18,430 --> 00:01:22,450
had a lot of things to cover and Frank I

35
00:01:20,950 --> 00:01:24,850
will turn it over to you to get us

36
00:01:22,450 --> 00:01:26,700
started yeah you know I will apologize

37
00:01:24,849 --> 00:01:30,549
that I was out of the country i was in

38
00:01:26,700 --> 00:01:33,760
vancouver for a week so we oughta stay

39
00:01:30,549 --> 00:01:38,189
pretty busy month for vacations and

40
00:01:33,760 --> 00:01:41,200
travel and such so we will do now a

41
00:01:38,189 --> 00:01:43,599
extra big show extra cool stories for

42
00:01:41,200 --> 00:01:45,040
you today okay cool yeah there's some

43
00:01:43,599 --> 00:01:46,479

research stuff that happened last week

44

00:01:45,040 --> 00:01:47,680

or last month I think that you covered

45

00:01:46,480 --> 00:01:49,600

that you're going to also cover with it

46

00:01:47,680 --> 00:01:51,460

so exactly and that's gonna be my first

47

00:01:49,599 --> 00:01:54,069

story okay because this happened just

48

00:01:51,459 --> 00:01:58,389

before I left for Vancouver alright so

49

00:01:54,069 --> 00:02:04,689

story number one rosetta rendezvous with

50

00:01:58,390 --> 00:02:08,019

rubber ducky okay like that rubber ducky

51

00:02:04,689 --> 00:02:09,639

bardot j-just where do you see ladies as

52

00:02:08,019 --> 00:02:11,560

you know all about this all right Oh

53

00:02:09,639 --> 00:02:14,049

first of all this is about the Rosetta

54

00:02:11,560 --> 00:02:18,360

mission and it's a mission to

55

00:02:14,050 --> 00:02:24,490

a comet comet 67p churyumov-gerasimenko

56

00:02:18,360 --> 00:02:27,610

oh that's a tough thing to say as you

57

00:02:24,490 --> 00:02:31,900

can see pictured here of they've got the

58
00:02:27,610 --> 00:02:33,670
Rosetta is the low the spacecraft with

59
00:02:31,900 --> 00:02:35,620
the long wings on it that's that's the

60
00:02:33,669 --> 00:02:40,149
Rosetta mission itself and then they

61
00:02:35,620 --> 00:02:42,879
also have the the feel a pro but that is

62
00:02:40,150 --> 00:02:46,950
going to land on the comet okay so its

63
00:02:42,879 --> 00:02:49,299
guts combination of a flyby as well as a

64
00:02:46,949 --> 00:02:52,269
probe landing on it although it's

65
00:02:49,300 --> 00:02:54,340
actually more than just a flyby okay now

66
00:02:52,270 --> 00:02:56,860
we've been passed a bunch of other

67
00:02:54,340 --> 00:03:00,640
comments before and as you can see in

68
00:02:56,860 --> 00:03:02,700
this slide here the here are what six

69
00:03:00,639 --> 00:03:04,779
different comets that we have visited

70
00:03:02,699 --> 00:03:07,629
basically generally generally with

71
00:03:04,780 --> 00:03:09,969
flybys and you can see there you know

72
00:03:07,629 --> 00:03:12,009
about five miles cross from one miles to

73
00:03:09,969 --> 00:03:15,370
nine miles across and they've got these

74
00:03:12,009 --> 00:03:17,379
oblong shapes and most of them were sort

75
00:03:15,370 --> 00:03:19,659
of roundish or potato ish although I

76
00:03:17,379 --> 00:03:21,849
think barley and Hartley they could they

77
00:03:19,659 --> 00:03:24,039
could be bowling pin comets all right

78
00:03:21,849 --> 00:03:25,419
they look like bowling pins but my

79
00:03:24,039 --> 00:03:31,750
professor always called him oblate

80
00:03:25,419 --> 00:03:34,029
spheroids but deep impact actually hit

81
00:03:31,750 --> 00:03:36,039
we didn't just fly by right ya know deep

82
00:03:34,030 --> 00:03:38,979
impact we actually did a flyby and we

83
00:03:36,039 --> 00:03:41,310
did a smash in if we did both us fly by

84
00:03:38,979 --> 00:03:43,299
and and we didn't land gently okay

85
00:03:41,310 --> 00:03:44,680
that's the difference with this one this

86

00:03:43,300 --> 00:03:46,770
one we're going to try and land gently

87
00:03:44,680 --> 00:03:50,260
with deep impact we actually tried to

88
00:03:46,770 --> 00:03:51,640
smash it smash into it we saw all the

89
00:03:50,259 --> 00:03:53,560
powdery stuff come out of it so we've

90
00:03:51,639 --> 00:03:57,879
been there we sort of know but what

91
00:03:53,560 --> 00:04:01,060
we've never done is actually travel

92
00:03:57,879 --> 00:04:03,009
along with the for an extended period so

93
00:04:01,060 --> 00:04:05,080
this is what rosetta's going to do here

94
00:04:03,009 --> 00:04:06,459
is the whole timeline okay you can try

95
00:04:05,080 --> 00:04:08,350
and read that the problems fonts

96
00:04:06,459 --> 00:04:10,890
probably too small read over this but

97
00:04:08,349 --> 00:04:15,579
the idea is that it's it launched in

98
00:04:10,889 --> 00:04:18,069
2004 march of 2004 it's gotten yeah I

99
00:04:15,580 --> 00:04:22,080
got gravity assists from Earth Mars

100
00:04:18,069 --> 00:04:26,689

Earth asteroid Stein's earth again

101

00:04:22,079 --> 00:04:28,430
asteroid Natasha and

102

00:04:26,689 --> 00:04:32,329
yeah so it's got like seven different

103

00:04:28,430 --> 00:04:35,660
gravity assists in order to make in size

104

00:04:32,329 --> 00:04:37,609
and gravity huh extra an extreme

105

00:04:35,660 --> 00:04:41,060
exercise in celestial mechanics okay

106

00:04:37,610 --> 00:04:44,389
yeah the but the point was it arrived at

107

00:04:41,060 --> 00:04:47,000
the comet August sixth of last month now

108

00:04:44,389 --> 00:04:49,039
it's better understand the the orbits if

109

00:04:47,000 --> 00:04:51,730
you show it here and so here you can see

110

00:04:49,040 --> 00:04:54,560
the orbital pass and all of the early

111

00:04:51,730 --> 00:04:57,530
gravity assists were there to put it on

112

00:04:54,560 --> 00:05:00,319
a much more elliptical orbit so that it

113

00:04:57,529 --> 00:05:02,419
could match the orbit of chair yamaha

114

00:05:00,319 --> 00:05:03,740
jeramaz seem ankle are those does it

115
00:05:02,420 --> 00:05:05,530
take a lot of energy to get into an

116
00:05:03,740 --> 00:05:10,220
orbit like that 02 an elliptical orbit

117
00:05:05,529 --> 00:05:12,289
well yeah simply because your earth is

118
00:05:10,220 --> 00:05:14,540
on a circular orbit when you launch from

119
00:05:12,290 --> 00:05:17,180
Earth you're launching basically with

120
00:05:14,540 --> 00:05:19,610
Earth's momentum around the Sun and so

121
00:05:17,180 --> 00:05:23,930
you've got to change that momentum into

122
00:05:19,610 --> 00:05:26,060
a much more elongated orbit so while the

123
00:05:23,930 --> 00:05:27,980
as you can see the red line and the

124
00:05:26,060 --> 00:05:30,199
green line are almost coincident at one

125
00:05:27,980 --> 00:05:32,300
point in terms of their perihelion the

126
00:05:30,199 --> 00:05:34,879
closest approach to the Sun the aphelion

127
00:05:32,300 --> 00:05:37,520
is so much further away for church for

128
00:05:34,879 --> 00:05:40,668
comet 67p that you've got to add a lot

129
00:05:37,519 --> 00:05:44,539
of energy to get out of that right mmm

130
00:05:40,668 --> 00:05:48,620
so the really cool thing about rosetta

131
00:05:44,540 --> 00:05:51,290
mission is after it has a met up with a

132
00:05:48,620 --> 00:05:53,740
comet it's going to stay with the comet

133
00:05:51,290 --> 00:05:56,210
all the way through perihelion passage

134
00:05:53,740 --> 00:05:58,160
so it's not an orbit around the comet

135
00:05:56,209 --> 00:06:00,469
it's just sort of tracking along in its

136
00:05:58,160 --> 00:06:02,570
orbit yeah it's tracking along with it

137
00:06:00,470 --> 00:06:05,360
it's doing a library orbit near the

138
00:06:02,569 --> 00:06:07,339
comet actually as I saw it described

139
00:06:05,360 --> 00:06:08,629
once that it sits in front of the comet

140
00:06:07,339 --> 00:06:10,519
it's not actually orbiting around the

141
00:06:08,629 --> 00:06:14,168
comet is orbiting along with comments so

142
00:06:10,519 --> 00:06:17,599
it's on the same path at the same speed

143

00:06:14,168 --> 00:06:20,839
and so you can see how difficult it is

144
00:06:17,600 --> 00:06:23,030
and if you want to do it inexpensively

145
00:06:20,839 --> 00:06:25,279
to you to do all this sort of stuff the

146
00:06:23,029 --> 00:06:28,099
amount of energy that it takes to match

147
00:06:25,279 --> 00:06:29,989
orbits okay so this is really cool we

148
00:06:28,100 --> 00:06:31,970
have now matched up with a comet and I

149
00:06:29,990 --> 00:06:34,960
was going to go through some of the

150
00:06:31,970 --> 00:06:37,940
images that we had of the common

151
00:06:34,959 --> 00:06:40,000
approaching it okay so this is the first

152
00:06:37,939 --> 00:06:42,339
image released this year March twenty

153
00:06:40,000 --> 00:06:46,000
seventh and the main thing in this image

154
00:06:42,339 --> 00:06:47,319
is the globular cluster m12 7 okay so

155
00:06:46,000 --> 00:06:49,810
this is I think it's in the

156
00:06:47,319 --> 00:06:51,430
constellation of UKISS that's m107 and

157
00:06:49,810 --> 00:06:54,160

then what looks like just one of the

158

00:06:51,430 --> 00:06:56,860

stars of m107 are the stars nearby m107

159

00:06:54,160 --> 00:07:00,430

that's actually the comet okay so that

160

00:06:56,860 --> 00:07:03,910

circle is around the comet 67p I'm

161

00:07:00,430 --> 00:07:05,350

calling 67 PCG desperate for I'm glad

162

00:07:03,910 --> 00:07:07,840

that circles there it makes it mailed

163

00:07:05,350 --> 00:07:12,700

lemak Rosetta easier to find absolutely

164

00:07:07,839 --> 00:07:14,019

impossible spot otherwise then the next

165

00:07:12,699 --> 00:07:16,029

thing the next thing that was

166

00:07:14,019 --> 00:07:19,509

interesting that they released was July

167

00:07:16,029 --> 00:07:21,699

4th on Independence Day in the US this

168

00:07:19,509 --> 00:07:24,370

year they released these three images

169

00:07:21,699 --> 00:07:26,889

here and these three images show you

170

00:07:24,370 --> 00:07:29,560

that it's more than just a dot it looks

171

00:07:26,889 --> 00:07:31,209

like sort of an elongated dot okay and

172
00:07:29,560 --> 00:07:33,310
you know you can't really see it it's

173
00:07:31,209 --> 00:07:35,019
all very pixelated everything but you're

174
00:07:33,310 --> 00:07:36,189
starting to see that well this is kind

175
00:07:35,019 --> 00:07:38,319
of interesting it probably has that

176
00:07:36,189 --> 00:07:41,680
potato shape that we seen for all the

177
00:07:38,319 --> 00:07:43,659
other comments right but they save the

178
00:07:41,680 --> 00:07:48,668
best for French Independence Day

179
00:07:43,660 --> 00:07:51,160
Bastille Day july 14 2014 the french

180
00:07:48,668 --> 00:07:57,279
annalise yeah you got well it is a

181
00:07:51,160 --> 00:07:58,930
European mission right so on that's on

182
00:07:57,279 --> 00:08:01,809
bastille day they released this image

183
00:07:58,930 --> 00:08:04,418
and this immediately shows you that that

184
00:08:01,810 --> 00:08:07,269
dark line of shadow or commander showed

185
00:08:04,418 --> 00:08:09,699
you this looks like two objects it looks

186
00:08:07,269 --> 00:08:12,279
like to snow balls hanging around each

187
00:08:09,699 --> 00:08:14,228
other not not one object it looks like

188
00:08:12,279 --> 00:08:17,349
two objects together which was really

189
00:08:14,228 --> 00:08:20,409
cool and then everything really went

190
00:08:17,350 --> 00:08:23,140
crazy the next week this sequence of

191
00:08:20,410 --> 00:08:24,910
images from July 23 to 27 hit the

192
00:08:23,139 --> 00:08:27,459
internet and and everybody started

193
00:08:24,910 --> 00:08:31,030
freaking out this wasn't just a single

194
00:08:27,459 --> 00:08:35,019
comet this was a contact binary comet

195
00:08:31,029 --> 00:08:38,408
all right it was absolutely amazing this

196
00:08:35,019 --> 00:08:39,819
is what I call comet rubber ducky okay

197
00:08:38,408 --> 00:08:42,019
not just me a lot of people have called

198
00:08:39,820 --> 00:08:44,060
a comet rubber ducky

199
00:08:42,019 --> 00:08:46,909
so you got us you got explain to us what

200

00:08:44,059 --> 00:08:50,299
a comment with a binary uh what was it

201
00:08:46,909 --> 00:08:52,429
you said binary contact binary okay Mary

202
00:08:50,299 --> 00:08:54,819
what is that thank you for asking that's

203
00:08:52,429 --> 00:08:57,649
just where I was going to launch into

204
00:08:54,820 --> 00:08:59,629
well alright so the point is is that you

205
00:08:57,649 --> 00:09:02,090
know you it's obviously two separate

206
00:08:59,629 --> 00:09:04,820
pieces that have joined together at the

207
00:09:02,090 --> 00:09:06,590
neck of the duck and in order for these

208
00:09:04,820 --> 00:09:09,950
things and now comets can be relatively

209
00:09:06,590 --> 00:09:12,350
fragile objects right comets can be just

210
00:09:09,950 --> 00:09:15,290
sort of rubble piles or ice as their

211
00:09:12,350 --> 00:09:19,240
snowballs if they came together too hard

212
00:09:15,289 --> 00:09:22,219
they would smash and break up okay and

213
00:09:19,240 --> 00:09:24,649
what the calculations were on this one

214
00:09:22,220 --> 00:09:27,350

was that for these two objects to stick

215

00:09:24,649 --> 00:09:29,149

together they had to approach each other

216

00:09:27,350 --> 00:09:31,580

at a speed of like three meters per

217

00:09:29,149 --> 00:09:33,470

second now three meters per second is

218

00:09:31,580 --> 00:09:35,300

fast for you with me but in the solar

219

00:09:33,470 --> 00:09:37,970

system that's actually quite slow

220

00:09:35,299 --> 00:09:41,809

because Earth orbits around the Sun at

221

00:09:37,970 --> 00:09:44,540

30 kilometers per second so in order to

222

00:09:41,809 --> 00:09:46,849

match up the these two objects had to be

223

00:09:44,539 --> 00:09:49,219

almost on exactly the same orbits and

224

00:09:46,850 --> 00:09:52,190

very I think and then this sort of

225

00:09:49,220 --> 00:09:55,970

gently smashing together and stay in

226

00:09:52,190 --> 00:09:58,670

contact with one another so it's really

227

00:09:55,970 --> 00:10:00,470

interesting we don't know how strongly

228

00:09:58,669 --> 00:10:02,719

they're held together they obviously are

229
00:10:00,470 --> 00:10:05,090
held a low strongly enough to resist the

230
00:10:02,720 --> 00:10:06,800
the rotation the rotational forces that

231
00:10:05,090 --> 00:10:08,540
might pull them apart right I was going

232
00:10:06,799 --> 00:10:11,029
to say that that must be acting against

233
00:10:08,539 --> 00:10:14,329
it so it's hard to imagine this is just

234
00:10:11,029 --> 00:10:16,220
gravity doing the the sticking together

235
00:10:14,330 --> 00:10:19,370
is it or do you think that's all it is

236
00:10:16,220 --> 00:10:21,379
well it's it's gravity plus there can be

237
00:10:19,370 --> 00:10:22,730
some chemical bonds you know and what

238
00:10:21,379 --> 00:10:24,019
holds a snowball together right yeah

239
00:10:22,730 --> 00:10:26,090
they kind of got squished together like

240
00:10:24,019 --> 00:10:27,799
a packing a snowball melted a little bit

241
00:10:26,090 --> 00:10:29,600
and kind of stuck together mean you

242
00:10:27,799 --> 00:10:31,909
could consider this a solar system

243

00:10:29,600 --> 00:10:34,070

exploration in making a snowman right

244

00:10:31,909 --> 00:10:35,990

you get a third one okay and then you

245

00:10:34,070 --> 00:10:39,350

get we can have a snowman comment but I

246

00:10:35,990 --> 00:10:41,029

think that's highly unlikely happen yeah

247

00:10:39,350 --> 00:10:43,909

that bring that together would be

248

00:10:41,029 --> 00:10:46,519

impressive ok so this got everyone's

249

00:10:43,909 --> 00:10:48,730

attention on it I think from what I

250

00:10:46,519 --> 00:10:52,730

heard some of these images were released

251

00:10:48,730 --> 00:10:53,720

prematurely the the the team the science

252

00:10:52,730 --> 00:10:54,769

team behind it didn't want to release

253

00:10:53,720 --> 00:10:55,730

them till they really know what they're

254

00:10:54,769 --> 00:10:57,939

looking at but

255

00:10:55,730 --> 00:11:02,060

it was just so cool somebody had some

256

00:10:57,940 --> 00:11:03,589

somebody had to put it out and so the

257

00:11:02,059 --> 00:11:05,778
next week actually need some earlier

258
00:11:03,589 --> 00:11:07,699
images from the osiris team that

259
00:11:05,778 --> 00:11:09,799
actually had even higher resolution and

260
00:11:07,698 --> 00:11:12,919
you can really see this this double

261
00:11:09,799 --> 00:11:15,679
contact binary so we're watching really

262
00:11:12,919 --> 00:11:18,828
closely as it was going into rendezvous

263
00:11:15,679 --> 00:11:21,349
which was unlocked august sixth so here

264
00:11:18,828 --> 00:11:24,559
on july 24th based upon those date that

265
00:11:21,350 --> 00:11:27,829
data they made this animated gif this

266
00:11:24,559 --> 00:11:29,239
spinning 3d model okay so a rough model

267
00:11:27,828 --> 00:11:32,179
of it where you can see you've got a

268
00:11:29,240 --> 00:11:34,549
larger one that looks very much like the

269
00:11:32,179 --> 00:11:36,859
ones we got we've got a smaller circular

270
00:11:34,549 --> 00:11:39,528
one again the two of them separately

271
00:11:36,860 --> 00:11:41,329

look very much like the other comets

272

00:11:39,528 --> 00:11:45,078

we've seen but then they get smashed

273

00:11:41,328 --> 00:11:47,569

together by this neck feature all right

274

00:11:45,078 --> 00:11:50,599

august first we start to see all the

275

00:11:47,570 --> 00:11:52,339

detail in it all the crag eNOS that we

276

00:11:50,600 --> 00:11:54,409

saw on all the previous comets starts to

277

00:11:52,339 --> 00:11:58,850

come into view we get a little closer

278

00:11:54,409 --> 00:12:01,189

daily august 3rd I mean that almost

279

00:11:58,850 --> 00:12:03,860

looks like a mushroom cloud no no no

280

00:12:01,190 --> 00:12:05,810

yeah really it was like mommy mom I was

281

00:12:03,860 --> 00:12:09,528

gonna rub ur duckies out the window now

282

00:12:05,809 --> 00:12:12,409

I don't don't worry rubber ducky will

283

00:12:09,528 --> 00:12:14,088

come back okay that one this one had a

284

00:12:12,409 --> 00:12:16,338

feeling like a mushroom Club but what I

285

00:12:14,089 --> 00:12:19,069

loved about this one is it showed you

286
00:12:16,339 --> 00:12:21,290
the narrow features of the neck and how

287
00:12:19,068 --> 00:12:23,870
tenuous the connection between them

288
00:12:21,289 --> 00:12:25,849
right yeah it's as if they smash

289
00:12:23,870 --> 00:12:28,759
together and rebounded and you formed

290
00:12:25,850 --> 00:12:31,970
this bridge there and then just no

291
00:12:28,759 --> 00:12:35,269
material was left in between on that so

292
00:12:31,970 --> 00:12:37,459
that was really cool to me yeah because

293
00:12:35,269 --> 00:12:40,190
almost like it would kind of hit and

294
00:12:37,458 --> 00:12:41,629
then heat it up sort of merged and

295
00:12:40,190 --> 00:12:43,220
squish to melt a little bit and when I

296
00:12:41,629 --> 00:12:44,889
started to go apart it froze that's what

297
00:12:43,220 --> 00:12:47,209
I think happened Frank yeah it's okay

298
00:12:44,889 --> 00:12:49,399
prize later I just want to say I think

299
00:12:47,208 --> 00:12:52,250
you won alright well that is a

300
00:12:49,399 --> 00:12:54,289
reasonable reasonable hypothesis uh you

301
00:12:52,250 --> 00:12:55,610
just have to calculate what the speeds

302
00:12:54,289 --> 00:12:57,289
and the physical properties that would

303
00:12:55,610 --> 00:12:59,870
happen during that before you get your

304
00:12:57,289 --> 00:13:03,169
Nobel price though Emily Emily was she

305
00:12:59,870 --> 00:13:05,360
on the team no I'll tell you at the end

306
00:13:03,169 --> 00:13:07,219
of this thought I still to this easy

307
00:13:05,360 --> 00:13:09,470
asst to steal all the images these

308
00:13:07,220 --> 00:13:12,889
images was from her blog okay

309
00:13:09,470 --> 00:13:14,810
yes he's really she was really good so

310
00:13:12,889 --> 00:13:16,850
in I mean I got a lot of things from a

311
00:13:14,809 --> 00:13:18,049
lot of places and I was this like to try

312
00:13:16,850 --> 00:13:19,340
and assemble it for this talk it was

313
00:13:18,049 --> 00:13:21,740
like yeah we'll just go to Emily and

314

00:13:19,340 --> 00:13:23,960
she's got it she'll know it you'll have

315
00:13:21,740 --> 00:13:25,519
a deal she reprocessed a bunch of these

316
00:13:23,960 --> 00:13:27,500
images to clean them up and make them

317
00:13:25,519 --> 00:13:30,919
look better before posting on her blog

318
00:13:27,500 --> 00:13:33,320
so she added her added her name to the

319
00:13:30,919 --> 00:13:37,159
credit list for actually the credit

320
00:13:33,320 --> 00:13:40,160
lists are monstrously huge for this one

321
00:13:37,159 --> 00:13:43,129
of these some of these anyway so August

322
00:13:40,159 --> 00:13:45,139
fourth again you see some serious craggy

323
00:13:43,129 --> 00:13:47,450
and bumpy features and stuff it's really

324
00:13:45,139 --> 00:13:50,689
you know taking shape it's starting to

325
00:13:47,450 --> 00:13:52,759
be a real object okay and then after

326
00:13:50,690 --> 00:13:55,760
August fourth on august sixth we had

327
00:13:52,759 --> 00:13:59,090
rendezvous and rendezvous was successful

328
00:13:55,759 --> 00:14:01,250

they did the insertion burn to slow down

329

00:13:59,090 --> 00:14:02,389

to get to the speed of the comet because

330

00:14:01,250 --> 00:14:04,220

they've been catching up to the comment

331

00:14:02,389 --> 00:14:06,379

and then they slowed down and there and

332

00:14:04,220 --> 00:14:08,480

they're in this library orbit around it

333

00:14:06,379 --> 00:14:11,960

basically in front of it looking at it

334

00:14:08,480 --> 00:14:13,970

with the cameras well after rendezvous

335

00:14:11,960 --> 00:14:15,680

they were so close that they were only

336

00:14:13,970 --> 00:14:18,350

getting pieces of the comet they

337

00:14:15,679 --> 00:14:19,909

couldn't show you the whole comet nobody

338

00:14:18,350 --> 00:14:22,310

camera had one in a field of view huh

339

00:14:19,909 --> 00:14:23,569

right well you know you want to be that

340

00:14:22,309 --> 00:14:26,629

close to because you've got to scan

341

00:14:23,570 --> 00:14:29,660

places for where this Lander is going to

342

00:14:26,629 --> 00:14:33,320

look going to land right so they

343
00:14:29,659 --> 00:14:36,319
released a mosaic like this okay of four

344
00:14:33,320 --> 00:14:40,100
different images and then they said to

345
00:14:36,320 --> 00:14:42,410
image processors okay here are the four

346
00:14:40,100 --> 00:14:45,139
images that we took that mosaic over the

347
00:14:42,409 --> 00:14:47,419
whole thing how about if you go out and

348
00:14:45,139 --> 00:14:50,990
try and mosaic them together because you

349
00:14:47,419 --> 00:14:53,509
know as the as the as the orbiter is

350
00:14:50,990 --> 00:14:55,190
moving around it the lighting is going

351
00:14:53,509 --> 00:14:57,169
to change the Quetta the comments going

352
00:14:55,190 --> 00:14:58,640
to rotate a little bit so it was a

353
00:14:57,169 --> 00:15:02,179
significant amount of image processing

354
00:14:58,639 --> 00:15:05,029
to combine these guys together right and

355
00:15:02,179 --> 00:15:08,239
so a gentleman named Daniel Maha check

356
00:15:05,029 --> 00:15:10,279
put together this one from the August

357
00:15:08,240 --> 00:15:13,399
thirty-first mosaic and that I think is

358
00:15:10,279 --> 00:15:15,259
really cool and although it looks kind

359
00:15:13,399 --> 00:15:17,149
of mean it certainly does look like a

360
00:15:15,259 --> 00:15:19,610
rubber duck there don't you think yeah I

361
00:15:17,149 --> 00:15:21,019
guess so I guess while you're talking

362
00:15:19,610 --> 00:15:22,009
about this Frank I want to energy I

363
00:15:21,019 --> 00:15:23,539
could comment from

364
00:15:22,009 --> 00:15:25,700
d Schmidt she's made a comment about

365
00:15:23,539 --> 00:15:28,730
what you're saying she said despite how

366
00:15:25,700 --> 00:15:30,470
the photos look and it and being a

367
00:15:28,730 --> 00:15:32,420
snowball the comet is actually very dark

368
00:15:30,470 --> 00:15:35,120
in color always surprising to learn how

369
00:15:32,419 --> 00:15:38,750
dark some things are like the moon is

370
00:15:35,120 --> 00:15:40,940
pretty much charcoal so that is correct

371

00:15:38,750 --> 00:15:42,409
yeah thank you Judy a good good insight

372
00:15:40,940 --> 00:15:44,330
that's true this is what you're looking

373
00:15:42,409 --> 00:15:47,600
at of course is reflections from the Sun

374
00:15:44,330 --> 00:15:51,770
but this is a pretty dark object yeah

375
00:15:47,600 --> 00:15:55,040
the standard thing is that the comet is

376
00:15:51,769 --> 00:15:57,319
as dark as the asphalt on the road okay

377
00:15:55,039 --> 00:15:58,639
and that because it's been traveling

378
00:15:57,320 --> 00:16:02,810
around in outer space for billions of

379
00:15:58,639 --> 00:16:05,899
years any particles that hit it you know

380
00:16:02,809 --> 00:16:08,029
cover up all the school quotes no you

381
00:16:05,899 --> 00:16:10,309
don't see white snow on comets okay

382
00:16:08,029 --> 00:16:13,069
because the outer layers are the starry

383
00:16:10,309 --> 00:16:15,259
gyuki stuff the inner layers are white

384
00:16:13,070 --> 00:16:17,060
and bright and would be would be your

385
00:16:15,259 --> 00:16:19,879

snow like substances but the outer

386

00:16:17,059 --> 00:16:23,179

layers I've definitely been baked in the

387

00:16:19,879 --> 00:16:25,370

solar heat all of the volatiles on the

388

00:16:23,179 --> 00:16:27,699

surface have evaporated away leaving

389

00:16:25,370 --> 00:16:30,320

behind this sort of tar like residue

390

00:16:27,700 --> 00:16:33,230

okay so they're sure there's your rubber

391

00:16:30,320 --> 00:16:35,060

duck okay but here's the question and

392

00:16:33,230 --> 00:16:37,850

the question they're studying this month

393

00:16:35,059 --> 00:16:39,889

is where on this rubber duck are they

394

00:16:37,850 --> 00:16:47,000

going to land okay where are they going

395

00:16:39,889 --> 00:16:48,439

to put that Lander to be the the problem

396

00:16:47,000 --> 00:16:50,990

is is that because it's got this

397

00:16:48,440 --> 00:16:52,820

irregular shape the orbit around it is

398

00:16:50,990 --> 00:16:55,190

actually not that difficult you know

399

00:16:52,820 --> 00:16:57,260

it's just an irregular moment of inertia

400
00:16:55,190 --> 00:16:59,300
to work with but now you've got to try

401
00:16:57,259 --> 00:17:01,279
and land on this while it's rotating

402
00:16:59,299 --> 00:17:03,349
with this kind of irregular shape so

403
00:17:01,279 --> 00:17:06,319
that sort of the places that are

404
00:17:03,350 --> 00:17:08,269
possible to land and so the plan was to

405
00:17:06,319 --> 00:17:10,909
come up with five potential landing

406
00:17:08,269 --> 00:17:14,980
sites toward the end of August which

407
00:17:10,910 --> 00:17:17,269
they did and here is a refined 3d model

408
00:17:14,980 --> 00:17:21,220
and with the five potential landing

409
00:17:17,269 --> 00:17:23,599
sites for the feel a lander a they

410
00:17:21,220 --> 00:17:25,549
obviously they hit big chose a lot more

411
00:17:23,599 --> 00:17:29,209
because they got a B and C but then they

412
00:17:25,549 --> 00:17:32,180
have I and J yeah I don't know I haven't

413
00:17:29,210 --> 00:17:34,460
dismissed d through H seem to have

414
00:17:32,180 --> 00:17:35,670
disappeared make the cut yeah didn't

415
00:17:34,460 --> 00:17:37,559
make the cut alright so the

416
00:17:35,670 --> 00:17:39,600
the five potential landing sites well

417
00:17:37,559 --> 00:17:42,419
then they release some high-resolution

418
00:17:39,599 --> 00:17:45,089
photographs of those landing sites so

419
00:17:42,420 --> 00:17:48,600
here's the ABC I and J landing sites on

420
00:17:45,089 --> 00:17:52,619
the scale and this is one kilometer on

421
00:17:48,599 --> 00:17:56,519
aside for each of these right so that's

422
00:17:52,619 --> 00:17:58,619
really interesting k um I actually look

423
00:17:56,519 --> 00:18:00,990
at these pictures and my favorite

424
00:17:58,619 --> 00:18:04,019
landing site might be site B because it

425
00:18:00,990 --> 00:18:05,940
looks much sort of like a lunar mari

426
00:18:04,019 --> 00:18:07,889
very smooth yeah I was going to say the

427
00:18:05,940 --> 00:18:09,600
same thing I predict that's what I think

428

00:18:07,890 --> 00:18:13,140
it's be B should be the one the other

429
00:18:09,599 --> 00:18:14,659
ones look too scary yeah but what

430
00:18:13,140 --> 00:18:17,850
they're going to do is they're going to

431
00:18:14,660 --> 00:18:21,000
survey these five sites at a resolution

432
00:18:17,849 --> 00:18:25,500
of what they said like you know half a

433
00:18:21,000 --> 00:18:26,970
meter per pixel which is amazing but

434
00:18:25,500 --> 00:18:29,279
sensitive that close they will look at

435
00:18:26,970 --> 00:18:31,350
these sites in great detail and about

436
00:18:29,279 --> 00:18:33,809
half a meter per pixel resolution and

437
00:18:31,349 --> 00:18:36,839
then before they choose their primary

438
00:18:33,809 --> 00:18:38,940
landing site and I'm told that their

439
00:18:36,839 --> 00:18:40,829
primary landing site will be chosen in

440
00:18:38,940 --> 00:18:42,539
mid-september so we got a couple weeks

441
00:18:40,829 --> 00:18:44,339
before we'll find out what the primary

442
00:18:42,539 --> 00:18:46,440

landing site is so let me ask you this

443

00:18:44,339 --> 00:18:48,990

frankly the spinning of the comment and

444

00:18:46,440 --> 00:18:50,789

the the rotation and the fact that they

445

00:18:48,990 --> 00:18:54,029

found out this thing is not a very

446

00:18:50,789 --> 00:18:56,789

regular object does that substantially

447

00:18:54,029 --> 00:18:58,139

complicate the the orbiting are the

448

00:18:56,789 --> 00:19:00,240

landing equations that are going to be

449

00:18:58,140 --> 00:19:02,340

needed or the trajectories or are they

450

00:19:00,240 --> 00:19:05,970

they concerned about that at all do you

451

00:19:02,339 --> 00:19:08,099

know well they very quickly when they

452

00:19:05,970 --> 00:19:10,049

made the initial models of it from what

453

00:19:08,099 --> 00:19:12,750

I understand they recognize that they

454

00:19:10,049 --> 00:19:15,509

couldn't really land on the neck okay on

455

00:19:12,750 --> 00:19:17,579

just because of the way the rotation of

456

00:19:15,509 --> 00:19:20,700

it trying to get into the neck might not

457
00:19:17,579 --> 00:19:22,980
be a really good spot ok so i guess if i

458
00:19:20,700 --> 00:19:25,380
go to the previous one you can see that

459
00:19:22,980 --> 00:19:28,289
they've got three sites that are on the

460
00:19:25,380 --> 00:19:29,850
top of the head and then they've got two

461
00:19:28,289 --> 00:19:32,430
sites on what i would call the tail of

462
00:19:29,849 --> 00:19:37,319
the duck okay we're gonna lay those but

463
00:19:32,430 --> 00:19:39,090
sightsee all right so landing on the

464
00:19:37,319 --> 00:19:41,629
duckies tail or landing on the duckies

465
00:19:39,089 --> 00:19:44,189
head seemed to be the favored sites of

466
00:19:41,630 --> 00:19:46,860
both in terms of the orbital mechanics

467
00:19:44,190 --> 00:19:49,149
of it and perhaps in terms of the

468
00:19:46,859 --> 00:19:53,738
smoothness of the site for for a landing

469
00:19:49,148 --> 00:19:55,928
right that is awesome ya need so here's

470
00:19:53,739 --> 00:19:59,679
a point where Itay amazing things about

471
00:19:55,929 --> 00:20:02,048
ms Emily lakdawala she perceived too

472
00:19:59,679 --> 00:20:04,719
many yes she writes a blog for the

473
00:20:02,048 --> 00:20:07,450
Planetary Society and I just want to

474
00:20:04,719 --> 00:20:09,580
give her a tip of the hat not a wag of

475
00:20:07,450 --> 00:20:11,558
the finger a tip of the hat because so

476
00:20:09,579 --> 00:20:13,028
many it was easy just to go through a

477
00:20:11,558 --> 00:20:15,908
lot of her blog posts and pull out

478
00:20:13,028 --> 00:20:19,808
images for this I will note that the

479
00:20:15,909 --> 00:20:21,580
landing for feel a will occur starting

480
00:20:19,808 --> 00:20:23,678
on November 11th the orbital maneuver

481
00:20:21,579 --> 00:20:26,558
will start on remember 11th and it will

482
00:20:23,679 --> 00:20:30,899
land on november nineteenth so for

483
00:20:26,558 --> 00:20:34,928
thanksgiving we may be serving duck okay

484
00:20:30,898 --> 00:20:38,678
in rubber form rubber duck for

485

00:20:34,929 --> 00:20:40,450
thanksgiving okay alright so that's

486
00:20:38,679 --> 00:20:42,909
great know an emily is outstanding

487
00:20:40,450 --> 00:20:44,739
resource for anybody who wants to keep

488
00:20:42,909 --> 00:20:46,719
abreast of the absolute latest for

489
00:20:44,739 --> 00:20:48,909
twitter feed is also a really a good

490
00:20:46,719 --> 00:20:51,429
source i follow it and I learn more from

491
00:20:48,909 --> 00:20:54,179
that about that small ways like Frank

492
00:20:51,429 --> 00:20:58,419
one of my first choices to go to alright

493
00:20:54,179 --> 00:21:01,210
seldomly that's a story number one I got

494
00:20:58,419 --> 00:21:02,769
three more ritual bit shorter this and

495
00:21:01,210 --> 00:21:04,179
then we actually and in these ones we

496
00:21:02,769 --> 00:21:05,888
actually get back to Hubble because

497
00:21:04,179 --> 00:21:10,359
there wasn't really a Hubble tie-in for

498
00:21:05,888 --> 00:21:12,998
comment rubber ducky there no okay so

499
00:21:10,358 --> 00:21:16,569

our second story today is big bursts of

500

00:21:12,999 --> 00:21:18,909

star formation in distant dwarf galaxies

501

00:21:16,569 --> 00:21:22,148

now what we're really talking about here

502

00:21:18,909 --> 00:21:25,028

are star bursting galaxies okay galaxies

503

00:21:22,148 --> 00:21:28,628

that have these immense amounts of star

504

00:21:25,028 --> 00:21:31,979

formation and one of the prime examples

505

00:21:28,628 --> 00:21:34,598

2.2 is the antennae galaxies shown here

506

00:21:31,979 --> 00:21:36,669

you can see there are two heads and then

507

00:21:34,598 --> 00:21:39,638

these two long tails that go off from

508

00:21:36,669 --> 00:21:42,549

each other these two galaxies were

509

00:21:39,638 --> 00:21:45,488

determined about almost she was the

510

00:21:42,548 --> 00:21:47,679

1970s so that that's 40 years ago it was

511

00:21:45,489 --> 00:21:51,038

determined that these two galaxies have

512

00:21:47,679 --> 00:21:53,499

been on a collision okay and 74 years

513

00:21:51,038 --> 00:21:56,408

yes the collision lasts about a billion

514
00:21:53,499 --> 00:21:58,838
years but it was 40 years ago when the

515
00:21:56,409 --> 00:22:00,669
tomb ray brothers were actually able to

516
00:21:58,838 --> 00:22:02,470
deduce and show from computer

517
00:22:00,669 --> 00:22:04,690
simulations very very

518
00:22:02,470 --> 00:22:07,029
very similar computer simulations back

519
00:22:04,690 --> 00:22:09,788
then that the two galaxies were actually

520
00:22:07,029 --> 00:22:11,740
in the fact of colliding and we believe

521
00:22:09,788 --> 00:22:13,750
that the collision insights star

522
00:22:11,740 --> 00:22:15,880
formation and that star formation is

523
00:22:13,750 --> 00:22:18,579
greatly seen when we go to this Hubble

524
00:22:15,880 --> 00:22:21,490
image of just the central part of it and

525
00:22:18,579 --> 00:22:23,710
you can see all those bright pink

526
00:22:21,490 --> 00:22:26,169
regions which are star forming regions

527
00:22:23,710 --> 00:22:29,470
and all those bright blue stars which

528
00:22:26,169 --> 00:22:31,870
are hot newborn massive stars so all

529
00:22:29,470 --> 00:22:33,819
those pink regions are areas where stars

530
00:22:31,869 --> 00:22:36,279
are currently being born within this

531
00:22:33,819 --> 00:22:38,349
collision right and they are they are

532
00:22:36,279 --> 00:22:41,139
regions that make the Orion Nebula look

533
00:22:38,349 --> 00:22:43,119
puny all right now the Orion Nebula is

534
00:22:41,140 --> 00:22:45,130
one of our closest on our fate most

535
00:22:43,119 --> 00:22:47,408
favorite star forming regions it's got

536
00:22:45,130 --> 00:22:51,010
like about four thousand stars forming

537
00:22:47,409 --> 00:22:53,169
within it these are super star clusters

538
00:22:51,009 --> 00:22:55,658
that are forming here with tens of

539
00:22:53,169 --> 00:22:57,429
thousands of stars and hunt and lots of

540
00:22:55,659 --> 00:22:59,830
lots and lots of stars in the inner

541
00:22:57,429 --> 00:23:01,650
formation so you know these are really

542

00:22:59,829 --> 00:23:04,178
these are big star forming regions

543
00:23:01,650 --> 00:23:05,559
there's a ton of star formation going on

544
00:23:04,179 --> 00:23:08,980
in here and that's what defines

545
00:23:05,558 --> 00:23:10,389
starburst okay are there any preference

546
00:23:08,980 --> 00:23:12,159
the kinds of stars being born here or

547
00:23:10,390 --> 00:23:14,679
there are they a specific type of star

548
00:23:12,159 --> 00:23:17,289
or they just all kinds know we found

549
00:23:14,679 --> 00:23:20,769
that when you form stars you tend to

550
00:23:17,288 --> 00:23:23,500
form stars of all different masses you

551
00:23:20,769 --> 00:23:27,029
form your you form a few really big

552
00:23:23,500 --> 00:23:32,130
massive stars and then a lot of faint

553
00:23:27,029 --> 00:23:34,808
stars I think the average the average

554
00:23:32,130 --> 00:23:36,820
size of a star in a star-forming region

555
00:23:34,808 --> 00:23:39,700
is only a seven tenths of the size of

556
00:23:36,819 --> 00:23:41,769

the Sun stars can go up to hundreds of

557

00:23:39,700 --> 00:23:43,840

times the size of the Sun and down to

558

00:23:41,769 --> 00:23:47,230

about a tenth the size of the Sun but

559

00:23:43,839 --> 00:23:50,769

the average mass is about seven tenths

560

00:23:47,230 --> 00:23:52,839

the size of a sun so you for all the

561

00:23:50,769 --> 00:23:54,460

really big stars you can see here there

562

00:23:52,839 --> 00:23:59,949

are lots more small stars that of course

563

00:23:54,460 --> 00:24:03,880

you can't see so starburst we believe

564

00:23:59,950 --> 00:24:05,710

are induced by an event normal galaxies

565

00:24:03,880 --> 00:24:07,929

just don't have this much star formation

566

00:24:05,710 --> 00:24:11,890

going on here the event is the merging

567

00:24:07,929 --> 00:24:13,840

of two galaxies so we wanted to when

568

00:24:11,890 --> 00:24:15,490

we've studied starbursts we want to

569

00:24:13,839 --> 00:24:16,168

actually study the star formation

570

00:24:15,490 --> 00:24:17,878

history of the

571
00:24:16,169 --> 00:24:19,440
universe and these starburst and

572
00:24:17,878 --> 00:24:21,388
galaxies are the easiest ones to study

573
00:24:19,440 --> 00:24:23,788
because they got so much star formation

574
00:24:21,388 --> 00:24:26,488
going on in them and as we looked out

575
00:24:23,788 --> 00:24:29,249
into the distant universe we use these

576
00:24:26,489 --> 00:24:32,700
deep images from Hubble we've been able

577
00:24:29,249 --> 00:24:34,589
to study star bursting in the big

578
00:24:32,700 --> 00:24:37,200
galaxies and even some of the

579
00:24:34,589 --> 00:24:38,939
medium-sized galaxies so as we look out

580
00:24:37,200 --> 00:24:42,090
into the universe in the formation of

581
00:24:38,940 --> 00:24:46,409
stars and we find that the the peak of

582
00:24:42,089 --> 00:24:49,798
star formation was about 4 or 5 billion

583
00:24:46,409 --> 00:24:53,009
years after the Big Bang okay we sort of

584
00:24:49,798 --> 00:24:54,628
look in the redshift range 1 to 2 which

585
00:24:53,009 --> 00:24:56,519
is about 2 billion years after the Big

586
00:24:54,628 --> 00:24:59,189
Bang to about six or seven billion years

587
00:24:56,519 --> 00:25:01,169
after the Big Bang okay so that there

588
00:24:59,190 --> 00:25:04,259
was a period when most of the stars in

589
00:25:01,169 --> 00:25:05,549
the universe were born exactly okay so

590
00:25:04,259 --> 00:25:08,009
those sort of the peak of star formation

591
00:25:05,548 --> 00:25:10,048
in the universe and so we've looked at

592
00:25:08,009 --> 00:25:11,849
the star bursting galaxies in those

593
00:25:10,048 --> 00:25:16,019
range but only the medium and large ones

594
00:25:11,849 --> 00:25:17,638
and with the wide field camera 3 and in

595
00:25:16,019 --> 00:25:20,399
particular the increased infrared

596
00:25:17,638 --> 00:25:23,008
sensitivity of whiffs III on Hubble

597
00:25:20,398 --> 00:25:26,819
we've been able to extend those studies

598
00:25:23,009 --> 00:25:30,929
to send sample the smaller galaxies and

599

00:25:26,819 --> 00:25:36,509
so this image here there are there are

600
00:25:30,929 --> 00:25:39,330
six red circles around six of the small

601
00:25:36,509 --> 00:25:42,989
dwarf galaxies that they found to be

602
00:25:39,329 --> 00:25:46,739
star bursting ok and they were able to

603
00:25:42,989 --> 00:25:48,480
study these dwarf galaxies in the having

604
00:25:46,739 --> 00:25:50,700
starburst between two and six billion

605
00:25:48,480 --> 00:25:53,339
years out there and it's really

606
00:25:50,700 --> 00:25:55,100
important because dwarf galaxies are the

607
00:25:53,339 --> 00:25:57,178
most numerous galaxies in the universe

608
00:25:55,099 --> 00:25:59,038
just like I said that you know there are

609
00:25:57,179 --> 00:26:01,350
many more smaller stars and there are

610
00:25:59,038 --> 00:26:04,079
big stars there are also many more

611
00:26:01,349 --> 00:26:06,599
smaller galaxies than there are big

612
00:26:04,079 --> 00:26:09,509
galaxies so if these dwarf galaxies are

613
00:26:06,599 --> 00:26:11,128

undergoing starbursts as well well then

614

00:26:09,509 --> 00:26:13,739

that can have a significant effect and

615

00:26:11,128 --> 00:26:17,308

it turns out that they have a really

616

00:26:13,739 --> 00:26:20,009

huge star formation that they can double

617

00:26:17,308 --> 00:26:22,349

the number of stars in them within only

618

00:26:20,009 --> 00:26:25,558

a hundred million or 150 million years

619

00:26:22,349 --> 00:26:27,089

so why is that so why is that so

620

00:26:25,558 --> 00:26:30,009

significant if door because dwarf

621

00:26:27,089 --> 00:26:31,990

galaxies are the most common type of gal

622

00:26:30,009 --> 00:26:34,119

so the most numerous of the galaxies

623

00:26:31,990 --> 00:26:35,799

exactly there's no ser if they're

624

00:26:34,119 --> 00:26:37,719

showing a lot of rapid star formation

625

00:26:35,799 --> 00:26:40,869

then there's a lot more stars than we

626

00:26:37,720 --> 00:26:42,460

think there are maybe exactly if only

627

00:26:40,869 --> 00:26:45,759

you know ten percent of your population

628
00:26:42,460 --> 00:26:47,319
is doing something right well then that

629
00:26:45,759 --> 00:26:50,379
sort of says well you know it's it's

630
00:26:47,319 --> 00:26:52,210
it's a good sub group but it might not

631
00:26:50,380 --> 00:26:54,190
be able to dominate what's really going

632
00:26:52,210 --> 00:26:55,990
on but if ninety percent of your

633
00:26:54,190 --> 00:26:58,590
population is doing something well this

634
00:26:55,990 --> 00:27:03,190
by sheer number they can dominate I

635
00:26:58,589 --> 00:27:05,470
guess we could relate it to the post-war

636
00:27:03,190 --> 00:27:07,150
generation right the baby boomers how

637
00:27:05,470 --> 00:27:08,950
they've had so much population here in

638
00:27:07,150 --> 00:27:10,450
the US and they've been able to dominate

639
00:27:08,950 --> 00:27:14,440
culture as they go through their lives

640
00:27:10,450 --> 00:27:16,900
and cetera so you want the the most

641
00:27:14,440 --> 00:27:19,870
massive population find out what they're

642
00:27:16,900 --> 00:27:22,180
doing then you'll get a better handle on

643
00:27:19,869 --> 00:27:24,069
what's over all happening right well I

644
00:27:22,180 --> 00:27:26,200
don't I don't we I don't want you to put

645
00:27:24,069 --> 00:27:27,399
you on the spot here and so I mean if

646
00:27:26,200 --> 00:27:31,330
you don't know the answer that's okay

647
00:27:27,400 --> 00:27:34,060
but do you have a sense of how much how

648
00:27:31,329 --> 00:27:35,710
many in terms of percent is it like ten

649
00:27:34,059 --> 00:27:37,389
percent more stars twenty percent more

650
00:27:35,710 --> 00:27:40,000
stars than we thought fifty percent more

651
00:27:37,390 --> 00:27:42,220
stars I'll get to that I get to that

652
00:27:40,000 --> 00:27:43,869
number at the end of all I don't want to

653
00:27:42,220 --> 00:27:45,309
steal your punchlines I'm not going to

654
00:27:43,869 --> 00:27:47,649
give you my punchline until a doll and

655
00:27:45,309 --> 00:27:50,440
ready for enough fair enough we're very

656

00:27:47,650 --> 00:27:52,720
close to this okay so these are in the

657
00:27:50,440 --> 00:27:56,529
range what we call extreme emission-line

658
00:27:52,720 --> 00:27:58,720
galaxies ee lg's okay hey we're

659
00:27:56,529 --> 00:28:00,879
measuring their star formation by

660
00:27:58,720 --> 00:28:03,460
looking at the hydrogen alpha line okay

661
00:28:00,880 --> 00:28:05,110
so the amount of hydrogen emission

662
00:28:03,460 --> 00:28:07,620
that's coming on there which we found to

663
00:28:05,109 --> 00:28:10,689
be a very good measure of star formation

664
00:28:07,619 --> 00:28:13,989
and that they are producing stars you

665
00:28:10,690 --> 00:28:16,960
know 100 times more rapidly than normal

666
00:28:13,990 --> 00:28:19,720
galaxies and even several times more

667
00:28:16,960 --> 00:28:22,480
rapidly than our normal star bursts in

668
00:28:19,720 --> 00:28:25,299
the large galaxies so when you add up

669
00:28:22,480 --> 00:28:28,029
all of these uh dwarf galaxies and the

670
00:28:25,299 --> 00:28:30,039

extreme star bursting that they're going

671

00:28:28,029 --> 00:28:31,180

through they calculate well depending

672

00:28:30,039 --> 00:28:35,079

them on how you do things they could

673

00:28:31,180 --> 00:28:38,590

cover about 13 to thirty four percent of

674

00:28:35,079 --> 00:28:40,619

the star formation going on between two

675

00:28:38,589 --> 00:28:43,359

and six billion years after the Big Bang

676

00:28:40,619 --> 00:28:45,129

so they can account for up to one

677

00:28:43,359 --> 00:28:48,548

third of all the star formation

678

00:28:45,130 --> 00:28:49,690

happening at that time previously we

679

00:28:48,548 --> 00:28:52,480

didn't have any information on the

680

00:28:49,690 --> 00:28:55,808

divorce and you know should the divorce

681

00:28:52,480 --> 00:28:57,579

be there awfully awfully small you know

682

00:28:55,808 --> 00:28:59,920

they're down to what 1% the size of a

683

00:28:57,579 --> 00:29:02,529

big galaxy should they really be

684

00:28:59,920 --> 00:29:05,558

considered well the answer is yes it's

685
00:29:02,529 --> 00:29:08,950
very surprising just how much they make

686
00:29:05,558 --> 00:29:10,960
might contribute okay so let me just go

687
00:29:08,950 --> 00:29:13,150
back for a minute here sure we've all

688
00:29:10,960 --> 00:29:15,370
seen this pie chart of the composition

689
00:29:13,150 --> 00:29:16,840
of the universe where all the matter

690
00:29:15,369 --> 00:29:19,119
that we know in the universe is like

691
00:29:16,839 --> 00:29:20,918
four or five percent dark matter makes

692
00:29:19,119 --> 00:29:22,779
up twenty or some odd twenty-five

693
00:29:20,919 --> 00:29:25,660
percent and dark energy makes up the

694
00:29:22,779 --> 00:29:28,359
remaining seventy percent what effect is

695
00:29:25,660 --> 00:29:33,130
this going to do if any on the five

696
00:29:28,359 --> 00:29:34,659
percent slice of pie okay so that five

697
00:29:33,130 --> 00:29:36,730
percent slice of pie will stay the same

698
00:29:34,660 --> 00:29:39,100
okay doesn't it's not changing the

699
00:29:36,730 --> 00:29:40,240
amount of baryonic matter in the

700
00:29:39,099 --> 00:29:43,209
universe the normal matter in the

701
00:29:40,240 --> 00:29:45,460
universe right so let's conserve then I

702
00:29:43,210 --> 00:29:47,890
guess I'll data that that that that does

703
00:29:45,460 --> 00:29:52,120
not affect here what this does have is

704
00:29:47,890 --> 00:29:55,509
where do the stars that we see today get

705
00:29:52,119 --> 00:29:58,149
born are they born in large galaxies are

706
00:29:55,509 --> 00:30:01,000
they born in medium galaxies or are they

707
00:29:58,150 --> 00:30:02,590
born in star and small galaxies what

708
00:30:01,000 --> 00:30:05,829
this result is saying is that up to a

709
00:30:02,589 --> 00:30:08,470
third of them may be born in small

710
00:30:05,829 --> 00:30:10,298
galaxies good all right and I think I

711
00:30:08,470 --> 00:30:12,190
wanted to make because I I don't I don't

712
00:30:10,298 --> 00:30:13,779
want people to think we've discovered a

713

00:30:12,190 --> 00:30:16,269
whole bunch of stars that we didn't know

714
00:30:13,779 --> 00:30:17,859
we're there before it's it's all there

715
00:30:16,269 --> 00:30:21,039
just we're getting a better idea of

716
00:30:17,859 --> 00:30:23,769
where and how these stars are forming at

717
00:30:21,039 --> 00:30:26,379
lynn in the history of universe exactly

718
00:30:23,769 --> 00:30:28,298
we know that we can under we can

719
00:30:26,380 --> 00:30:30,640
approximate the stellar content of the

720
00:30:28,298 --> 00:30:32,798
universe today and we're trying to

721
00:30:30,640 --> 00:30:35,440
figure out how when did they form and

722
00:30:32,798 --> 00:30:37,808
where did they form we figured out when

723
00:30:35,440 --> 00:30:39,130
they formed it appears but now we're

724
00:30:37,808 --> 00:30:41,168
seeing that they actually more of them

725
00:30:39,130 --> 00:30:44,169
form in small galaxies than we had

726
00:30:41,169 --> 00:30:47,410
previously suspected awesome all right

727
00:30:44,169 --> 00:30:49,480

thank you Frank that's cool that is that

728

00:30:47,410 --> 00:30:53,980

story and we're going to move on to

729

00:30:49,480 --> 00:30:57,159

another star bursting object we're going

730

00:30:53,980 --> 00:30:58,749

to talk about a baby elliptical

731

00:30:57,159 --> 00:30:59,919

we've talked about rubber duckies now

732

00:30:58,749 --> 00:31:04,899

we're gonna go cute little baby

733

00:30:59,919 --> 00:31:06,220

elliptical galaxy here so uh when we

734

00:31:04,898 --> 00:31:09,548

think I love to play so there was such a

735

00:31:06,220 --> 00:31:12,009

thing to be honest we've never seen one

736

00:31:09,548 --> 00:31:14,229

before that's the point of this story ok

737

00:31:12,009 --> 00:31:16,509

when you think of ellipticals you don't

738

00:31:14,229 --> 00:31:18,098

think of cute little objects gay maybe

739

00:31:16,509 --> 00:31:20,950

gig there are some dwarf ellipticals

740

00:31:18,098 --> 00:31:23,858

that are small and just galaxies in the

741

00:31:20,950 --> 00:31:26,798

university's right ok so this image here

742
00:31:23,858 --> 00:31:30,278
is of the Perseus cluster of galaxies

743
00:31:26,798 --> 00:31:32,378
all right and because it's far away

744
00:31:30,278 --> 00:31:34,929
right most of the galaxies here are

745
00:31:32,378 --> 00:31:38,138
roughly the same distance so you can

746
00:31:34,929 --> 00:31:40,119
actually compare sizes one to another

747
00:31:38,138 --> 00:31:42,158
and you can see that the largest ones

748
00:31:40,118 --> 00:31:44,769
here are these elliptical galaxies near

749
00:31:42,159 --> 00:31:46,179
the center you can pick out a few spiral

750
00:31:44,769 --> 00:31:48,878
galaxies in here and they're all

751
00:31:46,179 --> 00:31:52,210
considerably smaller so you've got these

752
00:31:48,878 --> 00:31:53,648
giant elliptical galaxies ok I'm sorry

753
00:31:52,210 --> 00:31:56,739
nice thing how far away this cluster was

754
00:31:53,648 --> 00:31:58,418
i did not i actually just wanted to use

755
00:31:56,739 --> 00:32:02,229
this as an example of giant ellipticals

756
00:31:58,419 --> 00:32:04,119
ok ok veral rocks they're all about the

757
00:32:02,229 --> 00:32:05,319
same all the same way very far away

758
00:32:04,118 --> 00:32:07,689
there are hundreds of millions of light

759
00:32:05,319 --> 00:32:11,079
years away how about that yeah ok all

760
00:32:07,690 --> 00:32:12,940
right and so we got these giant

761
00:32:11,079 --> 00:32:14,858
ellipticals and we believe that dense

762
00:32:12,940 --> 00:32:17,889
they existed they we find them a lot of

763
00:32:14,858 --> 00:32:20,918
the cores of clusters that they accrete

764
00:32:17,888 --> 00:32:22,748
their their mass by merging ok I showed

765
00:32:20,919 --> 00:32:24,580
you one an image of merging previously

766
00:32:22,749 --> 00:32:26,200
but at the center of a cluster of

767
00:32:24,579 --> 00:32:28,388
galaxies you would naturally get more

768
00:32:26,200 --> 00:32:31,509
merging and that was where you find

769
00:32:28,388 --> 00:32:33,459
these giant ellipticals but so we can

770

00:32:31,509 --> 00:32:36,159
see how they grow but we wanted to know

771
00:32:33,460 --> 00:32:37,960
how do these giant elliptical start

772
00:32:36,159 --> 00:32:40,210
these these galaxies that become the

773
00:32:37,960 --> 00:32:42,909
these big galaxies how do they really

774
00:32:40,210 --> 00:32:46,149
start and we can look back out and out

775
00:32:42,909 --> 00:32:49,629
into these deep images all right we can

776
00:32:46,148 --> 00:32:51,219
take a look at this is a galaxy in the

777
00:32:49,628 --> 00:32:54,248
coma cluster Nalepa GALEX in the coma

778
00:32:51,220 --> 00:32:57,639
cluster and so they have these dense

779
00:32:54,249 --> 00:33:00,038
cores at their Center and we believe

780
00:32:57,638 --> 00:33:02,258
that these must form relatively early on

781
00:33:00,038 --> 00:33:05,048
in the universe ok because you got very

782
00:33:02,259 --> 00:33:08,019
old stars in here and we can account for

783
00:33:05,048 --> 00:33:09,308
growth by emerging and we can look out

784
00:33:08,019 --> 00:33:10,359

into the universe and trace them back

785

00:33:09,308 --> 00:33:12,099

but

786

00:33:10,359 --> 00:33:15,399

what we really wanted to find is that

787

00:33:12,099 --> 00:33:17,829

formation of that core all right and we

788

00:33:15,400 --> 00:33:19,480

hadn't been able to see that yet okay we

789

00:33:17,829 --> 00:33:21,490

wanted to find the formation of that

790

00:33:19,480 --> 00:33:25,240

that that initial core which probably

791

00:33:21,490 --> 00:33:27,299

grew very very very fast well we did one

792

00:33:25,240 --> 00:33:31,809

of these deep images of the universe

793

00:33:27,299 --> 00:33:35,319

searching for this and again using the

794

00:33:31,809 --> 00:33:36,819

infrared capabilities of with c3 just

795

00:33:35,319 --> 00:33:39,970

letting you know that the infrared is is

796

00:33:36,819 --> 00:33:42,669

is proven to be extremely useful on with

797

00:33:39,970 --> 00:33:46,150

c3 they identify this object here this

798

00:33:42,670 --> 00:33:48,880

orangish object here as pot as being a

799
00:33:46,150 --> 00:33:51,850
really good candidate for being the core

800
00:33:48,880 --> 00:33:54,460
of what would become a future elliptical

801
00:33:51,849 --> 00:33:56,230
galaxy now what are the special

802
00:33:54,460 --> 00:33:58,630
characteristics of this object that make

803
00:33:56,230 --> 00:34:01,509
it so make it a candidate well it's

804
00:33:58,630 --> 00:34:05,200
really tiny it's about 6,000 light-years

805
00:34:01,509 --> 00:34:07,420
across whereas a galaxy like our Milky

806
00:34:05,200 --> 00:34:10,539
Way is a hundred thousand light-years

807
00:34:07,420 --> 00:34:12,780
across six thousand verses a hundred

808
00:34:10,539 --> 00:34:16,179
thousand so this is smaller even than

809
00:34:12,780 --> 00:34:18,760
the Bulge of our Milky Way galaxy the

810
00:34:16,179 --> 00:34:25,269
core of a large galaxy it's smaller than

811
00:34:18,760 --> 00:34:28,630
that but already this object has as many

812
00:34:25,269 --> 00:34:31,619
stars in it as are in our entire Milky

813
00:34:28,630 --> 00:34:35,400
Way galaxy so it's a ton of stars

814
00:34:31,619 --> 00:34:38,529
compressed down to a very small region

815
00:34:35,400 --> 00:34:43,780
furthermore this object is seen at a

816
00:34:38,530 --> 00:34:45,550
redshift of 2.3 which places it at three

817
00:34:43,780 --> 00:34:49,870
billion years after the Big Bang or

818
00:34:45,550 --> 00:34:52,600
eleven billion years ago so

819
00:34:49,869 --> 00:34:54,909
this is an object that happened very

820
00:34:52,599 --> 00:34:59,739
early in the universe formed a ton of

821
00:34:54,909 --> 00:35:02,769
stars into a very small region they

822
00:34:59,739 --> 00:35:05,079
measured and the able to measure the

823
00:35:02,769 --> 00:35:07,090
star-formation rate going on in here and

824
00:35:05,079 --> 00:35:09,099
again intensely high another star

825
00:35:07,090 --> 00:35:11,289
bursting thing and looking at the

826
00:35:09,099 --> 00:35:13,539
history of it trying to gauge the ages

827

00:35:11,289 --> 00:35:15,369
of things so that they could try and

828
00:35:13,539 --> 00:35:17,050
interpolate the history of it they

829
00:35:15,369 --> 00:35:19,480
figured probably had been going on for

830
00:35:17,050 --> 00:35:22,480
about a billion years so you're talking

831
00:35:19,480 --> 00:35:23,869
tense star-formation rate for about a

832
00:35:22,480 --> 00:35:26,630
billion years

833
00:35:23,869 --> 00:35:28,970
now it wasn't just Hubble that was

834
00:35:26,630 --> 00:35:31,548
involved in this study that

835
00:35:28,969 --> 00:35:33,469
star-formation rate from Hubble would

836
00:35:31,548 --> 00:35:35,599
have actually been about one-sixth of

837
00:35:33,469 --> 00:35:40,578
the star-formation rate I just quoted to

838
00:35:35,599 --> 00:35:42,920
you instead they used observations from

839
00:35:40,579 --> 00:35:45,740
the Spitzer Space Telescope and from

840
00:35:42,920 --> 00:35:47,349
Herschel Space Telescope to look deeper

841
00:35:45,739 --> 00:35:50,778

into the infrared than Hubble can see

842

00:35:47,349 --> 00:35:53,269

and find more information and the deeper

843

00:35:50,778 --> 00:35:54,440

infrared wavelengths that showed that

844

00:35:53,268 --> 00:35:57,169

the star-formation rate was actually

845

00:35:54,440 --> 00:35:59,389

higher than we would deduce from just

846

00:35:57,170 --> 00:36:02,900

Hubble's observations actually about six

847

00:35:59,389 --> 00:36:05,389

times higher all right so by having this

848

00:36:02,900 --> 00:36:08,240

incredibly high star-formation rate and

849

00:36:05,389 --> 00:36:10,429

not being able to see it with Hubble the

850

00:36:08,239 --> 00:36:14,419

implication of that is that there's a

851

00:36:10,429 --> 00:36:18,739

lot of dust obscuring this galaxy okay

852

00:36:14,420 --> 00:36:22,490

or this core of a galaxy so the the

853

00:36:18,739 --> 00:36:24,258

postulations conclusion really is that

854

00:36:22,489 --> 00:36:28,488

the reason we haven't seen these before

855

00:36:24,259 --> 00:36:30,619

is that we haven't that they are highly

856
00:36:28,489 --> 00:36:32,269
obscured with lots of dust there's

857
00:36:30,619 --> 00:36:35,119
tremendous amount of star formation

858
00:36:32,268 --> 00:36:37,219
kicking up lots of dust or within this

859
00:36:35,119 --> 00:36:39,739
galaxy they're heavily reddened and

860
00:36:37,219 --> 00:36:41,568
obscured by this dust and so we're not

861
00:36:39,739 --> 00:36:44,179
going to see them very well with visible

862
00:36:41,568 --> 00:36:45,619
or with near-infrared light we need a

863
00:36:44,179 --> 00:36:47,028
little bit longer infrared light to be

864
00:36:45,619 --> 00:36:49,400
able to penetrate through some of that

865
00:36:47,028 --> 00:36:52,429
dust and be able to find more of these

866
00:36:49,400 --> 00:36:53,989
cores of elliptical galaxies which James

867
00:36:52,429 --> 00:36:56,149
Webb will be able to do pretty well oh

868
00:36:53,989 --> 00:36:58,548
you go straight to the punch line there

869
00:36:56,150 --> 00:37:01,489
yeah we go that's that's the conclusion

870
00:36:58,548 --> 00:37:03,858
that we have to jump to right no simply

871
00:37:01,489 --> 00:37:06,880
because a we're going to need the longer

872
00:37:03,858 --> 00:37:08,869
wavelengths james j ust will have the

873
00:37:06,880 --> 00:37:10,970
infrared wavelengths it will have the

874
00:37:08,869 --> 00:37:14,690
resolution of Hubble it will be able to

875
00:37:10,969 --> 00:37:17,389
see objects like this are much much more

876
00:37:14,690 --> 00:37:20,778
easily than either Hubble or Spitzer or

877
00:37:17,389 --> 00:37:23,778
Herschel ok so we got it we got an

878
00:37:20,778 --> 00:37:25,730
elliptical here three billion years

879
00:37:23,778 --> 00:37:28,068
after the after the Big Bang it's been

880
00:37:25,730 --> 00:37:30,650
burning that's been forming stars for

881
00:37:28,068 --> 00:37:33,048
about a billion years yep give us some

882
00:37:30,650 --> 00:37:35,920
context compare that with our Milky Way

883
00:37:33,048 --> 00:37:39,309
how old is our Milky Way galaxy and how

884

00:37:35,920 --> 00:37:43,059
let's see the the basic core of our

885
00:37:39,309 --> 00:37:45,039
Milky Way galaxy the basic dis / / Milky

886
00:37:43,059 --> 00:37:48,250
Way galaxy we believe is about 9 or 10

887
00:37:45,039 --> 00:37:50,289
billion years old so about a billion to

888
00:37:48,250 --> 00:37:52,659
two billion years after the core of this

889
00:37:50,289 --> 00:37:54,400
elliptical galaxies formed would be when

890
00:37:52,659 --> 00:37:57,039
the basic structure of our Milky Way

891
00:37:54,400 --> 00:37:59,110
formed but we wait a mountain elkeson ah

892
00:37:57,039 --> 00:38:01,509
so we've got a galaxy that's very old

893
00:37:59,110 --> 00:38:04,360
and we're still a spiral I thought

894
00:38:01,510 --> 00:38:06,550
ellipticals were among the oldest and

895
00:38:04,360 --> 00:38:08,860
they were among the they were the result

896
00:38:06,550 --> 00:38:11,380
of a lot of galaxy collisions that

897
00:38:08,860 --> 00:38:12,820
ultimately did not have stars forming in

898
00:38:11,380 --> 00:38:14,860

them and you've shown us an elliptical

899

00:38:12,820 --> 00:38:16,690

that does have stars forming in them so

900

00:38:14,860 --> 00:38:20,050

the processes can't be the same right

901

00:38:16,690 --> 00:38:22,480

this this elliptical wasn't formed like

902

00:38:20,050 --> 00:38:24,430

most elliptical well this elliptical was

903

00:38:22,480 --> 00:38:28,570

formed very early it started its

904

00:38:24,429 --> 00:38:30,849

formation very early and had uh and and

905

00:38:28,570 --> 00:38:34,269

and could not have formed in a low

906

00:38:30,849 --> 00:38:36,730

density quiescent way okay and if a

907

00:38:34,269 --> 00:38:39,400

galaxy forms quietly you know and things

908

00:38:36,730 --> 00:38:42,570

slowly drift on to collapse onto it

909

00:38:39,400 --> 00:38:45,010

right the angular momentum of the

910

00:38:42,570 --> 00:38:48,070

collapse is going to naturally produce a

911

00:38:45,010 --> 00:38:51,280

disk all right so spirals form in a

912

00:38:48,070 --> 00:38:53,980

relatively quiet fashion okay if you

913
00:38:51,280 --> 00:38:55,840
form in a very dense neighborhood when

914
00:38:53,980 --> 00:38:58,150
you get lots of small sub clumps that

915
00:38:55,840 --> 00:39:00,070
gather together and smash together like

916
00:38:58,150 --> 00:39:03,220
the early universe right the earlier

917
00:39:00,070 --> 00:39:05,410
universe which was was denser right then

918
00:39:03,219 --> 00:39:07,599
you're going to naturally get a more

919
00:39:05,409 --> 00:39:10,539
randomization of your orbits and you'll

920
00:39:07,599 --> 00:39:12,819
end up with elliptical shapes awesome

921
00:39:10,539 --> 00:39:15,000
all right thank you ya got that makes I

922
00:39:12,820 --> 00:39:17,289
understand that's cool thanks okay so

923
00:39:15,000 --> 00:39:19,179
that the main question that we want to

924
00:39:17,289 --> 00:39:22,449
be able to answer is just how many of

925
00:39:19,179 --> 00:39:24,489
these exist how prevalent are these can

926
00:39:22,449 --> 00:39:29,589
we get lots of baby elliptical galaxies

927
00:39:24,489 --> 00:39:31,539
and how can we really study this as a

928
00:39:29,590 --> 00:39:34,150
group because if you have one object

929
00:39:31,539 --> 00:39:36,099
okay that's great that's a nice tick

930
00:39:34,150 --> 00:39:38,200
mark you can I care but can you

931
00:39:36,099 --> 00:39:41,110
extrapolate from that into the

932
00:39:38,199 --> 00:39:42,699
characteristics or group no you want to

933
00:39:41,110 --> 00:39:44,230
be able to get a group of these and that

934
00:39:42,699 --> 00:39:45,819
is something that we will definitely

935
00:39:44,230 --> 00:39:46,740
study with the James Webb Space

936
00:39:45,820 --> 00:39:49,350
Telescope

937
00:39:46,739 --> 00:39:50,669
okay all right all right let me just

938
00:39:49,349 --> 00:39:52,409
before we leave this topic judy has

939
00:39:50,670 --> 00:39:53,579
another question and I just wanted since

940
00:39:52,409 --> 00:39:54,960
it's relevant I'll bring it up Judy

941

00:39:53,579 --> 00:39:56,730
Schmidt that does this bring us any

942
00:39:54,960 --> 00:39:59,099
closer to understanding the origins of

943
00:39:56,730 --> 00:40:00,690
globular clusters I meant this question

944
00:39:59,099 --> 00:40:04,920
in reference to the dwarf galaxy study

945
00:40:00,690 --> 00:40:09,420
so so in terms of the understanding of

946
00:40:04,920 --> 00:40:12,360
globular clusters that's a special topic

947
00:40:09,420 --> 00:40:14,789
ok because globular clusters can have

948
00:40:12,360 --> 00:40:19,740
hundreds of thousands to even millions

949
00:40:14,789 --> 00:40:22,050
of stars and we know that the globular

950
00:40:19,739 --> 00:40:25,259
clusters in our Milky Way galaxy are all

951
00:40:22,050 --> 00:40:27,930
very old general generally very very old

952
00:40:25,260 --> 00:40:29,700
and that there was a special formation

953
00:40:27,929 --> 00:40:33,029
process for these globular clusters

954
00:40:29,699 --> 00:40:35,460
about 12 billion years ago all right so

955
00:40:33,030 --> 00:40:39,090

even a little earlier than this galaxy

956

00:40:35,460 --> 00:40:42,240

that we see here and we've also found

957

00:40:39,090 --> 00:40:45,180

that we believe that that when you see

958

00:40:42,239 --> 00:40:48,629

evidence of mergers you also see a

959

00:40:45,179 --> 00:40:51,509

higher number of globular clusters so

960

00:40:48,630 --> 00:40:55,500

that globular clusters seem to also be

961

00:40:51,510 --> 00:40:58,230

formed during mergers so the merging

962

00:40:55,500 --> 00:41:01,260

sequences can obviously incite the kind

963

00:40:58,230 --> 00:41:04,349

of the kind of conditions that form

964

00:41:01,260 --> 00:41:05,880

globular clusters so the formation of a

965

00:41:04,349 --> 00:41:08,489

globular cluster seems to be an extreme

966

00:41:05,880 --> 00:41:10,890

version of star cluster formation and

967

00:41:08,489 --> 00:41:13,079

we're not exactly sure what the

968

00:41:10,889 --> 00:41:18,659

characteristics are of that it's still

969

00:41:13,079 --> 00:41:21,029

actively understudy and this this this

970
00:41:18,659 --> 00:41:23,159
shows us is on a much larger scale in

971
00:41:21,030 --> 00:41:25,740
terms of the number of stars here so it

972
00:41:23,159 --> 00:41:28,379
gives us some implication in terms of

973
00:41:25,739 --> 00:41:29,849
when the galaxy start forming but the

974
00:41:28,380 --> 00:41:32,400
globular clusters that are small parts

975
00:41:29,849 --> 00:41:34,618
of those it doesn't quite tell us

976
00:41:32,400 --> 00:41:38,519
anything about that okay Causton thank

977
00:41:34,619 --> 00:41:43,380
you Judy all right so our final topic

978
00:41:38,519 --> 00:41:45,989
for today a Space Oddity all right and

979
00:41:43,380 --> 00:41:47,970
I'm going to start with a image that you

980
00:41:45,989 --> 00:41:50,309
may have seen before actually I hope you

981
00:41:47,969 --> 00:41:54,989
have seen before it's a cool image of a

982
00:41:50,309 --> 00:41:57,619
galaxy cluster called a bill 68 and a

983
00:41:54,989 --> 00:41:59,969
bell 68 is one of those gravitationally

984
00:41:57,619 --> 00:42:01,829
gravitational lensing clusters

985
00:41:59,969 --> 00:42:05,009
alright if you know will that know what

986
00:42:01,829 --> 00:42:08,279
that means Einstein's theory of general

987
00:42:05,010 --> 00:42:10,680
relativity tells us that mass warps

988
00:42:08,280 --> 00:42:12,780
space actually that's my favorite three

989
00:42:10,679 --> 00:42:16,799
word summary of general relativity mass

990
00:42:12,780 --> 00:42:18,410
warps space okay that's that's all you

991
00:42:16,800 --> 00:42:22,200
need to know about general relativity

992
00:42:18,409 --> 00:42:25,019
but in this case there is so much mass

993
00:42:22,199 --> 00:42:27,629
here in this cluster of galaxies that it

994
00:42:25,019 --> 00:42:30,750
warps space so much that the light

995
00:42:27,630 --> 00:42:34,440
passing through that space changes in

996
00:42:30,750 --> 00:42:36,780
diverges okay it acts like a lens and it

997
00:42:34,440 --> 00:42:40,920
redirects the light from galaxies that

998

00:42:36,780 --> 00:42:43,200
on the far side this cluster and there's

999
00:42:40,920 --> 00:42:45,358
a really cool effect of that happens you

1000
00:42:43,199 --> 00:42:47,969
can see they're a bunch of streaky

1001
00:42:45,358 --> 00:42:50,039
things around this cluster long thin

1002
00:42:47,969 --> 00:42:51,480
things that these are galaxies that are

1003
00:42:50,039 --> 00:42:53,730
behind the cluster whose light has been

1004
00:42:51,480 --> 00:42:55,619
stretched out into these long streaky

1005
00:42:53,730 --> 00:43:00,240
things by the gravitational lensing of

1006
00:42:55,619 --> 00:43:02,369
the cluster but there's also this object

1007
00:43:00,239 --> 00:43:06,929
right here that I put a box around okay

1008
00:43:02,369 --> 00:43:12,289
um and if we blow that guy up uh you can

1009
00:43:06,929 --> 00:43:12,289
see it's God really interesting shape

1010
00:43:12,858 --> 00:43:18,630
matter of fact it doesn't belong in a

1011
00:43:15,929 --> 00:43:22,529
galaxy cluster it looks like it belongs

1012
00:43:18,630 --> 00:43:29,519

in a 1970s video game yeah I knew you're

1013

00:43:22,530 --> 00:43:32,269

going there definitely space invaders so

1014

00:43:29,519 --> 00:43:35,460

this week all the space invader galaxy

1015

00:43:32,269 --> 00:43:37,769

but of course it's not a space invader

1016

00:43:35,460 --> 00:43:39,838

galaxy this is not it's true shape it's

1017

00:43:37,769 --> 00:43:42,119

been gravitationally lens you can see

1018

00:43:39,838 --> 00:43:44,429

the two yellow dots that form the eyes

1019

00:43:42,119 --> 00:43:47,220

of the space invader right well that's

1020

00:43:44,429 --> 00:43:49,440

the same yellow dot but traveling to

1021

00:43:47,219 --> 00:43:51,029

different paths through the mass of the

1022

00:43:49,440 --> 00:43:53,429

cluster through this warped space around

1023

00:43:51,030 --> 00:43:54,960

this cluster it's doubly image so that

1024

00:43:53,429 --> 00:43:58,949

you can see there's sort of a mirror

1025

00:43:54,960 --> 00:44:01,559

reflection left to right of the the

1026

00:43:58,949 --> 00:44:03,210

features of this galaxy so the galaxies

1027
00:44:01,559 --> 00:44:05,549
features have been warped Stape and

1028
00:44:03,210 --> 00:44:08,550
changed and they've been mirrored so

1029
00:44:05,550 --> 00:44:09,720
that you see two mirror images of it and

1030
00:44:08,550 --> 00:44:12,450
then you get this beautiful space

1031
00:44:09,719 --> 00:44:13,679
invader I don't know if you ever saw a

1032
00:44:12,449 --> 00:44:15,629
movie in nineteen

1033
00:44:13,679 --> 00:44:17,699
he's called crawl it was this really

1034
00:44:15,630 --> 00:44:20,610
kind of cheesy fantasy movie looks like

1035
00:44:17,699 --> 00:44:23,009
a bad guy in that had really big really

1036
00:44:20,610 --> 00:44:24,090
big horns and got kinda looks like horn

1037
00:44:23,010 --> 00:44:28,950
sticking out of his head and everything

1038
00:44:24,090 --> 00:44:31,740
else I reminded me of that too okay well

1039
00:44:28,949 --> 00:44:35,789
you could definitely use this as a bad

1040
00:44:31,739 --> 00:44:37,919
guy to moving but a bell 68 has more

1041
00:44:35,789 --> 00:44:39,960
interesting features than this ad listen

1042
00:44:37,920 --> 00:44:42,269
there's another oddity in a bell 68 that

1043
00:44:39,960 --> 00:44:44,190
I wanted to point out so that one was

1044
00:44:42,269 --> 00:44:47,070
gravitational lensing but this one over

1045
00:44:44,190 --> 00:44:49,170
here in the upper right you can see this

1046
00:44:47,070 --> 00:44:51,690
galaxy here now let me pull that up and

1047
00:44:49,170 --> 00:44:54,090
big alright and you can see this is a

1048
00:44:51,690 --> 00:44:56,760
galaxy where it looks like it's raining

1049
00:44:54,090 --> 00:45:00,180
right you've got all these sort of

1050
00:44:56,760 --> 00:45:03,210
droplets coming down coming down from

1051
00:45:00,179 --> 00:45:08,969
the galaxy and we're looking at that I

1052
00:45:03,210 --> 00:45:11,460
have to mute my phone anyways um look

1053
00:45:08,969 --> 00:45:13,609
like it's raining down and then how that

1054
00:45:11,460 --> 00:45:16,199
looks really strange to that's an oddity

1055

00:45:13,610 --> 00:45:19,680
what's happening here is not

1056
00:45:16,199 --> 00:45:21,449
gravitational lensing instead the galaxy

1057
00:45:19,679 --> 00:45:23,639
is moving through the intracluster gas

1058
00:45:21,449 --> 00:45:26,879
there's lots of gas in between these

1059
00:45:23,639 --> 00:45:30,239
galaxies and that gas is actually Ram

1060
00:45:26,880 --> 00:45:33,690
pressure stripping material out of this

1061
00:45:30,239 --> 00:45:35,789
galaxy that's amazing yeah so what looks

1062
00:45:33,690 --> 00:45:39,119
like teardrops falling from this galaxy

1063
00:45:35,789 --> 00:45:41,340
this crying galaxy is actually material

1064
00:45:39,119 --> 00:45:43,889
just being stripped so as you're moving

1065
00:45:41,340 --> 00:45:46,470
through this dense intracluster medium

1066
00:45:43,889 --> 00:45:47,849
some of the gas is being stripped all

1067
00:45:46,469 --> 00:45:50,549
right and we're getting star formation

1068
00:45:47,849 --> 00:45:53,849
in that strip gas forming these

1069
00:45:50,550 --> 00:45:55,500

wonderful wonderful little raindrops

1070

00:45:53,849 --> 00:45:57,900
coming out of the galaxy or tears

1071

00:45:55,500 --> 00:46:03,090
flowing down from the galaxy it's a sad

1072

00:45:57,900 --> 00:46:05,099
GALEX so this is a really cool image

1073

00:46:03,090 --> 00:46:09,750
here in a bell 68 in that you get to see

1074

00:46:05,099 --> 00:46:14,360
both a gravitational lensing oddity as

1075

00:46:09,750 --> 00:46:17,880
well as a physics-based oddity okay so

1076

00:46:14,360 --> 00:46:21,269
with Hubble we're doing a study looking

1077

00:46:17,880 --> 00:46:25,820
at gravitational lensing clusters and in

1078

00:46:21,269 --> 00:46:27,599
one of the clusters they saw this and

1079

00:46:25,820 --> 00:46:28,710
here you can see this

1080

00:46:27,599 --> 00:46:29,849
is a cluster that's producing

1081

00:46:28,710 --> 00:46:31,710
gravitational lensing if you look

1082

00:46:29,849 --> 00:46:33,028
carefully you can see some streaks and

1083

00:46:31,710 --> 00:46:37,019
arching especially see this almost

1084
00:46:33,028 --> 00:46:39,088
circular grouping of streaks and arcs

1085
00:46:37,018 --> 00:46:41,399
around the central center of the cluster

1086
00:46:39,088 --> 00:46:42,838
and you say wow that's a lot of

1087
00:46:41,400 --> 00:46:46,349
gravitational lensing going on here

1088
00:46:42,838 --> 00:46:49,768
right yes so when you look in the center

1089
00:46:46,349 --> 00:46:51,720
and you see these blue crazy little are

1090
00:46:49,768 --> 00:46:52,828
key you know things you immediately

1091
00:46:51,719 --> 00:46:56,598
think well that's got to be

1092
00:46:52,829 --> 00:46:59,579
gravitational lensing right it's not

1093
00:46:56,599 --> 00:47:01,650
they did a study with another telescope

1094
00:46:59,579 --> 00:47:03,869
and within the radio telescope to look

1095
00:47:01,650 --> 00:47:05,970
forward to try and look at the the

1096
00:47:03,869 --> 00:47:08,460
details of it and they proved that it's

1097
00:47:05,969 --> 00:47:12,088
not gravitational lensing which makes

1098
00:47:08,460 --> 00:47:14,369
you go whoa okay now what are we going

1099
00:47:12,088 --> 00:47:17,338
to do this because where are you going

1100
00:47:14,369 --> 00:47:22,309
to get these bright blue sort of spiral

1101
00:47:17,338 --> 00:47:25,798
shapes really long elongated knots of

1102
00:47:22,309 --> 00:47:27,298
what looked like bright stars here okay

1103
00:47:25,798 --> 00:47:29,639
so let's just look at it

1104
00:47:27,298 --> 00:47:31,739
phenomenologically first okay this thing

1105
00:47:29,639 --> 00:47:34,889
is about a hundred thousand light years

1106
00:47:31,739 --> 00:47:36,690
long alright that's stretching from side

1107
00:47:34,889 --> 00:47:39,018
to side all the way across the Milky Way

1108
00:47:36,690 --> 00:47:43,440
galaxy so this is a galactic scale

1109
00:47:39,018 --> 00:47:45,568
streamer plus it's got some spirals

1110
00:47:43,440 --> 00:47:47,639
shape too it's got a little to a bit of

1111
00:47:45,568 --> 00:47:50,608
a coil shaped and it seems to be wrapped

1112

00:47:47,639 --> 00:47:54,179
in amongst these two colliding galaxies

1113
00:47:50,608 --> 00:47:56,909
so you've got a lot of this long thin

1114
00:47:54,179 --> 00:47:58,739
streamer with this spiraling shape

1115
00:47:56,909 --> 00:48:01,558
alright and then you've got these knots

1116
00:47:58,739 --> 00:48:05,039
along it and if you analyze those knots

1117
00:48:01,559 --> 00:48:09,048
they believe that these knots are star

1118
00:48:05,039 --> 00:48:12,749
clusters not just star clusters but

1119
00:48:09,048 --> 00:48:14,460
super star clusters like the big star

1120
00:48:12,748 --> 00:48:21,028
clusters that we saw in the antennae

1121
00:48:14,460 --> 00:48:22,228
galaxies so it's really kind of cool all

1122
00:48:21,028 --> 00:48:24,748
right that you've got this amazing

1123
00:48:22,228 --> 00:48:26,489
structure and they wanted to do an

1124
00:48:24,748 --> 00:48:29,218
analogy for it for the press release and

1125
00:48:26,489 --> 00:48:31,528
so they took the analogy well the

1126
00:48:29,219 --> 00:48:34,469

physical process behind this is what we

1127

00:48:31,528 --> 00:48:38,009

call the genes instability okay and the

1128

00:48:34,469 --> 00:48:40,309

genes instability governs when a a cloud

1129

00:48:38,009 --> 00:48:41,429

of gas becomes self-gravitating and

1130

00:48:40,309 --> 00:48:44,490

color

1131

00:48:41,429 --> 00:48:48,449

apps down to form stars or star clusters

1132

00:48:44,489 --> 00:48:50,129

okay and so when you get a jeans mass of

1133

00:48:48,449 --> 00:48:52,739

material then it can become

1134

00:48:50,130 --> 00:48:57,568

self-gravitating and unstable to forming

1135

00:48:52,739 --> 00:49:00,959

stars and clusters right but that's kind

1136

00:48:57,568 --> 00:49:03,088

of in this long thin in this long thin

1137

00:49:00,960 --> 00:49:05,818

streamer you would have separate regions

1138

00:49:03,088 --> 00:49:07,949

that reach green jeans mass criticality

1139

00:49:05,818 --> 00:49:09,808

and and then would start to start to

1140

00:49:07,949 --> 00:49:13,289

collapse and that's how you get these

1141
00:49:09,809 --> 00:49:14,790
knots along the streamer so the analogy

1142
00:49:13,289 --> 00:49:17,308
that they they used in the press release

1143
00:49:14,789 --> 00:49:20,789
was with the water coming out of the

1144
00:49:17,309 --> 00:49:24,390
faucet in your kitchen sink if you have

1145
00:49:20,789 --> 00:49:27,779
a smooth very thin laminar flow leaving

1146
00:49:24,389 --> 00:49:30,808
your faucet at some point it's going to

1147
00:49:27,780 --> 00:49:33,599
collapse in upon itself and form water

1148
00:49:30,809 --> 00:49:37,319
droplets okay this is a well-known

1149
00:49:33,599 --> 00:49:40,380
physical effect and it has a similar

1150
00:49:37,318 --> 00:49:42,539
analogy of the physical effects as to

1151
00:49:40,380 --> 00:49:46,108
the formation of these clusters along

1152
00:49:42,539 --> 00:49:47,880
the long thin streamer of gas now I have

1153
00:49:46,108 --> 00:49:49,828
to be totally honest with you it's not

1154
00:49:47,880 --> 00:49:52,108
an exact analogy in terms of physics

1155
00:49:49,829 --> 00:49:53,609
because the water involves the

1156
00:49:52,108 --> 00:49:56,548
turbulence and within the water and the

1157
00:49:53,608 --> 00:49:59,009
Reynolds number as well as the surface

1158
00:49:56,548 --> 00:50:01,880
tension of the water also plays a very

1159
00:49:59,010 --> 00:50:03,809
important role and you've got a

1160
00:50:01,880 --> 00:50:05,849
gravitational field that that's within

1161
00:50:03,809 --> 00:50:08,519
so it's not a perfect analogy here but

1162
00:50:05,849 --> 00:50:10,700
it's a useful visual analogue for you to

1163
00:50:08,519 --> 00:50:14,969
understand that these physical processes

1164
00:50:10,699 --> 00:50:19,460
that happen in your kitchen sink can

1165
00:50:14,969 --> 00:50:24,000
also happen on scales of entire galaxies

1166
00:50:19,460 --> 00:50:25,619
and that's that's a lot of fun yeah was

1167
00:50:24,000 --> 00:50:27,088
I mean it was just a time when everybody

1168
00:50:25,619 --> 00:50:28,920
thought that everything happened up in

1169

00:50:27,088 --> 00:50:31,019
this guy was if the universe was very

1170
00:50:28,920 --> 00:50:32,970
static place had never changed much and

1171
00:50:31,019 --> 00:50:34,619
with tell over the past 25 years with

1172
00:50:32,969 --> 00:50:35,969
Hubble and even though you know so many

1173
00:50:34,619 --> 00:50:38,730
other instruments we're learning that

1174
00:50:35,969 --> 00:50:41,250
how the universe is like completely on

1175
00:50:38,730 --> 00:50:44,039
just fire it's just doing all kinds of

1176
00:50:41,250 --> 00:50:46,469
things and as far from static so you and

1177
00:50:44,039 --> 00:50:49,829
you know and educationally it's a

1178
00:50:46,469 --> 00:50:52,318
fundamental lesson of science that what

1179
00:50:49,829 --> 00:50:54,359
happens here on earth happens elsewhere

1180
00:50:52,318 --> 00:50:55,050
in the universe you know that's sort of

1181
00:50:54,358 --> 00:50:57,239
an assumption

1182
00:50:55,050 --> 00:50:59,130
we make in science but here's a skiff

1183
00:50:57,239 --> 00:51:00,899

this is the you know got to be the

1184
00:50:59,130 --> 00:51:03,090
biggest scale change one of the biggest

1185
00:51:00,900 --> 00:51:04,889
fail scale change possible going from

1186
00:51:03,090 --> 00:51:07,559
your kitchen sink all the way to the

1187
00:51:04,889 --> 00:51:09,119
scale of an entire galaxy using the same

1188
00:51:07,559 --> 00:51:11,039
sort of physics showing that they hate

1189
00:51:09,119 --> 00:51:13,859
the physics equations work here they

1190
00:51:11,039 --> 00:51:16,469
also work there that's uh that's that's

1191
00:51:13,860 --> 00:51:18,000
a nice perspective on the universe I

1192
00:51:16,469 --> 00:51:19,500
think it's amazing what did you say that

1193
00:51:18,000 --> 00:51:23,940
did you say with how far the way this

1194
00:51:19,500 --> 00:51:26,849
was I didn't hot I got the press release

1195
00:51:23,940 --> 00:51:29,880
in front of me here zoop zoop zoop zoop

1196
00:51:26,849 --> 00:51:31,049
zoop zoop i mean it's just not that

1197
00:51:29,880 --> 00:51:33,240
critical just trying to get a sense of

1198
00:51:31,050 --> 00:51:36,210
how far back you know after the Big Bang

1199
00:51:33,239 --> 00:51:37,829
this was so yeah it's not that far it's

1200
00:51:36,210 --> 00:51:40,250
not these aren't high redshift clusters

1201
00:51:37,829 --> 00:51:42,779
i will say i would say they're

1202
00:51:40,250 --> 00:51:44,940
definitely less than richest of a half

1203
00:51:42,780 --> 00:51:45,990
so there may be a couple built this is

1204
00:51:44,940 --> 00:51:47,880
probably a couple billion light-years

1205
00:51:45,989 --> 00:51:49,409
out there it's not to me it's not gonna

1206
00:51:47,880 --> 00:51:51,240
be 10 billion light years at maybe two

1207
00:51:49,409 --> 00:51:52,409
three billion light-years out there all

1208
00:51:51,239 --> 00:51:54,379
right I was just curious yeah it was

1209
00:51:52,409 --> 00:51:57,899
because the universe was a lot different

1210
00:51:54,380 --> 00:52:00,660
at high redshift than it is then in the

1211
00:51:57,900 --> 00:52:02,789
lower ones and so one can imagine maybe

1212
00:52:00,659 --> 00:52:05,069
things not working maybe analogy not

1213
00:52:02,789 --> 00:52:06,269
working out even more so back then but

1214
00:52:05,070 --> 00:52:09,570
it sounds like that's not the issue here

1215
00:52:06,269 --> 00:52:11,159
now this is roughly this is rough enough

1216
00:52:09,570 --> 00:52:14,370
to be considered a local universe okay

1217
00:52:11,159 --> 00:52:17,699
okay did you have another slide I had

1218
00:52:14,369 --> 00:52:22,889
actually just um one last question for

1219
00:52:17,699 --> 00:52:26,279
to pose about this okay why um how do

1220
00:52:22,889 --> 00:52:29,369
you get at galaxy no no no no no no how

1221
00:52:26,280 --> 00:52:33,060
do you get a 100,000 light year long

1222
00:52:29,369 --> 00:52:34,500
streamer of gas all right no matter what

1223
00:52:33,059 --> 00:52:37,799
its shape is no matter what it's done

1224
00:52:34,500 --> 00:52:41,550
how do you get that I'm gonna say black

1225
00:52:37,800 --> 00:52:44,250
holes that's my answer to everything I

1226

00:52:41,550 --> 00:52:48,380
don't understand all right up till the

1227
00:52:44,250 --> 00:52:48,380
answer is that we don't understand okay

1228
00:52:50,539 --> 00:52:54,599
there are three possibilities mentioned

1229
00:52:53,250 --> 00:52:58,699
in the press release none of them are

1230
00:52:54,599 --> 00:53:01,469
compelling okay how does material

1231
00:52:58,699 --> 00:53:03,989
collapse it you can come up with an idea

1232
00:53:01,469 --> 00:53:06,179
that material should cool down towards

1233
00:53:03,989 --> 00:53:08,399
the center of a cluster of galaxies but

1234
00:53:06,179 --> 00:53:11,339
that doesn't form it into a streamer

1235
00:53:08,400 --> 00:53:13,079
okay you could say that you know this is

1236
00:53:11,340 --> 00:53:15,300
maybe he's a title the remnant of a

1237
00:53:13,079 --> 00:53:17,519
title tail wrapped around these galaxies

1238
00:53:15,300 --> 00:53:19,019
but you know the kinematic so that

1239
00:53:17,519 --> 00:53:21,619
doesn't really quite work why is it

1240
00:53:19,019 --> 00:53:23,789

wrapped in between the galaxies and such

1241
00:53:21,619 --> 00:53:25,619
there's going to be a lot more study to

1242
00:53:23,789 --> 00:53:27,090
understand this way how sure are they

1243
00:53:25,619 --> 00:53:29,759
this is this is actually not some kind

1244
00:53:27,090 --> 00:53:31,769
of a loser II effect with it with you

1245
00:53:29,760 --> 00:53:33,870
know the line of sight or something how

1246
00:53:31,769 --> 00:53:37,849
do they sure these droplets or these

1247
00:53:33,869 --> 00:53:40,440
blue dots are in between intertwined I

1248
00:53:37,849 --> 00:53:42,210
would believe that the sense they are

1249
00:53:40,440 --> 00:53:45,539
star clusters they have emission lines

1250
00:53:42,210 --> 00:53:46,590
and they can rich if the bishop taking a

1251
00:53:45,539 --> 00:53:48,269
look at the road trip to the emission

1252
00:53:46,590 --> 00:53:50,370
lines they can look at the redshift of

1253
00:53:48,269 --> 00:53:52,769
the galaxies and make sure that they are

1254
00:53:50,369 --> 00:53:55,650
the same okay all right so they do have

1255
00:53:52,769 --> 00:53:58,230
sort of a 3d structure to this then by

1256
00:53:55,650 --> 00:54:01,619
looking at the specular so this is one

1257
00:53:58,230 --> 00:54:03,929
of my fun points to make is that we

1258
00:54:01,619 --> 00:54:06,599
don't know the answer and you know what

1259
00:54:03,929 --> 00:54:09,239
that's not bad that's actually really

1260
00:54:06,599 --> 00:54:12,509
good okay one its job security for us

1261
00:54:09,239 --> 00:54:14,669
right all right but to when you see

1262
00:54:12,510 --> 00:54:16,980
something like this it's your indication

1263
00:54:14,670 --> 00:54:19,320
that hey we don't know what's going on

1264
00:54:16,980 --> 00:54:22,260
there's something new to understand

1265
00:54:19,320 --> 00:54:24,240
about the universe we love and

1266
00:54:22,260 --> 00:54:25,770
confronting our ignorance because it

1267
00:54:24,239 --> 00:54:27,929
shows us there's something new to

1268
00:54:25,769 --> 00:54:29,699
understand okay yeah i think was it

1269
00:54:27,929 --> 00:54:31,079
George gamma for somebody back in the

1270
00:54:29,699 --> 00:54:32,429
day said that we know just about

1271
00:54:31,079 --> 00:54:36,360
everything there is to know or at least

1272
00:54:32,429 --> 00:54:39,029
we will and hug people have said that

1273
00:54:36,360 --> 00:54:42,440
over the centuries yeah always been so

1274
00:54:39,030 --> 00:54:45,570
wrong it out already we know most things

1275
00:54:42,440 --> 00:54:47,220
okay so i put up the slide that we we

1276
00:54:45,570 --> 00:54:51,900
said we would do about the upcoming

1277
00:54:47,219 --> 00:54:53,279
public lectures so go ahead the day just

1278
00:54:51,900 --> 00:54:55,740
wanted to point out to everybody that

1279
00:54:53,280 --> 00:54:57,630
this little hangout the Frank and I do

1280
00:54:55,739 --> 00:54:59,639
every month is in conjunction with the

1281
00:54:57,630 --> 00:55:01,860
Hubble public lecture series that we

1282
00:54:59,639 --> 00:55:04,859
have on the first Tuesday of every month

1283

00:55:01,860 --> 00:55:07,740
but Frank September 18th isn't the first

1284
00:55:04,860 --> 00:55:12,510
Tuesday not the first Tuesday we've got

1285
00:55:07,739 --> 00:55:14,939
a special lecture for you ray-j Ardana

1286
00:55:12,510 --> 00:55:17,070
from York University's coming in he's

1287
00:55:14,940 --> 00:55:19,139
giving a colloquium here a scientific

1288
00:55:17,070 --> 00:55:21,630
colloquium and he also agreed to give a

1289
00:55:19,139 --> 00:55:22,389
public lecture on that Thursday so I

1290
00:55:21,630 --> 00:55:24,309
said

1291
00:55:22,389 --> 00:55:27,190
eight will add you to the schedule and

1292
00:55:24,309 --> 00:55:30,369
we have a live an amazing talk on

1293
00:55:27,190 --> 00:55:32,349
nutrino hunters the ghostly particles of

1294
00:55:30,369 --> 00:55:33,940
neutrinos that you know you've got a

1295
00:55:32,349 --> 00:55:36,278
billion neutrinos passing through you

1296
00:55:33,940 --> 00:55:39,369
every second right now and you don't

1297
00:55:36,278 --> 00:55:41,858

feel anything but we can also use these

1298

00:55:39,369 --> 00:55:45,369

neutrinos to unlock cosmic secrets and

1299

00:55:41,858 --> 00:55:46,838

he will talk about that awesome and then

1300

00:55:45,369 --> 00:55:48,880

of course our regular one first Tuesday

1301

00:55:46,838 --> 00:55:51,369

of the month october seventh Greg Snyder

1302

00:55:48,880 --> 00:55:54,519

will talk about simulating the universe

1303

00:55:51,369 --> 00:55:56,950

the illustrious computational simulation

1304

00:55:54,518 --> 00:56:00,189

when the largest computer simulations of

1305

00:55:56,949 --> 00:56:01,868

how structure forms in the universe he

1306

00:56:00,190 --> 00:56:04,088

is part of that team and he will tell

1307

00:56:01,869 --> 00:56:06,220

you all sorts of secrets of how to make

1308

00:56:04,088 --> 00:56:08,528

a fake universe and see if it matches

1309

00:56:06,219 --> 00:56:09,759

the real universe yeah I'm really

1310

00:56:08,528 --> 00:56:11,380

excited about that one because if you

1311

00:56:09,760 --> 00:56:13,778

haven't heard of this do a search for

1312
00:56:11,380 --> 00:56:15,760
Don Gong Gong on Google and it'll come

1313
00:56:13,778 --> 00:56:17,768
up there's a youtube video that nature

1314
00:56:15,760 --> 00:56:20,049
put out that shows this simulation to

1315
00:56:17,768 --> 00:56:21,219
it's just amazing you've got to check

1316
00:56:20,048 --> 00:56:23,500
it's one of the neatest things I've ever

1317
00:56:21,219 --> 00:56:25,118
seen it all so in addition to checking

1318
00:56:23,500 --> 00:56:27,278
out the public lecture next month I

1319
00:56:25,119 --> 00:56:28,890
definitely do a search on that you'll be

1320
00:56:27,278 --> 00:56:33,278
haven't seen it yet it it's

1321
00:56:28,889 --> 00:56:34,509
mind-boggling so okay frankly a couple

1322
00:56:33,278 --> 00:56:37,119
of questions here I want to get to a few

1323
00:56:34,509 --> 00:56:39,190
things we're running out of time but

1324
00:56:37,119 --> 00:56:42,099
i'll start with an easy one this one's

1325
00:56:39,190 --> 00:56:43,659
from angel lights three how long does

1326
00:56:42,099 --> 00:56:48,160
the hubble take to do a complete

1327
00:56:43,659 --> 00:56:51,548
rotation around our mother earth okay

1328
00:56:48,159 --> 00:56:54,879
Hubble does orbits around Earth every

1329
00:56:51,548 --> 00:56:58,358
ninety seven minutes if you watch the

1330
00:56:54,880 --> 00:57:01,450
movie gravity they put it at like 90

1331
00:56:58,358 --> 00:57:04,449
minutes right yeah and it's actually 97

1332
00:57:01,449 --> 00:57:06,639
minutes at the the orbit of Hubble bear

1333
00:57:04,449 --> 00:57:08,409
i always say 90 minutes but yes Proxima

1334
00:57:06,639 --> 00:57:10,268
90 minutes so we've been talking for

1335
00:57:08,409 --> 00:57:12,219
almost an hour Hubble has completed two

1336
00:57:10,268 --> 00:57:15,368
thirds of an orbit around the earth

1337
00:57:12,219 --> 00:57:17,889
while we've been chatting here yeah good

1338
00:57:15,369 --> 00:57:19,000
question okay here's one from we're

1339
00:57:17,889 --> 00:57:22,358
getting some questions on this i'll

1340

00:57:19,000 --> 00:57:25,469
start with stargazer nation what's what

1341
00:57:22,358 --> 00:57:28,960
is next for the telescope any uploading

1342
00:57:25,469 --> 00:57:30,669
upcoming highlights I wonder how close

1343
00:57:28,960 --> 00:57:32,470
it would focus and are they going to see

1344
00:57:30,670 --> 00:57:34,240
siding spring there's a couple of

1345
00:57:32,469 --> 00:57:36,009
questions about that and if you had any

1346
00:57:34,239 --> 00:57:42,189
news on site

1347
00:57:36,010 --> 00:57:43,870
spring on that as well so okay first of

1348
00:57:42,190 --> 00:57:47,679
all Hubble will be observing comet

1349
00:57:43,869 --> 00:57:50,519
siding spring Hubble the comet siding

1350
00:57:47,679 --> 00:57:53,379
spring is going to pass close to mars

1351
00:57:50,519 --> 00:57:58,150
the information on comet siding spring

1352
00:57:53,380 --> 00:58:02,050
is that it is not its comas not growing

1353
00:57:58,150 --> 00:58:05,230
as fast as it one might have thought so

1354
00:58:02,050 --> 00:58:06,580

the coma of common sidng spring which I

1355

00:58:05,230 --> 00:58:08,199

never thought was actually going to

1356

00:58:06,579 --> 00:58:10,360

encompass Mars doesn't look like it's

1357

00:58:08,199 --> 00:58:11,769

going to encompass Mars although you

1358

00:58:10,360 --> 00:58:13,930

know the density falls off very very

1359

00:58:11,769 --> 00:58:16,059

slowly so definitely some particles

1360

00:58:13,929 --> 00:58:19,869

traveling with comet sidng Springs will

1361

00:58:16,059 --> 00:58:23,170

impact Mars but the risk to the Mars

1362

00:58:19,869 --> 00:58:26,230

orbiters etc is a little lower than we

1363

00:58:23,170 --> 00:58:27,670

have might have been feared calm Hubble

1364

00:58:26,230 --> 00:58:29,920

will be looking at the comment itself

1365

00:58:27,670 --> 00:58:32,710

because Hubble has the best resolution

1366

00:58:29,920 --> 00:58:35,800

of any telescope here located at earth

1367

00:58:32,710 --> 00:58:37,480

and so we can't see the full the the

1368

00:58:35,800 --> 00:58:41,350

size of deciding Springs it's so small

1369
00:58:37,480 --> 00:58:43,030
we will be able to see if any parts any

1370
00:58:41,349 --> 00:58:45,039
pieces of it break off anything

1371
00:58:43,030 --> 00:58:47,080
happening with the comet Hubble will be

1372
00:58:45,039 --> 00:58:49,900
monitoring it during the closest

1373
00:58:47,079 --> 00:58:52,840
approach and that it comes up in October

1374
00:58:49,900 --> 00:58:56,260
doesn't it I think so yes yeah okay and

1375
00:58:52,840 --> 00:58:59,710
that is also a Geneva Bevan also from

1376
00:58:56,260 --> 00:59:02,260
the Q&A app was asking about siding

1377
00:58:59,710 --> 00:59:06,250
spring so there you go folks thank good

1378
00:59:02,260 --> 00:59:11,340
questions and here's one from Eamon of

1379
00:59:06,250 --> 00:59:17,110
Brampton who's asking um where to go

1380
00:59:11,340 --> 00:59:21,670
then it went away uh come back okay all

1381
00:59:17,110 --> 00:59:23,530
right fine so so Janine I was also

1382
00:59:21,670 --> 00:59:26,670
saying all now I'm sitting in my desk

1383
00:59:23,530 --> 00:59:31,240
coming along to rubber ducky thanks guys

1384
00:59:26,670 --> 00:59:36,789
ducky or the one you may drag astronomy

1385
00:59:31,239 --> 00:59:38,769
so much fun that's right now all saying

1386
00:59:36,789 --> 00:59:39,909
thank you for that yes rubber duck okay

1387
00:59:38,769 --> 00:59:41,800
I don't know what happened to that

1388
00:59:39,909 --> 00:59:43,929
question it had to do with exoplanets

1389
00:59:41,800 --> 00:59:46,300
but it disappeared from my Q&A app I'm

1390
00:59:43,929 --> 00:59:48,789
really sorry about that I guess that'll

1391
00:59:46,300 --> 00:59:49,870
be so that is it for our time I don't

1392
00:59:48,789 --> 00:59:52,840
see any other

1393
00:59:49,869 --> 00:59:56,440
shins or comments that I should read out

1394
00:59:52,840 --> 00:59:58,300
thank you all for watching the four

1395
00:59:56,440 --> 01:00:00,610
participating during the Q&A app I

1396
00:59:58,300 --> 01:00:04,000
really appreciate that we will be back

1397

01:00:00,610 --> 01:00:05,079
again next month with Frank oh no no sep

1398
01:00:04,000 --> 01:00:06,909
tember we are we going to do this again

1399
01:00:05,079 --> 01:00:09,009
this month are we going to just wait

1400
01:00:06,909 --> 01:00:10,569
till October well we're already into

1401
01:00:09,010 --> 01:00:12,570
September this is sep tember i know we

1402
01:00:10,570 --> 01:00:15,580
had another public lecture so ah i

1403
01:00:12,570 --> 01:00:18,269
wanted to i wasn't planning on doing a

1404
01:00:15,579 --> 01:00:20,289
huge news summary for the September 18th

1405
01:00:18,269 --> 01:00:22,690
I'm alright and we won't worry about

1406
01:00:20,289 --> 01:00:24,279
that will diff if something amazing

1407
01:00:22,690 --> 01:00:26,500
happens with siding Springs or anything

1408
01:00:24,280 --> 01:00:30,790
we can jump in and do that actually I'll

1409
01:00:26,500 --> 01:00:33,969
be my son's going to color ok I'll

1410
01:00:30,789 --> 01:00:37,029
late-september so we'll have to do it in

1411
01:00:33,969 --> 01:00:39,189

October ok look yes so look back for for

1412

01:00:37,030 --> 01:00:40,660

the next episode of this with Frank I at

1413

01:00:39,190 --> 01:00:42,130

the beginning of October right after the

1414

01:00:40,659 --> 01:00:44,019

public lecture series we just talked

1415

01:00:42,130 --> 01:00:45,670

about I want to thank you Frank this was

1416

01:00:44,019 --> 01:00:47,019

awesome as always you've done an

1417

01:00:45,670 --> 01:00:49,030

excellent job bringing some awesome crowd

1418

01:00:47,019 --> 01:00:51,159

stories to us so thank you very much

1419

01:00:49,030 --> 01:00:54,300

we're an excellent job of asking

1420

01:00:51,159 --> 01:00:57,789

questions and keeping me honest about it

1421

01:00:54,300 --> 01:00:59,560

my job as what I do all right all right

1422

01:00:57,789 --> 01:01:03,989

folks anyway thank you all for watching

1423

01:00:59,559 --> 01:01:03,989

and as always keep looking up