
HUBBLE
hangouts
News from Hubble and Across the Universe
with Dr. Frank Summers
Wednesday, September 3 2014, 4pm EDT, 8pm UTC

1
00:00:12,030 --> 00:00:10,259
hello everybody and welcome to news from

2
00:00:14,130 --> 00:00:12,040
Hubble and across the universe this is

3
00:00:16,980 --> 00:00:14,140
our monthly hangout where we get to meet

4
00:00:19,109 --> 00:00:16,990
with dr. Frank summers to discuss a lot

5
00:00:20,489 --> 00:00:19,119
of great new science and happenings in

6
00:00:22,950 --> 00:00:20,499
both astronomy and with the Hubble Space

7
00:00:24,329 --> 00:00:22,960
Telescope my name is Tony Darnell I work

8
00:00:26,669 --> 00:00:24,339
at the Space Telescope Science Institute

9
00:00:29,069 --> 00:00:26,679
with Frank and welcome Frank it's good

10
00:00:31,079 --> 00:00:29,079
to see you again get to see you Tony how

11
00:00:33,060 --> 00:00:31,089
how everything's in this last month we

12
00:00:34,560 --> 00:00:33,070
haven't actually talked since July now I

13
00:00:36,420 --> 00:00:34,570

know it's been it's been a while since

14
00:00:38,250 --> 00:00:36,430
we've been doing this so we got a lot to

15
00:00:39,959 --> 00:00:38,260
catch up on but before we get started

16
00:00:41,279 --> 00:00:39,969
let me remind everybody how you can

17
00:00:42,810 --> 00:00:41,289
interact with us if you want to leave

18
00:00:45,180 --> 00:00:42,820
comments or ask questions we've got the

19
00:00:47,639 --> 00:00:45,190
Google+ app we've got our the Google+

20
00:00:49,770 --> 00:00:47,649
event page we have the quip the Q&A app

21
00:00:52,590 --> 00:00:49,780
on both YouTube and Google+ and I'm

22
00:00:53,970 --> 00:00:52,600
looking at the hubble hubble hang out

23
00:00:55,470 --> 00:00:53,980
hashtag all that will probably change

24
00:00:57,540 --> 00:00:55,480
that for future shows but for right now

25
00:01:00,200 --> 00:00:57,550
if you want to leave a tweak Hubble hash

26
00:01:02,810 --> 00:01:00,210
Hubble hangout is what I'm looking at Oh

27
00:01:06,450 --> 00:01:02,820
many h's on that kills me every time

28
00:01:08,550 --> 00:01:06,460
anyway uh so this month Frank is back

29
00:01:10,260 --> 00:01:08,560
like last Frank mentioned we missed last

30
00:01:13,680 --> 00:01:10,270
month for two reasons I was on vacation

31
00:01:15,540 --> 00:01:13,690
I was one and another was we just

32
00:01:18,420 --> 00:01:15,550
couldn't get our stuff together and time

33
00:01:20,940 --> 00:01:18,430
to make it happen so we are going to we

34
00:01:22,440 --> 00:01:20,950
had a lot of things to cover and Frank I

35
00:01:24,840 --> 00:01:22,450
will turn it over to you to get us

36
00:01:26,690 --> 00:01:24,850
started yeah you know I will apologize

37
00:01:30,540 --> 00:01:26,700
that I was out of the country i was in

38
00:01:33,750 --> 00:01:30,550

vancouver for a week so we oughta stay

39
00:01:38,180 --> 00:01:33,760
pretty busy month for vacations and

40
00:01:41,190 --> 00:01:38,190
travel and such so we will do now a

41
00:01:43,590 --> 00:01:41,200
extra big show extra cool stories for

42
00:01:45,030 --> 00:01:43,600
you today okay cool yeah there's some

43
00:01:46,470 --> 00:01:45,040
research stuff that happened last week

44
00:01:47,670 --> 00:01:46,480
or last month I think that you covered

45
00:01:49,590 --> 00:01:47,680
that you're going to also cover with it

46
00:01:51,450 --> 00:01:49,600
so exactly and that's gonna be my first

47
00:01:54,060 --> 00:01:51,460
story okay because this happened just

48
00:01:58,380 --> 00:01:54,070
before I left for Vancouver alright so

49
00:02:04,680 --> 00:01:58,390
story number one rosetta rendezvous with

50
00:02:08,009 --> 00:02:04,690
rubber ducky okay like that rubber ducky

51
00:02:09,630 --> 00:02:08,019
bardot j-just where do you see ladies as

52
00:02:11,550 --> 00:02:09,640
you know all about this all right Oh

53
00:02:14,040 --> 00:02:11,560
first of all this is about the Rosetta

54
00:02:18,350 --> 00:02:14,050
mission and it's a mission to

55
00:02:24,480 --> 00:02:18,360
a comet comet 67p churyumov-gerasimenko

56
00:02:27,600 --> 00:02:24,490
oh that's a tough thing to say as you

57
00:02:31,890 --> 00:02:27,610
can see pictured here of they've got the

58
00:02:33,660 --> 00:02:31,900
Rosetta is the low the spacecraft with

59
00:02:35,610 --> 00:02:33,670
the long wings on it that's that's the

60
00:02:40,140 --> 00:02:35,620
Rosetta mission itself and then they

61
00:02:42,870 --> 00:02:40,150
also have the the feel a pro but that is

62
00:02:46,940 --> 00:02:42,880
going to land on the comet okay so its

63
00:02:49,290 --> 00:02:46,950

guts combination of a flyby as well as a

64
00:02:52,260 --> 00:02:49,300
probe landing on it although it's

65
00:02:54,330 --> 00:02:52,270
actually more than just a flyby okay now

66
00:02:56,850 --> 00:02:54,340
we've been passed a bunch of other

67
00:03:00,630 --> 00:02:56,860
comments before and as you can see in

68
00:03:02,690 --> 00:03:00,640
this slide here the here are what six

69
00:03:04,770 --> 00:03:02,700
different comets that we have visited

70
00:03:07,620 --> 00:03:04,780
basically generally generally with

71
00:03:09,960 --> 00:03:07,630
flybys and you can see there you know

72
00:03:12,000 --> 00:03:09,970
about five miles cross from one miles to

73
00:03:15,360 --> 00:03:12,010
nine miles across and they've got these

74
00:03:17,370 --> 00:03:15,370
oblong shapes and most of them were sort

75
00:03:19,650 --> 00:03:17,380
of roundish or potato ish although I

76
00:03:21,840 --> 00:03:19,660
think barley and Hartley they could they

77
00:03:24,030 --> 00:03:21,850
could be bowling pin comets all right

78
00:03:25,410 --> 00:03:24,040
they look like bowling pins but my

79
00:03:31,740 --> 00:03:25,420
professor always called him oblate

80
00:03:34,020 --> 00:03:31,750
spheroids but deep impact actually hit

81
00:03:36,030 --> 00:03:34,030
we didn't just fly by right ya know deep

82
00:03:38,970 --> 00:03:36,040
impact we actually did a flyby and we

83
00:03:41,300 --> 00:03:38,980
did a smash in if we did both us fly by

84
00:03:43,290 --> 00:03:41,310
and and we didn't land gently okay

85
00:03:44,670 --> 00:03:43,300
that's the difference with this one this

86
00:03:46,760 --> 00:03:44,680
one we're going to try and land gently

87
00:03:50,250 --> 00:03:46,770
with deep impact we actually tried to

88
00:03:51,630 --> 00:03:50,260

smash it smash into it we saw all the

89
00:03:53,550 --> 00:03:51,640
powdery stuff come out of it so we've

90
00:03:57,870 --> 00:03:53,560
been there we sort of know but what

91
00:04:01,050 --> 00:03:57,880
we've never done is actually travel

92
00:04:03,000 --> 00:04:01,060
along with the for an extended period so

93
00:04:05,070 --> 00:04:03,010
this is what rosetta's going to do here

94
00:04:06,449 --> 00:04:05,080
is the whole timeline okay you can try

95
00:04:08,340 --> 00:04:06,459
and read that the problems fonts

96
00:04:10,880 --> 00:04:08,350
probably too small read over this but

97
00:04:15,570 --> 00:04:10,890
the idea is that it's it launched in

98
00:04:18,060 --> 00:04:15,580
2004 march of 2004 it's gotten yeah I

99
00:04:22,070 --> 00:04:18,070
got gravity assists from Earth Mars

100
00:04:26,680 --> 00:04:22,080
Earth asteroid Stein's earth again

101
00:04:28,420 --> 00:04:26,690
asteroid Natasha and

102
00:04:32,320 --> 00:04:28,430
yeah so it's got like seven different

103
00:04:35,650 --> 00:04:32,330
gravity assists in order to make in size

104
00:04:37,600 --> 00:04:35,660
and gravity huh extra an extreme

105
00:04:41,050 --> 00:04:37,610
exercise in celestial mechanics okay

106
00:04:44,380 --> 00:04:41,060
yeah the but the point was it arrived at

107
00:04:46,990 --> 00:04:44,390
the comet August sixth of last month now

108
00:04:49,030 --> 00:04:47,000
it's better understand the the orbits if

109
00:04:51,720 --> 00:04:49,040
you show it here and so here you can see

110
00:04:54,550 --> 00:04:51,730
the orbital pass and all of the early

111
00:04:57,520 --> 00:04:54,560
gravity assists were there to put it on

112
00:05:00,310 --> 00:04:57,530
a much more elliptical orbit so that it

113
00:05:02,410 --> 00:05:00,320

could match the orbit of chair yamaha

114
00:05:03,730 --> 00:05:02,420
jeramaz seem ankle are those does it

115
00:05:05,520 --> 00:05:03,740
take a lot of energy to get into an

116
00:05:10,210 --> 00:05:05,530
orbit like that 02 an elliptical orbit

117
00:05:12,280 --> 00:05:10,220
well yeah simply because your earth is

118
00:05:14,530 --> 00:05:12,290
on a circular orbit when you launch from

119
00:05:17,170 --> 00:05:14,540
Earth you're launching basically with

120
00:05:19,600 --> 00:05:17,180
Earth's momentum around the Sun and so

121
00:05:23,920 --> 00:05:19,610
you've got to change that momentum into

122
00:05:26,050 --> 00:05:23,930
a much more elongated orbit so while the

123
00:05:27,970 --> 00:05:26,060
as you can see the red line and the

124
00:05:30,190 --> 00:05:27,980
green line are almost coincident at one

125
00:05:32,290 --> 00:05:30,200
point in terms of their perihelion the

126
00:05:34,870 --> 00:05:32,300
closest approach to the Sun the aphelion

127
00:05:37,510 --> 00:05:34,880
is so much further away for church for

128
00:05:40,659 --> 00:05:37,520
comet 67p that you've got to add a lot

129
00:05:44,530 --> 00:05:40,669
of energy to get out of that right mmm

130
00:05:48,610 --> 00:05:44,540
so the really cool thing about rosetta

131
00:05:51,280 --> 00:05:48,620
mission is after it has a met up with a

132
00:05:53,730 --> 00:05:51,290
comet it's going to stay with the comet

133
00:05:56,200 --> 00:05:53,740
all the way through perihelion passage

134
00:05:58,150 --> 00:05:56,210
so it's not an orbit around the comet

135
00:06:00,460 --> 00:05:58,160
it's just sort of tracking along in its

136
00:06:02,560 --> 00:06:00,470
orbit yeah it's tracking along with it

137
00:06:05,350 --> 00:06:02,570
it's doing a library orbit near the

138
00:06:07,330 --> 00:06:05,360

comet actually as I saw it described

139
00:06:08,620 --> 00:06:07,340
once that it sits in front of the comet

140
00:06:10,510 --> 00:06:08,630
it's not actually orbiting around the

141
00:06:14,159 --> 00:06:10,520
comet is orbiting along with comments so

142
00:06:17,590 --> 00:06:14,169
it's on the same path at the same speed

143
00:06:20,830 --> 00:06:17,600
and so you can see how difficult it is

144
00:06:23,020 --> 00:06:20,840
and if you want to do it inexpensively

145
00:06:25,270 --> 00:06:23,030
to you to do all this sort of stuff the

146
00:06:28,090 --> 00:06:25,280
amount of energy that it takes to match

147
00:06:29,980 --> 00:06:28,100
orbits okay so this is really cool we

148
00:06:31,960 --> 00:06:29,990
have now matched up with a comet and I

149
00:06:34,950 --> 00:06:31,970
was going to go through some of the

150
00:06:37,930 --> 00:06:34,960
images that we had of the common

151
00:06:39,990 --> 00:06:37,940
approaching it okay so this is the first

152
00:06:42,330 --> 00:06:40,000
image released this year March twenty

153
00:06:45,990 --> 00:06:42,340
seventh and the main thing in this image

154
00:06:47,310 --> 00:06:46,000
is the globular cluster m12 7 okay so

155
00:06:49,800 --> 00:06:47,320
this is I think it's in the

156
00:06:51,420 --> 00:06:49,810
constellation of UKISS that's m107 and

157
00:06:54,150 --> 00:06:51,430
then what looks like just one of the

158
00:06:56,850 --> 00:06:54,160
stars of m107 are the stars nearby m107

159
00:07:00,420 --> 00:06:56,860
that's actually the comet okay so that

160
00:07:03,900 --> 00:07:00,430
circle is around the comet 67p I'm

161
00:07:05,340 --> 00:07:03,910
calling 67 PCG desperate for I'm glad

162
00:07:07,830 --> 00:07:05,350
that circles there it makes it mailed

163
00:07:12,690 --> 00:07:07,840

lemak Rosetta easier to find absolutely

164
00:07:14,010 --> 00:07:12,700
impossible spot otherwise then the next

165
00:07:16,020 --> 00:07:14,020
thing the next thing that was

166
00:07:19,500 --> 00:07:16,030
interesting that they released was July

167
00:07:21,690 --> 00:07:19,510
4th on Independence Day in the US this

168
00:07:24,360 --> 00:07:21,700
year they released these three images

169
00:07:26,880 --> 00:07:24,370
here and these three images show you

170
00:07:29,550 --> 00:07:26,890
that it's more than just a dot it looks

171
00:07:31,200 --> 00:07:29,560
like sort of an elongated dot okay and

172
00:07:33,300 --> 00:07:31,210
you know you can't really see it it's

173
00:07:35,010 --> 00:07:33,310
all very pixelated everything but you're

174
00:07:36,180 --> 00:07:35,020
starting to see that well this is kind

175
00:07:38,310 --> 00:07:36,190
of interesting it probably has that

176
00:07:41,670 --> 00:07:38,320
potato shape that we seen for all the

177
00:07:43,650 --> 00:07:41,680
other comments right but they save the

178
00:07:48,659 --> 00:07:43,660
best for French Independence Day

179
00:07:51,150 --> 00:07:48,669
Bastille Day july 14 2014 the french

180
00:07:57,270 --> 00:07:51,160
annalise yeah you got well it is a

181
00:07:58,920 --> 00:07:57,280
European mission right so on that's on

182
00:08:01,800 --> 00:07:58,930
bastille day they released this image

183
00:08:04,409 --> 00:08:01,810
and this immediately shows you that that

184
00:08:07,260 --> 00:08:04,419
dark line of shadow or commander showed

185
00:08:09,690 --> 00:08:07,270
you this looks like two objects it looks

186
00:08:12,270 --> 00:08:09,700
like to snow balls hanging around each

187
00:08:14,219 --> 00:08:12,280
other not not one object it looks like

188
00:08:17,340 --> 00:08:14,229

two objects together which was really

189
00:08:20,400 --> 00:08:17,350
cool and then everything really went

190
00:08:23,130 --> 00:08:20,410
crazy the next week this sequence of

191
00:08:24,900 --> 00:08:23,140
images from July 23 to 27 hit the

192
00:08:27,450 --> 00:08:24,910
internet and and everybody started

193
00:08:31,020 --> 00:08:27,460
freaking out this wasn't just a single

194
00:08:35,010 --> 00:08:31,030
comet this was a contact binary comet

195
00:08:38,399 --> 00:08:35,020
all right it was absolutely amazing this

196
00:08:39,810 --> 00:08:38,409
is what I call comet rubber ducky okay

197
00:08:42,010 --> 00:08:39,820
not just me a lot of people have called

198
00:08:44,050 --> 00:08:42,020
a comet rubber ducky

199
00:08:46,900 --> 00:08:44,060
so you got us you got explain to us what

200
00:08:50,290 --> 00:08:46,910
a comment with a binary uh what was it

201
00:08:52,420 --> 00:08:50,300
you said binary contact binary okay Mary

202
00:08:54,810 --> 00:08:52,430
what is that thank you for asking that's

203
00:08:57,640 --> 00:08:54,820
just where I was going to launch into

204
00:08:59,620 --> 00:08:57,650
well alright so the point is is that you

205
00:09:02,080 --> 00:08:59,630
know you it's obviously two separate

206
00:09:04,810 --> 00:09:02,090
pieces that have joined together at the

207
00:09:06,580 --> 00:09:04,820
neck of the duck and in order for these

208
00:09:09,940 --> 00:09:06,590
things and now comets can be relatively

209
00:09:12,340 --> 00:09:09,950
fragile objects right comets can be just

210
00:09:15,280 --> 00:09:12,350
sort of rubble piles or ice as their

211
00:09:19,230 --> 00:09:15,290
snowballs if they came together too hard

212
00:09:22,210 --> 00:09:19,240
they would smash and break up okay and

213
00:09:24,640 --> 00:09:22,220

what the calculations were on this one

214
00:09:27,340 --> 00:09:24,650
was that for these two objects to stick

215
00:09:29,140 --> 00:09:27,350
together they had to approach each other

216
00:09:31,570 --> 00:09:29,150
at a speed of like three meters per

217
00:09:33,460 --> 00:09:31,580
second now three meters per second is

218
00:09:35,290 --> 00:09:33,470
fast for you with me but in the solar

219
00:09:37,960 --> 00:09:35,300
system that's actually quite slow

220
00:09:41,800 --> 00:09:37,970
because Earth orbits around the Sun at

221
00:09:44,530 --> 00:09:41,810
30 kilometers per second so in order to

222
00:09:46,840 --> 00:09:44,540
match up the these two objects had to be

223
00:09:49,210 --> 00:09:46,850
almost on exactly the same orbits and

224
00:09:52,180 --> 00:09:49,220
very I think and then this sort of

225
00:09:55,960 --> 00:09:52,190
gently smashing together and stay in

226
00:09:58,660 --> 00:09:55,970
contact with one another so it's really

227
00:10:00,460 --> 00:09:58,670
interesting we don't know how strongly

228
00:10:02,710 --> 00:10:00,470
they're held together they obviously are

229
00:10:05,080 --> 00:10:02,720
held a low strongly enough to resist the

230
00:10:06,790 --> 00:10:05,090
the rotation the rotational forces that

231
00:10:08,530 --> 00:10:06,800
might pull them apart right I was going

232
00:10:11,020 --> 00:10:08,540
to say that that must be acting against

233
00:10:14,320 --> 00:10:11,030
it so it's hard to imagine this is just

234
00:10:16,210 --> 00:10:14,330
gravity doing the the sticking together

235
00:10:19,360 --> 00:10:16,220
is it or do you think that's all it is

236
00:10:21,370 --> 00:10:19,370
well it's it's gravity plus there can be

237
00:10:22,720 --> 00:10:21,380
some chemical bonds you know and what

238
00:10:24,010 --> 00:10:22,730

holds a snowball together right yeah

239
00:10:26,080 --> 00:10:24,020
they kind of got squished together like

240
00:10:27,790 --> 00:10:26,090
a packing a snowball melted a little bit

241
00:10:29,590 --> 00:10:27,800
and kind of stuck together mean you

242
00:10:31,900 --> 00:10:29,600
could consider this a solar system

243
00:10:34,060 --> 00:10:31,910
exploration in making a snowman right

244
00:10:35,980 --> 00:10:34,070
you get a third one okay and then you

245
00:10:39,340 --> 00:10:35,990
get we can have a snowman comment but I

246
00:10:41,020 --> 00:10:39,350
think that's highly unlikely happen yeah

247
00:10:43,900 --> 00:10:41,030
that bring that together would be

248
00:10:46,510 --> 00:10:43,910
impressive ok so this got everyone's

249
00:10:48,720 --> 00:10:46,520
attention on it I think from what I

250
00:10:52,720 --> 00:10:48,730
heard some of these images were released

251
00:10:53,710 --> 00:10:52,730
prematurely the the the team the science

252
00:10:54,760 --> 00:10:53,720
team behind it didn't want to release

253
00:10:55,720 --> 00:10:54,770
them till they really know what they're

254
00:10:57,930 --> 00:10:55,730
looking at but

255
00:11:02,050 --> 00:10:57,940
it was just so cool somebody had some

256
00:11:03,579 --> 00:11:02,060
somebody had to put it out and so the

257
00:11:05,769 --> 00:11:03,589
next week actually need some earlier

258
00:11:07,689 --> 00:11:05,779
images from the osiris team that

259
00:11:09,790 --> 00:11:07,699
actually had even higher resolution and

260
00:11:12,910 --> 00:11:09,800
you can really see this this double

261
00:11:15,670 --> 00:11:12,920
contact binary so we're watching really

262
00:11:18,819 --> 00:11:15,680
closely as it was going into rendezvous

263
00:11:21,340 --> 00:11:18,829

which was unlocked august sixth so here

264
00:11:24,550 --> 00:11:21,350
on july 24th based upon those date that

265
00:11:27,819 --> 00:11:24,560
data they made this animated gif this

266
00:11:29,230 --> 00:11:27,829
spinning 3d model okay so a rough model

267
00:11:32,170 --> 00:11:29,240
of it where you can see you've got a

268
00:11:34,540 --> 00:11:32,180
larger one that looks very much like the

269
00:11:36,850 --> 00:11:34,550
ones we got we've got a smaller circular

270
00:11:39,519 --> 00:11:36,860
one again the two of them separately

271
00:11:41,319 --> 00:11:39,529
look very much like the other comets

272
00:11:45,069 --> 00:11:41,329
we've seen but then they get smashed

273
00:11:47,560 --> 00:11:45,079
together by this neck feature all right

274
00:11:50,590 --> 00:11:47,570
august first we start to see all the

275
00:11:52,329 --> 00:11:50,600
detail in it all the crag eNOS that we

276
00:11:54,400 --> 00:11:52,339
saw on all the previous comets starts to

277
00:11:58,840 --> 00:11:54,410
come into view we get a little closer

278
00:12:01,180 --> 00:11:58,850
daily august 3rd I mean that almost

279
00:12:03,850 --> 00:12:01,190
looks like a mushroom cloud no no no

280
00:12:05,800 --> 00:12:03,860
yeah really it was like mommy mom I was

281
00:12:09,519 --> 00:12:05,810
gonna rub ur duckies out the window now

282
00:12:12,400 --> 00:12:09,529
I don't don't worry rubber ducky will

283
00:12:14,079 --> 00:12:12,410
come back okay that one this one had a

284
00:12:16,329 --> 00:12:14,089
feeling like a mushroom Club but what I

285
00:12:19,059 --> 00:12:16,339
loved about this one is it showed you

286
00:12:21,280 --> 00:12:19,069
the narrow features of the neck and how

287
00:12:23,860 --> 00:12:21,290
tenuous the connection between them

288
00:12:25,840 --> 00:12:23,870

right yeah it's as if they smash

289
00:12:28,750 --> 00:12:25,850
together and rebounded and you formed

290
00:12:31,960 --> 00:12:28,760
this bridge there and then just no

291
00:12:35,259 --> 00:12:31,970
material was left in between on that so

292
00:12:37,449 --> 00:12:35,269
that was really cool to me yeah because

293
00:12:40,180 --> 00:12:37,459
almost like it would kind of hit and

294
00:12:41,620 --> 00:12:40,190
then heat it up sort of merged and

295
00:12:43,210 --> 00:12:41,630
squish to melt a little bit and when I

296
00:12:44,879 --> 00:12:43,220
started to go apart it froze that's what

297
00:12:47,199 --> 00:12:44,889
I think happened Frank yeah it's okay

298
00:12:49,389 --> 00:12:47,209
prize later I just want to say I think

299
00:12:52,240 --> 00:12:49,399
you won alright well that is a

300
00:12:54,280 --> 00:12:52,250
reasonable reasonable hypothesis uh you

301
00:12:55,600 --> 00:12:54,290
just have to calculate what the speeds

302
00:12:57,280 --> 00:12:55,610
and the physical properties that would

303
00:12:59,860 --> 00:12:57,290
happen during that before you get your

304
00:13:03,160 --> 00:12:59,870
Nobel price though Emily Emily was she

305
00:13:05,350 --> 00:13:03,170
on the team no I'll tell you at the end

306
00:13:07,210 --> 00:13:05,360
of this thought I still to this easy

307
00:13:09,460 --> 00:13:07,220
asst to steal all the images these

308
00:13:12,880 --> 00:13:09,470
images was from her blog okay

309
00:13:14,800 --> 00:13:12,890
yes he's really she was really good so

310
00:13:16,840 --> 00:13:14,810
in I mean I got a lot of things from a

311
00:13:18,040 --> 00:13:16,850
lot of places and I was this like to try

312
00:13:19,330 --> 00:13:18,050
and assemble it for this talk it was

313
00:13:21,730 --> 00:13:19,340

like yeah we'll just go to Emily and

314
00:13:23,950 --> 00:13:21,740
she's got it she'll know it you'll have

315
00:13:25,510 --> 00:13:23,960
a deal she reprocessed a bunch of these

316
00:13:27,490 --> 00:13:25,520
images to clean them up and make them

317
00:13:30,910 --> 00:13:27,500
look better before posting on her blog

318
00:13:33,310 --> 00:13:30,920
so she added her added her name to the

319
00:13:37,150 --> 00:13:33,320
credit list for actually the credit

320
00:13:40,150 --> 00:13:37,160
lists are monstrously huge for this one

321
00:13:43,120 --> 00:13:40,160
of these some of these anyway so August

322
00:13:45,130 --> 00:13:43,130
fourth again you see some serious craggy

323
00:13:47,440 --> 00:13:45,140
and bumpy features and stuff it's really

324
00:13:50,680 --> 00:13:47,450
you know taking shape it's starting to

325
00:13:52,750 --> 00:13:50,690
be a real object okay and then after

326
00:13:55,750 --> 00:13:52,760
August fourth on august sixth we had

327
00:13:59,080 --> 00:13:55,760
rendezvous and rendezvous was successful

328
00:14:01,240 --> 00:13:59,090
they did the insertion burn to slow down

329
00:14:02,380 --> 00:14:01,250
to get to the speed of the comic because

330
00:14:04,210 --> 00:14:02,390
they've been catching up to the comment

331
00:14:06,370 --> 00:14:04,220
and then they slowed down and there and

332
00:14:08,470 --> 00:14:06,380
they're in this library orbit around it

333
00:14:11,950 --> 00:14:08,480
basically in front of it looking at it

334
00:14:13,960 --> 00:14:11,960
with the cameras well after rendezvous

335
00:14:15,670 --> 00:14:13,970
they were so close that they were only

336
00:14:18,340 --> 00:14:15,680
getting pieces of the comet they

337
00:14:19,900 --> 00:14:18,350
couldn't show you the whole comet nobody

338
00:14:22,300 --> 00:14:19,910

camera had one in a field of view huh

339
00:14:23,560 --> 00:14:22,310
right well you know you want to be that

340
00:14:26,620 --> 00:14:23,570
close to because you've got to scan

341
00:14:29,650 --> 00:14:26,630
places for where this Lander is going to

342
00:14:33,310 --> 00:14:29,660
look going to land right so they

343
00:14:36,310 --> 00:14:33,320
released a mosaic like this okay of four

344
00:14:40,090 --> 00:14:36,320
different images and then they said to

345
00:14:42,400 --> 00:14:40,100
image processors okay here are the four

346
00:14:45,130 --> 00:14:42,410
images that we took that mosaic over the

347
00:14:47,410 --> 00:14:45,140
whole thing how about if you go out and

348
00:14:50,980 --> 00:14:47,420
try and mosaic them together because you

349
00:14:53,500 --> 00:14:50,990
know as the as the as the orbiter is

350
00:14:55,180 --> 00:14:53,510
moving around it the lighting is going

351
00:14:57,160 --> 00:14:55,190
to change the Quetta the comments going

352
00:14:58,630 --> 00:14:57,170
to rotate a little bit so it was a

353
00:15:02,170 --> 00:14:58,640
significant amount of image processing

354
00:15:05,020 --> 00:15:02,180
to combine these guys together right and

355
00:15:08,230 --> 00:15:05,030
so a gentleman named Daniel Maha check

356
00:15:10,270 --> 00:15:08,240
put together this one from the August

357
00:15:13,390 --> 00:15:10,280
thirty-first mosaic and that I think is

358
00:15:15,250 --> 00:15:13,400
really cool and although it looks kind

359
00:15:17,140 --> 00:15:15,260
of mean it certainly does look like a

360
00:15:19,600 --> 00:15:17,150
rubber duck there don't you think yeah I

361
00:15:21,010 --> 00:15:19,610
guess so I guess while you're talking

362
00:15:22,000 --> 00:15:21,020
about this Frank I want to energy I

363
00:15:23,530 --> 00:15:22,010

could comment from

364
00:15:25,690 --> 00:15:23,540
d Schmidt she's made a comment about

365
00:15:28,720 --> 00:15:25,700
what you're saying she said despite how

366
00:15:30,460 --> 00:15:28,730
the photos look and it and being a

367
00:15:32,410 --> 00:15:30,470
snowball the comet is actually very dark

368
00:15:35,110 --> 00:15:32,420
in color always surprising to learn how

369
00:15:38,740 --> 00:15:35,120
dark some things are like the moon is

370
00:15:40,930 --> 00:15:38,750
pretty much charcoal so that is correct

371
00:15:42,400 --> 00:15:40,940
yeah thank you Judy a good good insight

372
00:15:44,320 --> 00:15:42,410
that's true this is what you're looking

373
00:15:47,590 --> 00:15:44,330
at of course is reflections from the Sun

374
00:15:51,760 --> 00:15:47,600
but this is a pretty dark object yeah

375
00:15:55,030 --> 00:15:51,770
the standard thing is that the comet is

376
00:15:57,310 --> 00:15:55,040
as dark as the asphalt on the road okay

377
00:15:58,630 --> 00:15:57,320
and that because it's been traveling

378
00:16:02,800 --> 00:15:58,640
around in outer space for billions of

379
00:16:05,890 --> 00:16:02,810
years any particles that hit it you know

380
00:16:08,020 --> 00:16:05,900
cover up all the school quotes no you

381
00:16:10,300 --> 00:16:08,030
don't see white snow on comets okay

382
00:16:13,060 --> 00:16:10,310
because the outer layers are the starry

383
00:16:15,250 --> 00:16:13,070
gyuki stuff the inner layers are white

384
00:16:17,050 --> 00:16:15,260
and bright and would be would be your

385
00:16:19,870 --> 00:16:17,060
snow like substances but the outer

386
00:16:23,170 --> 00:16:19,880
layers I've definitely been baked in the

387
00:16:25,360 --> 00:16:23,180
solar heat all of the volatiles on the

388
00:16:27,690 --> 00:16:25,370

surface have evaporated away leaving

389
00:16:30,310 --> 00:16:27,700
behind this sort of tar like residue

390
00:16:33,220 --> 00:16:30,320
okay so they're sure there's your rubber

391
00:16:35,050 --> 00:16:33,230
duck okay but here's the question and

392
00:16:37,840 --> 00:16:35,060
the question they're studying this month

393
00:16:39,880 --> 00:16:37,850
is where on this rubber duck are they

394
00:16:46,990 --> 00:16:39,890
going to land okay where are they going

395
00:16:48,430 --> 00:16:47,000
to put that Lander to be the the problem

396
00:16:50,980 --> 00:16:48,440
is is that because it's got this

397
00:16:52,810 --> 00:16:50,990
irregular shape the orbit around it is

398
00:16:55,180 --> 00:16:52,820
actually not that difficult you know

399
00:16:57,250 --> 00:16:55,190
it's just an irregular moment of inertia

400
00:16:59,290 --> 00:16:57,260
to work with but now you've got to try

401
00:17:01,270 --> 00:16:59,300
and land on this while it's rotating

402
00:17:03,340 --> 00:17:01,280
with this kind of irregular shape so

403
00:17:06,310 --> 00:17:03,350
that sort of the places that are

404
00:17:08,260 --> 00:17:06,320
possible to lab and so the plan was to

405
00:17:10,900 --> 00:17:08,270
come up with five potential landing

406
00:17:14,970 --> 00:17:10,910
sites toward the end of August which

407
00:17:17,260 --> 00:17:14,980
they did and here is a refined 3d model

408
00:17:21,210 --> 00:17:17,270
and with the five potential landing

409
00:17:23,590 --> 00:17:21,220
sites for the feel a lander a they

410
00:17:25,540 --> 00:17:23,600
obviously they hit big chose a lot more

411
00:17:29,200 --> 00:17:25,550
because they got a B and C but then they

412
00:17:32,170 --> 00:17:29,210
have I and J yeah I don't know I haven't

413
00:17:34,450 --> 00:17:32,180

dismissed d through H seem to have

414
00:17:35,660 --> 00:17:34,460
disappeared make the cut yeah didn't

415
00:17:37,550 --> 00:17:35,670
make the cut alright so the

416
00:17:39,590 --> 00:17:37,560
the five potential landing sites well

417
00:17:42,410 --> 00:17:39,600
then they release some high-resolution

418
00:17:45,080 --> 00:17:42,420
photographs of those landing sites so

419
00:17:48,590 --> 00:17:45,090
here's the ABC I and J landing sites on

420
00:17:52,610 --> 00:17:48,600
the scale and this is one kilometer on

421
00:17:56,510 --> 00:17:52,620
aside for each of these right so that's

422
00:17:58,610 --> 00:17:56,520
really interesting k um I actually look

423
00:18:00,980 --> 00:17:58,620
at these pictures and my favorite

424
00:18:04,010 --> 00:18:00,990
landing site might be site B because it

425
00:18:05,930 --> 00:18:04,020
looks much sort of like a lunar mari

426
00:18:07,880 --> 00:18:05,940
very smooth yeah I was going to say the

427
00:18:09,590 --> 00:18:07,890
same thing I predict that's what I think

428
00:18:13,130 --> 00:18:09,600
it's be B should be the one the other

429
00:18:14,650 --> 00:18:13,140
ones look too scary yeah but what

430
00:18:17,840 --> 00:18:14,660
they're going to do is they're going to

431
00:18:20,990 --> 00:18:17,850
survey these five sites at a resolution

432
00:18:25,490 --> 00:18:21,000
of what they said like you know half a

433
00:18:26,960 --> 00:18:25,500
meter per pixel which is amazing but

434
00:18:29,270 --> 00:18:26,970
sensitive that close they will look at

435
00:18:31,340 --> 00:18:29,280
these sites in great detail and about

436
00:18:33,800 --> 00:18:31,350
half a meter per pixel resolution and

437
00:18:36,830 --> 00:18:33,810
then before they choose their primary

438
00:18:38,930 --> 00:18:36,840

landing site and I'm told that their

439
00:18:40,820 --> 00:18:38,940
primary landing site will be chosen in

440
00:18:42,530 --> 00:18:40,830
mid-september so we got a couple weeks

441
00:18:44,330 --> 00:18:42,540
before we'll find out what the primary

442
00:18:46,430 --> 00:18:44,340
landing site is so let me ask you this

443
00:18:48,980 --> 00:18:46,440
frankly the spinning of the comment and

444
00:18:50,780 --> 00:18:48,990
the the rotation and the fact that they

445
00:18:54,020 --> 00:18:50,790
found out this thing is not a very

446
00:18:56,780 --> 00:18:54,030
regular object does that substantially

447
00:18:58,130 --> 00:18:56,790
complicate the the orbiting are the

448
00:19:00,230 --> 00:18:58,140
landing equations that are going to be

449
00:19:02,330 --> 00:19:00,240
needed or the trajectories or are they

450
00:19:05,960 --> 00:19:02,340
they concerned about that at all do you

451
00:19:08,090 --> 00:19:05,970
know well they very quickly when they

452
00:19:10,040 --> 00:19:08,100
made the initial models of it from what

453
00:19:12,740 --> 00:19:10,050
I understand they recognize that they

454
00:19:15,500 --> 00:19:12,750
couldn't really land on the neck okay on

455
00:19:17,570 --> 00:19:15,510
just because of the way the rotation of

456
00:19:20,690 --> 00:19:17,580
it trying to get into the neck might not

457
00:19:22,970 --> 00:19:20,700
be a really good spot ok so i guess if i

458
00:19:25,370 --> 00:19:22,980
go to the previous one you can see that

459
00:19:28,280 --> 00:19:25,380
they've got three sites that are on the

460
00:19:29,840 --> 00:19:28,290
top of the head and then they've got two

461
00:19:32,420 --> 00:19:29,850
sites on what i would call the tail of

462
00:19:37,310 --> 00:19:32,430
the duck okay we're gonna lay those but

463
00:19:39,080 --> 00:19:37,320

sightsee all right so landing on the

464
00:19:41,620 --> 00:19:39,090
duckies tail or landing on the duckies

465
00:19:44,180 --> 00:19:41,630
head seemed to be the favored sites of

466
00:19:46,850 --> 00:19:44,190
both in terms of the orbital mechanics

467
00:19:49,139 --> 00:19:46,860
of it and perhaps in terms of the

468
00:19:53,729 --> 00:19:49,149
smoothness of the site for for a landing

469
00:19:55,919 --> 00:19:53,739
right that is awesome ya need so here's

470
00:19:59,669 --> 00:19:55,929
a point where Itay amazing things about

471
00:20:02,039 --> 00:19:59,679
ms Emily lakdawala she perceived too

472
00:20:04,709 --> 00:20:02,049
many yes she writes a blog for the

473
00:20:07,440 --> 00:20:04,719
Planetary Society and I just want to

474
00:20:09,570 --> 00:20:07,450
give her a tip of the hat not a wag of

475
00:20:11,549 --> 00:20:09,580
the finger a tip of the hat because so

476
00:20:13,019 --> 00:20:11,559
many it was easy just to go through a

477
00:20:15,899 --> 00:20:13,029
lot of her blog posts and pull out

478
00:20:19,799 --> 00:20:15,909
images for this I will note that the

479
00:20:21,570 --> 00:20:19,809
landing for feel a will occur starting

480
00:20:23,669 --> 00:20:21,580
on November 11th the orbital maneuver

481
00:20:26,549 --> 00:20:23,679
will start on remember 11th and it will

482
00:20:30,889 --> 00:20:26,559
land on november nineteenth so for

483
00:20:34,919 --> 00:20:30,899
thanksgiving we may be serving duck okay

484
00:20:38,669 --> 00:20:34,929
in rubber form rubber duck for

485
00:20:40,440 --> 00:20:38,679
thanksgiving okay alright so that's

486
00:20:42,899 --> 00:20:40,450
great know an emily is outstanding

487
00:20:44,729 --> 00:20:42,909
resource for anybody who wants to keep

488
00:20:46,709 --> 00:20:44,739

abreast of the absolute latest for

489
00:20:48,899 --> 00:20:46,719
twitter feed is also a really a good

490
00:20:51,419 --> 00:20:48,909
source i follow it and I learn more from

491
00:20:54,169 --> 00:20:51,429
that about that small ways like Frank

492
00:20:58,409 --> 00:20:54,179
one of my first choices to go to alright

493
00:21:01,200 --> 00:20:58,419
seldomly that's a story number one I got

494
00:21:02,759 --> 00:21:01,210
three more ritual bit shorter this and

495
00:21:04,169 --> 00:21:02,769
then we actually and in these ones we

496
00:21:05,879 --> 00:21:04,179
actually get back to Hubble because

497
00:21:10,349 --> 00:21:05,889
there wasn't really a Hubble tie-in for

498
00:21:12,989 --> 00:21:10,359
comment rubber ducky there no okay so

499
00:21:16,560 --> 00:21:12,999
our second story today is big bursts of

500
00:21:18,899 --> 00:21:16,570
star formation in distant dwarf galaxies

501
00:21:22,139 --> 00:21:18,909
now what we're really talking about here

502
00:21:25,019 --> 00:21:22,149
are star bursting galaxies okay galaxies

503
00:21:28,619 --> 00:21:25,029
that have these immense amounts of star

504
00:21:31,969 --> 00:21:28,629
formation and one of the prime examples

505
00:21:34,589 --> 00:21:31,979
2.2 is the antennae galaxies shown here

506
00:21:36,659 --> 00:21:34,599
you can see there are two heads and then

507
00:21:39,629 --> 00:21:36,669
these two long tails that go off from

508
00:21:42,539 --> 00:21:39,639
each other these two galaxies were

509
00:21:45,479 --> 00:21:42,549
determined about almost she was the

510
00:21:47,669 --> 00:21:45,489
1970s so that that's 40 years ago it was

511
00:21:51,029 --> 00:21:47,679
determined that these two galaxies have

512
00:21:53,489 --> 00:21:51,039
been on a collision okay and 74 years

513
00:21:56,399 --> 00:21:53,499

yes the collision lasts about a billion

514
00:21:58,829 --> 00:21:56,409
years but it was 40 years ago when the

515
00:22:00,659 --> 00:21:58,839
tomb ray brothers were actually able to

516
00:22:02,460 --> 00:22:00,669
deduce and show from computer

517
00:22:04,680 --> 00:22:02,470
simulations very very

518
00:22:07,020 --> 00:22:04,690
very similar computer simulations back

519
00:22:09,779 --> 00:22:07,030
then that the two galaxies were actually

520
00:22:11,730 --> 00:22:09,789
in the fact of colliding and we believe

521
00:22:13,740 --> 00:22:11,740
that the collision insights star

522
00:22:15,870 --> 00:22:13,750
formation and that star formation is

523
00:22:18,570 --> 00:22:15,880
greatly seen when we go to this Hubble

524
00:22:21,480 --> 00:22:18,580
image of just the central part of it and

525
00:22:23,700 --> 00:22:21,490
you can see all those bright pink

526
00:22:26,159 --> 00:22:23,710
regions which are star forming regions

527
00:22:29,460 --> 00:22:26,169
and all those bright blue stars which

528
00:22:31,860 --> 00:22:29,470
are hot newborn massive stars so all

529
00:22:33,810 --> 00:22:31,870
those pink regions are areas where stars

530
00:22:36,270 --> 00:22:33,820
are currently being born within this

531
00:22:38,340 --> 00:22:36,280
collision right and they are they are

532
00:22:41,130 --> 00:22:38,350
regions that make the Orion Nebula look

533
00:22:43,110 --> 00:22:41,140
puny all right now the Orion Nebula is

534
00:22:45,120 --> 00:22:43,120
one of our closest on our fate most

535
00:22:47,399 --> 00:22:45,130
favorite star forming regions it's got

536
00:22:51,000 --> 00:22:47,409
like about four thousand stars forming

537
00:22:53,159 --> 00:22:51,010
within it these are super star clusters

538
00:22:55,649 --> 00:22:53,169

that are forming here with tens of

539
00:22:57,419 --> 00:22:55,659
thousands of stars and hunt and lots of

540
00:22:59,820 --> 00:22:57,429
lots and lots of stars in the inner

541
00:23:01,640 --> 00:22:59,830
formation so you know these are really

542
00:23:04,169 --> 00:23:01,650
these are big star forming regions

543
00:23:05,549 --> 00:23:04,179
there's a ton of star formation going on

544
00:23:08,970 --> 00:23:05,559
in here and that's what defines

545
00:23:10,380 --> 00:23:08,980
starburst okay are there any preference

546
00:23:12,149 --> 00:23:10,390
the kinds of stars being born here or

547
00:23:14,669 --> 00:23:12,159
there are they a specific type of star

548
00:23:17,279 --> 00:23:14,679
or they just all kinds know we found

549
00:23:20,760 --> 00:23:17,289
that when you form stars you tend to

550
00:23:23,490 --> 00:23:20,770
form stars of all different masses you

551
00:23:27,020 --> 00:23:23,500
form your you form a few really big

552
00:23:32,120 --> 00:23:27,030
massive stars and then a lot of faint

553
00:23:34,799 --> 00:23:32,130
stars I think the average the average

554
00:23:36,810 --> 00:23:34,809
size of a star in a star-forming region

555
00:23:39,690 --> 00:23:36,820
is only a seven tenths of the size of

556
00:23:41,760 --> 00:23:39,700
the Sun stars can go up to hundreds of

557
00:23:43,830 --> 00:23:41,770
times the size of the Sun and down to

558
00:23:47,220 --> 00:23:43,840
about a tenth the size of the Sun but

559
00:23:50,760 --> 00:23:47,230
the average mass is about seven tenths

560
00:23:52,830 --> 00:23:50,770
the size of a son so you for all the

561
00:23:54,450 --> 00:23:52,840
really big stars you can see here there

562
00:23:59,940 --> 00:23:54,460
are lots more small stars that of course

563
00:24:03,870 --> 00:23:59,950

you can't see so starburst we believe

564
00:24:05,700 --> 00:24:03,880
are induced by an event normal galaxies

565
00:24:07,919 --> 00:24:05,710
just don't have this much star formation

566
00:24:11,880 --> 00:24:07,929
going on here the event is the merging

567
00:24:13,830 --> 00:24:11,890
of two galaxies so we wanted to when

568
00:24:15,480 --> 00:24:13,840
we've studied starbursts we want to

569
00:24:16,159 --> 00:24:15,490
actually study the star formation

570
00:24:17,869 --> 00:24:16,169
history of the

571
00:24:19,430 --> 00:24:17,879
universe and these starburst and

572
00:24:21,379 --> 00:24:19,440
galaxies are the easiest ones to study

573
00:24:23,779 --> 00:24:21,389
because they got so much star formation

574
00:24:26,479 --> 00:24:23,789
going on in them and as we looked out

575
00:24:29,239 --> 00:24:26,489
into the distant universe we use these

576
00:24:32,690 --> 00:24:29,249
deep images from Hubble we've been able

577
00:24:34,580 --> 00:24:32,700
to study star bursting in the big

578
00:24:37,190 --> 00:24:34,590
galaxies and even some of the

579
00:24:38,930 --> 00:24:37,200
medium-sized galaxies so as we look out

580
00:24:42,080 --> 00:24:38,940
into the universe in the formation of

581
00:24:46,399 --> 00:24:42,090
stars and we find that the the peak of

582
00:24:49,789 --> 00:24:46,409
star formation was about 4 or 5 billion

583
00:24:52,999 --> 00:24:49,799
years after the Big Bang okay we sort of

584
00:24:54,619 --> 00:24:53,009
look in the redshift range 1 to 2 which

585
00:24:56,509 --> 00:24:54,629
is about 2 billion years after the Big

586
00:24:59,180 --> 00:24:56,519
Bang to about six or seven billion years

587
00:25:01,159 --> 00:24:59,190
after the Big Bang okay so that there

588
00:25:04,249 --> 00:25:01,169

was a period when most of the stars in

589
00:25:05,539 --> 00:25:04,259
the universe were born exactly okay so

590
00:25:07,999 --> 00:25:05,549
those sort of the peak of star formation

591
00:25:10,039 --> 00:25:08,009
in the universe and so we've looked at

592
00:25:11,840 --> 00:25:10,049
the star bursting galaxies in those

593
00:25:16,009 --> 00:25:11,850
range but only the medium and large ones

594
00:25:17,629 --> 00:25:16,019
and with the wide field camera 3 and in

595
00:25:20,389 --> 00:25:17,639
particular the increased infrared

596
00:25:22,999 --> 00:25:20,399
sensitivity of whiffs III on Hubble

597
00:25:26,810 --> 00:25:23,009
we've been able to extend those studies

598
00:25:30,919 --> 00:25:26,820
to send sample the smaller galaxies and

599
00:25:36,499 --> 00:25:30,929
so this image here there are there are

600
00:25:39,320 --> 00:25:36,509
six red circles around six of the small

601
00:25:42,979 --> 00:25:39,330
dwarf galaxies that they found to be

602
00:25:46,729 --> 00:25:42,989
star bursting ok and they were able to

603
00:25:48,470 --> 00:25:46,739
study these dwarf galaxies in the having

604
00:25:50,690 --> 00:25:48,480
starburst between two and six billion

605
00:25:53,330 --> 00:25:50,700
years out there and it's really

606
00:25:55,090 --> 00:25:53,340
important because dwarf galaxies are the

607
00:25:57,169 --> 00:25:55,100
most numerous galaxies in the universe

608
00:25:59,029 --> 00:25:57,179
just like I said that you know there are

609
00:26:01,340 --> 00:25:59,039
many more smaller stars and there are

610
00:26:04,070 --> 00:26:01,350
big stars there are also many more

611
00:26:06,590 --> 00:26:04,080
smaller galaxies than there are big

612
00:26:09,499 --> 00:26:06,600
galaxies so if these dwarf galaxies are

613
00:26:11,119 --> 00:26:09,509

undergoing starbursts as well well then

614
00:26:13,729 --> 00:26:11,129
that can have a significant effect and

615
00:26:17,299 --> 00:26:13,739
it turns out that they have a really

616
00:26:19,999 --> 00:26:17,309
huge star formation that they can double

617
00:26:22,340 --> 00:26:20,009
the number of stars in them within only

618
00:26:25,549 --> 00:26:22,350
a hundred million or 150 million years

619
00:26:27,080 --> 00:26:25,559
so why is that so why is that so

620
00:26:30,000 --> 00:26:27,090
significant if door because dwarf

621
00:26:31,980 --> 00:26:30,010
galaxies are the most common type of gal

622
00:26:34,110 --> 00:26:31,990
so the most numerous of the galaxies

623
00:26:35,790 --> 00:26:34,120
exactly there's no ser if they're

624
00:26:37,710 --> 00:26:35,800
showing a lot of rapid star formation

625
00:26:40,860 --> 00:26:37,720
then there's a lot more stars than we

626
00:26:42,450 --> 00:26:40,870
think there are maybe exactly if only

627
00:26:45,750 --> 00:26:42,460
you know ten percent of your population

628
00:26:47,310 --> 00:26:45,760
is doing something right well then that

629
00:26:50,370 --> 00:26:47,320
sort of says well you know it's it's

630
00:26:52,200 --> 00:26:50,380
it's a good sub group but it might not

631
00:26:54,180 --> 00:26:52,210
be able to dominate what's really going

632
00:26:55,980 --> 00:26:54,190
on but if ninety percent of your

633
00:26:58,580 --> 00:26:55,990
population is doing something well this

634
00:27:03,180 --> 00:26:58,590
by sheer number they can dominate I

635
00:27:05,460 --> 00:27:03,190
guess we could relate it to the post-war

636
00:27:07,140 --> 00:27:05,470
generation right the baby boomers how

637
00:27:08,940 --> 00:27:07,150
they've had so much population here in

638
00:27:10,440 --> 00:27:08,950

the US and they've been able to dominate

639
00:27:14,430 --> 00:27:10,450
culture as they go through their lives

640
00:27:16,890 --> 00:27:14,440
and cetera so you want the the most

641
00:27:19,860 --> 00:27:16,900
massive population find out what they're

642
00:27:22,170 --> 00:27:19,870
doing then you'll get a better handle on

643
00:27:24,060 --> 00:27:22,180
what's over all happening right well I

644
00:27:26,190 --> 00:27:24,070
don't I don't we I don't want you to put

645
00:27:27,390 --> 00:27:26,200
you on the spot here and so I mean if

646
00:27:31,320 --> 00:27:27,400
you don't know the answer that's okay

647
00:27:34,050 --> 00:27:31,330
but do you have a sense of how much how

648
00:27:35,700 --> 00:27:34,060
many in terms of percent is it like ten

649
00:27:37,380 --> 00:27:35,710
percent more stars twenty percent more

650
00:27:39,990 --> 00:27:37,390
stars than we thought fifty percent more

651
00:27:42,210 --> 00:27:40,000
stars I'll get to that I get to that

652
00:27:43,860 --> 00:27:42,220
number at the end of all I don't want to

653
00:27:45,300 --> 00:27:43,870
steal your punchlines I'm not going to

654
00:27:47,640 --> 00:27:45,310
give you my punchline until a doll and

655
00:27:50,430 --> 00:27:47,650
ready for enough fair enough we're very

656
00:27:52,710 --> 00:27:50,440
close to this okay so these are in the

657
00:27:56,520 --> 00:27:52,720
range what we call extreme emission-line

658
00:27:58,710 --> 00:27:56,530
galaxies ee lg's okay hey we're

659
00:28:00,870 --> 00:27:58,720
measuring their star formation by

660
00:28:03,450 --> 00:28:00,880
looking at the hydrogen alpha line okay

661
00:28:05,100 --> 00:28:03,460
so the amount of hydrogen emission

662
00:28:07,610 --> 00:28:05,110
that's coming on there which we found to

663
00:28:10,680 --> 00:28:07,620

be a very good measure of star formation

664
00:28:13,980 --> 00:28:10,690
and that they are producing stars you

665
00:28:16,950 --> 00:28:13,990
know 100 times more rapidly than normal

666
00:28:19,710 --> 00:28:16,960
galaxies and even several times more

667
00:28:22,470 --> 00:28:19,720
rapidly than our normal star bursts in

668
00:28:25,290 --> 00:28:22,480
the large galaxies so when you add up

669
00:28:28,020 --> 00:28:25,300
all of these uh dwarf galaxies and the

670
00:28:30,030 --> 00:28:28,030
extreme star bursting that they're going

671
00:28:31,170 --> 00:28:30,040
through they calculate well depending

672
00:28:35,070 --> 00:28:31,180
them on how you do things they could

673
00:28:38,580 --> 00:28:35,080
cover about 13 to thirty four percent of

674
00:28:40,610 --> 00:28:38,590
the star formation going on between two

675
00:28:43,350 --> 00:28:40,620
and six billion years after the Big Bang

676
00:28:45,120 --> 00:28:43,360
so they can account for up to one

677
00:28:48,539 --> 00:28:45,130
third of all the star formation

678
00:28:49,680 --> 00:28:48,549
happening at that time previously we

679
00:28:52,470 --> 00:28:49,690
didn't have any information on the

680
00:28:55,799 --> 00:28:52,480
divorce and you know should the divorce

681
00:28:57,570 --> 00:28:55,809
be there awfully awfully small you know

682
00:28:59,910 --> 00:28:57,580
they're down to what 1% the size of a

683
00:29:02,520 --> 00:28:59,920
big galaxy should they really be

684
00:29:05,549 --> 00:29:02,530
considered well the answer is yes it's

685
00:29:08,940 --> 00:29:05,559
very surprising just how much they make

686
00:29:10,950 --> 00:29:08,950
might contribute okay so let me just go

687
00:29:13,140 --> 00:29:10,960
back for a minute here sure we've all

688
00:29:15,360 --> 00:29:13,150

seen this pie chart of the composition

689
00:29:16,830 --> 00:29:15,370
of the universe where all the matter

690
00:29:19,110 --> 00:29:16,840
that we know in the universe is like

691
00:29:20,909 --> 00:29:19,120
four or five percent dark matter makes

692
00:29:22,770 --> 00:29:20,919
up twenty or some odd twenty-five

693
00:29:25,650 --> 00:29:22,780
percent and dark energy makes up the

694
00:29:28,350 --> 00:29:25,660
remaining seventy percent what effect is

695
00:29:33,120 --> 00:29:28,360
this going to do if any on the five

696
00:29:34,650 --> 00:29:33,130
percent slice of pie okay so that five

697
00:29:36,720 --> 00:29:34,660
percent slice of pie will stay the same

698
00:29:39,090 --> 00:29:36,730
okay doesn't it's not changing the

699
00:29:40,230 --> 00:29:39,100
amount of baryonic matter in the

700
00:29:43,200 --> 00:29:40,240
universe the normal matter in the

701
00:29:45,450 --> 00:29:43,210
universe right so let's conserve then I

702
00:29:47,880 --> 00:29:45,460
guess I'll data that that that that does

703
00:29:52,110 --> 00:29:47,890
not affect here what this does have is

704
00:29:55,500 --> 00:29:52,120
where do the stars that we see today get

705
00:29:58,140 --> 00:29:55,510
born are they born in large galaxies are

706
00:30:00,990 --> 00:29:58,150
they born in medium galaxies or are they

707
00:30:02,580 --> 00:30:01,000
born in star and small galaxies what

708
00:30:05,820 --> 00:30:02,590
this result is saying is that up to a

709
00:30:08,460 --> 00:30:05,830
third of them may be born in small

710
00:30:10,289 --> 00:30:08,470
galaxies good all right and I think I

711
00:30:12,180 --> 00:30:10,299
wanted to make because I I don't I don't

712
00:30:13,770 --> 00:30:12,190
want people to think we've discovered a

713
00:30:16,260 --> 00:30:13,780

whole bunch of stars that we didn't know

714
00:30:17,850 --> 00:30:16,270
we're there before it's it's all there

715
00:30:21,030 --> 00:30:17,860
just we're getting a better idea of

716
00:30:23,760 --> 00:30:21,040
where and how these stars are forming at

717
00:30:26,370 --> 00:30:23,770
lynn in the history of universe exactly

718
00:30:28,289 --> 00:30:26,380
we know that we can under we can

719
00:30:30,630 --> 00:30:28,299
approximate the stellar content of the

720
00:30:32,789 --> 00:30:30,640
universe today and we're trying to

721
00:30:35,430 --> 00:30:32,799
figure out how when did they form and

722
00:30:37,799 --> 00:30:35,440
where did they form we figured out when

723
00:30:39,120 --> 00:30:37,809
they formed it appears but now we're

724
00:30:41,159 --> 00:30:39,130
seeing that they actually more of them

725
00:30:44,159 --> 00:30:41,169
form in small galaxies than we had

726
00:30:47,400 --> 00:30:44,169
previously suspected awesome all right

727
00:30:49,470 --> 00:30:47,410
thank you Frank that's cool that is that

728
00:30:53,970 --> 00:30:49,480
story and we're going to move on to

729
00:30:57,149 --> 00:30:53,980
another star bursting object we're going

730
00:30:58,739 --> 00:30:57,159
to talk about a baby elliptical

731
00:30:59,909 --> 00:30:58,749
we've talked about rubber duckies now

732
00:31:04,889 --> 00:30:59,919
we're gonna go cute little baby

733
00:31:06,210 --> 00:31:04,899
elliptical galaxy here so uh when we

734
00:31:09,539 --> 00:31:06,220
think I love to play so there was such a

735
00:31:11,999 --> 00:31:09,549
thing to be honest we've never seen one

736
00:31:14,219 --> 00:31:12,009
before that's the point of this story ok

737
00:31:16,499 --> 00:31:14,229
when you think of ellipticals you don't

738
00:31:18,089 --> 00:31:16,509

think of cute little objects gay maybe

739
00:31:20,940 --> 00:31:18,099
gig there are some dwarf ellipticals

740
00:31:23,849 --> 00:31:20,950
that are small and just galaxies in the

741
00:31:26,789 --> 00:31:23,859
university's right ok so this image here

742
00:31:30,269 --> 00:31:26,799
is of the Perseus cluster of galaxies

743
00:31:32,369 --> 00:31:30,279
all right and because it's far away

744
00:31:34,919 --> 00:31:32,379
right most of the galaxies here are

745
00:31:38,129 --> 00:31:34,929
roughly the same distance so you can

746
00:31:40,109 --> 00:31:38,139
actually compare sizes one to another

747
00:31:42,149 --> 00:31:40,119
and you can see that the largest ones

748
00:31:44,759 --> 00:31:42,159
here are these elliptical galaxies near

749
00:31:46,169 --> 00:31:44,769
the center you can pick out a few spiral

750
00:31:48,869 --> 00:31:46,179
galaxies in here and they're all

751
00:31:52,200 --> 00:31:48,879
considerably smaller so you've got these

752
00:31:53,639 --> 00:31:52,210
giant elliptical galaxies ok I'm sorry

753
00:31:56,729 --> 00:31:53,649
nice thing how far away this cluster was

754
00:31:58,409 --> 00:31:56,739
i did not i actually just wanted to use

755
00:32:02,219 --> 00:31:58,419
this as an example of giant ellipticals

756
00:32:04,109 --> 00:32:02,229
ok ok veral rocks they're all about the

757
00:32:05,310 --> 00:32:04,119
same all the same way very far away

758
00:32:07,680 --> 00:32:05,320
there are hundreds of millions of light

759
00:32:11,070 --> 00:32:07,690
years away how about that yeah ok all

760
00:32:12,930 --> 00:32:11,080
right and so we got these giant

761
00:32:14,849 --> 00:32:12,940
ellipticals and we believe that dense

762
00:32:17,879 --> 00:32:14,859
they existed they we find them a lot of

763
00:32:20,909 --> 00:32:17,889

the cores of clusters that they accrete

764
00:32:22,739 --> 00:32:20,919
their their mass by merging ok I showed

765
00:32:24,570 --> 00:32:22,749
you one an image of merging previously

766
00:32:26,190 --> 00:32:24,580
but at the center of a cluster of

767
00:32:28,379 --> 00:32:26,200
galaxies you would naturally get more

768
00:32:31,499 --> 00:32:28,389
merging and that was where you find

769
00:32:33,450 --> 00:32:31,509
these giant ellipticals but so we can

770
00:32:36,149 --> 00:32:33,460
see how they grow but we wanted to know

771
00:32:37,950 --> 00:32:36,159
how do these giant elliptical start

772
00:32:40,200 --> 00:32:37,960
these these galaxies that become the

773
00:32:42,899 --> 00:32:40,210
these big galaxies how do they really

774
00:32:46,139 --> 00:32:42,909
start and we can look back out and out

775
00:32:49,619 --> 00:32:46,149
into these deep images all right we can

776
00:32:51,210 --> 00:32:49,629
take a look at this is a galaxy in the

777
00:32:54,239 --> 00:32:51,220
coma cluster Nalepa GALEX in the coma

778
00:32:57,629 --> 00:32:54,249
cluster and so they have these dense

779
00:33:00,029 --> 00:32:57,639
cores at their Center and we believe

780
00:33:02,249 --> 00:33:00,039
that these must form relatively early on

781
00:33:05,039 --> 00:33:02,259
in the universe ok because you got very

782
00:33:08,009 --> 00:33:05,049
old stars in here and we can account for

783
00:33:09,299 --> 00:33:08,019
growth by emerging and we can look out

784
00:33:10,350 --> 00:33:09,309
into the universe and trace them back

785
00:33:12,090 --> 00:33:10,360
but

786
00:33:15,390 --> 00:33:12,100
what we really wanted to find is that

787
00:33:17,820 --> 00:33:15,400
formation of that core all right and we

788
00:33:19,470 --> 00:33:17,830

hadn't been able to see that yet okay we

789
00:33:21,480 --> 00:33:19,480
wanted to find the formation of that

790
00:33:25,230 --> 00:33:21,490
that that initial core which probably

791
00:33:27,290 --> 00:33:25,240
grew very very very fast well we did one

792
00:33:31,800 --> 00:33:27,300
of these deep images of the universe

793
00:33:35,310 --> 00:33:31,810
searching for this and again using the

794
00:33:36,810 --> 00:33:35,320
infrared capabilities of with c3 just

795
00:33:39,960 --> 00:33:36,820
letting you know that the infrared is is

796
00:33:42,660 --> 00:33:39,970
is proven to be extremely useful on with

797
00:33:46,140 --> 00:33:42,670
c3 they identify this object here this

798
00:33:48,870 --> 00:33:46,150
orangish object here as pot as being a

799
00:33:51,840 --> 00:33:48,880
really good candidate for being the core

800
00:33:54,450 --> 00:33:51,850
of what would become a future elliptical

801
00:33:56,220 --> 00:33:54,460
galaxy now what are the special

802
00:33:58,620 --> 00:33:56,230
characteristics of this object that make

803
00:34:01,500 --> 00:33:58,630
it so make it a candidate well it's

804
00:34:05,190 --> 00:34:01,510
really tiny it's about 6,000 light-years

805
00:34:07,410 --> 00:34:05,200
across whereas a galaxy like our Milky

806
00:34:10,530 --> 00:34:07,420
Way is a hundred thousand light-years

807
00:34:12,770 --> 00:34:10,540
across six thousand verses a hundred

808
00:34:16,170 --> 00:34:12,780
thousand so this is smaller even than

809
00:34:18,750 --> 00:34:16,180
the Bulge of our Milky Way galaxy the

810
00:34:25,260 --> 00:34:18,760
core of a large galaxy it's smaller than

811
00:34:28,620 --> 00:34:25,270
that but already this object has as many

812
00:34:31,610 --> 00:34:28,630
stars in it as are in our entire Milky

813
00:34:35,390 --> 00:34:31,620

Way galaxy so it's a ton of stars

814
00:34:38,520 --> 00:34:35,400
compressed down to a very small region

815
00:34:43,770 --> 00:34:38,530
furthermore this object is seen at a

816
00:34:45,540 --> 00:34:43,780
redshift of 2.3 which places it at three

817
00:34:49,860 --> 00:34:45,550
billion years after the Big Bang or

818
00:34:52,590 --> 00:34:49,870
eleven build 11 billion years ago so

819
00:34:54,900 --> 00:34:52,600
this is an object that happened very

820
00:34:59,730 --> 00:34:54,910
early in the universe formed a ton of

821
00:35:02,760 --> 00:34:59,740
stars into a very small region they

822
00:35:05,070 --> 00:35:02,770
measured and the able to measure the

823
00:35:07,080 --> 00:35:05,080
star-formation rate going on in here and

824
00:35:09,090 --> 00:35:07,090
again intensely high another star

825
00:35:11,280 --> 00:35:09,100
bursting thing and looking at the

826
00:35:13,530 --> 00:35:11,290
history of it trying to gauge the ages

827
00:35:15,360 --> 00:35:13,540
of things so that they could try and

828
00:35:17,040 --> 00:35:15,370
interpolate the history of it they

829
00:35:19,470 --> 00:35:17,050
figured probably had been going on for

830
00:35:22,470 --> 00:35:19,480
about a billion years so you're talking

831
00:35:23,859 --> 00:35:22,480
tense star-formation rate for about a

832
00:35:26,620 --> 00:35:23,869
billion years

833
00:35:28,960 --> 00:35:26,630
now it wasn't just Hubble that was

834
00:35:31,539 --> 00:35:28,970
involved in this study that

835
00:35:33,460 --> 00:35:31,549
star-formation rate from Hubble would

836
00:35:35,589 --> 00:35:33,470
have actually been about one-sixth of

837
00:35:40,569 --> 00:35:35,599
the star-formation rate I just quoted to

838
00:35:42,910 --> 00:35:40,579

you instead they used observations from

839
00:35:45,730 --> 00:35:42,920
the Spitzer Space Telescope and from

840
00:35:47,339 --> 00:35:45,740
Herschel Space Telescope to look deeper

841
00:35:50,769 --> 00:35:47,349
into the infrared than Hubble can see

842
00:35:53,259 --> 00:35:50,779
and find more information and the deeper

843
00:35:54,430 --> 00:35:53,269
infrared wavelengths that showed that

844
00:35:57,160 --> 00:35:54,440
the star-formation rate was actually

845
00:35:59,380 --> 00:35:57,170
higher than we would deduce from just

846
00:36:02,890 --> 00:35:59,390
Hubble's observations actually about six

847
00:36:05,380 --> 00:36:02,900
times higher all right so by having this

848
00:36:08,230 --> 00:36:05,390
incredibly high star-formation rate and

849
00:36:10,420 --> 00:36:08,240
not being able to see it with Hubble the

850
00:36:14,410 --> 00:36:10,430
implication of that is that there's a

851
00:36:18,730 --> 00:36:14,420
lot of dust obscuring this galaxy okay

852
00:36:22,480 --> 00:36:18,740
or this core of a galaxy so the the

853
00:36:24,249 --> 00:36:22,490
postulations conclusion really is that

854
00:36:28,479 --> 00:36:24,259
the reason we haven't seen these before

855
00:36:30,609 --> 00:36:28,489
is that we haven't that they are highly

856
00:36:32,259 --> 00:36:30,619
obscured with lots of dust there's

857
00:36:35,109 --> 00:36:32,269
tremendous amount of star formation

858
00:36:37,210 --> 00:36:35,119
kicking up lots of dust or within this

859
00:36:39,729 --> 00:36:37,220
galaxy they're heavily reddened and

860
00:36:41,559 --> 00:36:39,739
obscured by this dust and so we're not

861
00:36:44,170 --> 00:36:41,569
going to see them very well with visible

862
00:36:45,609 --> 00:36:44,180
or with near-infrared light we need a

863
00:36:47,019 --> 00:36:45,619

little bit longer infrared light to be

864
00:36:49,390 --> 00:36:47,029
able to penetrate through some of that

865
00:36:52,420 --> 00:36:49,400
dust and be able to find more of these

866
00:36:53,979 --> 00:36:52,430
cores of elliptical galaxies which James

867
00:36:56,140 --> 00:36:53,989
Webb will be able to do pretty well oh

868
00:36:58,539 --> 00:36:56,150
you go straight to the punch line there

869
00:37:01,479 --> 00:36:58,549
yeah we go that's that's the conclusion

870
00:37:03,849 --> 00:37:01,489
that we have to jump to right no simply

871
00:37:06,870 --> 00:37:03,859
because a we're going to need the longer

872
00:37:08,859 --> 00:37:06,880
wavelengths james j ust will have the

873
00:37:10,960 --> 00:37:08,869
infrared wavelengths it will have the

874
00:37:14,680 --> 00:37:10,970
resolution of Hubble it will be able to

875
00:37:17,380 --> 00:37:14,690
see objects like this are much much more

876
00:37:20,769 --> 00:37:17,390
easily than either Hubble or Spitzer or

877
00:37:23,769 --> 00:37:20,779
Herschel ok so we got it we got an

878
00:37:25,720 --> 00:37:23,779
elliptical here three billion years

879
00:37:28,059 --> 00:37:25,730
after the after the Big Bang it's been

880
00:37:30,640 --> 00:37:28,069
burning that's been forming stars for

881
00:37:33,039 --> 00:37:30,650
about a billion years yep give us some

882
00:37:35,910 --> 00:37:33,049
context compare that with our Milky Way

883
00:37:39,300 --> 00:37:35,920
how old is our Milky Way galaxy and how

884
00:37:43,050 --> 00:37:39,310
let's see the the basic core of our

885
00:37:45,030 --> 00:37:43,060
Milky Way galaxy the basic dis / / Milky

886
00:37:48,240 --> 00:37:45,040
Way galaxy we believe is about 9 or 10

887
00:37:50,280 --> 00:37:48,250
billion years old so about a billion to

888
00:37:52,650 --> 00:37:50,290

two billion years after the core of this

889
00:37:54,390 --> 00:37:52,660
elliptical galaxies formed would be when

890
00:37:57,030 --> 00:37:54,400
the basic structure of our Milky Way

891
00:37:59,100 --> 00:37:57,040
formed but we wait a mountain elkeson ah

892
00:38:01,500 --> 00:37:59,110
so we've got a galaxy that's very old

893
00:38:04,350 --> 00:38:01,510
and we're still a spiral I thought

894
00:38:06,540 --> 00:38:04,360
ellipticals were among the oldest and

895
00:38:08,850 --> 00:38:06,550
they were among the they were the result

896
00:38:11,370 --> 00:38:08,860
of a lot of galaxy collisions that

897
00:38:12,810 --> 00:38:11,380
ultimately did not have stars forming in

898
00:38:14,850 --> 00:38:12,820
them and you've shown us an elliptical

899
00:38:16,680 --> 00:38:14,860
that does have stars forming in them so

900
00:38:20,040 --> 00:38:16,690
the processes can't be the same right

901
00:38:22,470 --> 00:38:20,050
this this elliptical wasn't formed like

902
00:38:24,420 --> 00:38:22,480
most elliptical well this elliptical was

903
00:38:28,560 --> 00:38:24,430
formed very early it started its

904
00:38:30,840 --> 00:38:28,570
formation very early and had uh and and

905
00:38:34,260 --> 00:38:30,850
and could not have formed in a low

906
00:38:36,720 --> 00:38:34,270
density quiescent way okay and if a

907
00:38:39,390 --> 00:38:36,730
galaxy forms quietly you know and things

908
00:38:42,560 --> 00:38:39,400
slowly drift on to collapse onto it

909
00:38:45,000 --> 00:38:42,570
right the angular momentum of the

910
00:38:48,060 --> 00:38:45,010
collapse is going to naturally produce a

911
00:38:51,270 --> 00:38:48,070
disk all right so spirals form in a

912
00:38:53,970 --> 00:38:51,280
relatively quiet fashion okay if you

913
00:38:55,830 --> 00:38:53,980

form in a very dense neighborhood when

914
00:38:58,140 --> 00:38:55,840
you get lots of small sub clumps that

915
00:39:00,060 --> 00:38:58,150
gather together and smash together like

916
00:39:03,210 --> 00:39:00,070
the early universe right the earlier

917
00:39:05,400 --> 00:39:03,220
universe which was was denser right then

918
00:39:07,590 --> 00:39:05,410
you're going to naturally get a more

919
00:39:10,530 --> 00:39:07,600
randomization of your orbits and you'll

920
00:39:12,810 --> 00:39:10,540
end up with elliptical shapes awesome

921
00:39:14,990 --> 00:39:12,820
all right thank you ya got that makes I

922
00:39:17,280 --> 00:39:15,000
understand that's cool thanks okay so

923
00:39:19,170 --> 00:39:17,290
that the main question that we want to

924
00:39:22,440 --> 00:39:19,180
be able to answer is just how many of

925
00:39:24,480 --> 00:39:22,450
these exist how prevalent are these can

926
00:39:29,580 --> 00:39:24,490
we get lots of baby elliptical galaxies

927
00:39:31,530 --> 00:39:29,590
and how can we really study this as a

928
00:39:34,140 --> 00:39:31,540
group because if you have one object

929
00:39:36,090 --> 00:39:34,150
okay that's great that's a nice tick

930
00:39:38,190 --> 00:39:36,100
mark you can I care but can you

931
00:39:41,100 --> 00:39:38,200
extrapolate from that into the

932
00:39:42,690 --> 00:39:41,110
characteristics or group no you want to

933
00:39:44,220 --> 00:39:42,700
be able to get a group of these and that

934
00:39:45,810 --> 00:39:44,230
is something that we will definitely

935
00:39:46,730 --> 00:39:45,820
study with the James Webb Space

936
00:39:49,340 --> 00:39:46,740
Telescope

937
00:39:50,660 --> 00:39:49,350
okay all right all right let me just

938
00:39:52,400 --> 00:39:50,670

before we leave this topic judy has

939
00:39:53,570 --> 00:39:52,410
another question and I just wanted since

940
00:39:54,950 --> 00:39:53,580
it's relevant I'll bring it up Judy

941
00:39:56,720 --> 00:39:54,960
Schmidt that does this bring us any

942
00:39:59,090 --> 00:39:56,730
closer to understanding the origins of

943
00:40:00,680 --> 00:39:59,100
globular clusters I meant this question

944
00:40:04,910 --> 00:40:00,690
in reference to the dwarf galaxy study

945
00:40:09,410 --> 00:40:04,920
so so in terms of the understanding of

946
00:40:12,350 --> 00:40:09,420
globular clusters that's a special topic

947
00:40:14,780 --> 00:40:12,360
ok because globular clusters can have

948
00:40:19,730 --> 00:40:14,790
hundreds of thousands to even millions

949
00:40:22,040 --> 00:40:19,740
of stars and we know that the globular

950
00:40:25,250 --> 00:40:22,050
clusters in our Milky Way galaxy are all

951
00:40:27,920 --> 00:40:25,260
very old general generally very very old

952
00:40:29,690 --> 00:40:27,930
and that there was a special formation

953
00:40:33,020 --> 00:40:29,700
process for these globular clusters

954
00:40:35,450 --> 00:40:33,030
about 12 billion years ago all right so

955
00:40:39,080 --> 00:40:35,460
even a little earlier than this galaxy

956
00:40:42,230 --> 00:40:39,090
that we see here and we've also found

957
00:40:45,170 --> 00:40:42,240
that we believe that that when you see

958
00:40:48,620 --> 00:40:45,180
evidence of mergers you also see a

959
00:40:51,500 --> 00:40:48,630
higher number of globular clusters so

960
00:40:55,490 --> 00:40:51,510
that globular clusters seem to also be

961
00:40:58,220 --> 00:40:55,500
formed during mergers so the merging

962
00:41:01,250 --> 00:40:58,230
sequences can obviously incite the kind

963
00:41:04,340 --> 00:41:01,260

of the kind of conditions that form

964
00:41:05,870 --> 00:41:04,350
globular clusters so the formation of a

965
00:41:08,480 --> 00:41:05,880
globular cluster seems to be an extreme

966
00:41:10,880 --> 00:41:08,490
version of star cluster formation and

967
00:41:13,070 --> 00:41:10,890
we're not exactly sure what the

968
00:41:18,650 --> 00:41:13,080
characteristics are of that it's still

969
00:41:21,020 --> 00:41:18,660
actively understudy and this this this

970
00:41:23,150 --> 00:41:21,030
shows us is on a much larger scale in

971
00:41:25,730 --> 00:41:23,160
terms of the number of stars here so it

972
00:41:28,370 --> 00:41:25,740
gives us some implication in terms of

973
00:41:29,840 --> 00:41:28,380
when the galaxy start forming but the

974
00:41:32,390 --> 00:41:29,850
globular clusters that are small parts

975
00:41:34,609 --> 00:41:32,400
of those it doesn't quite tell us

976
00:41:38,510 --> 00:41:34,619
anything about that okay Causton thank

977
00:41:43,370 --> 00:41:38,520
you Judy all right so our final topic

978
00:41:45,980 --> 00:41:43,380
for today a Space Oddity all right and

979
00:41:47,960 --> 00:41:45,990
I'm going to start with a image that you

980
00:41:50,300 --> 00:41:47,970
may have seen before actually I hope you

981
00:41:54,980 --> 00:41:50,310
have seen before it's a cool image of a

982
00:41:57,609 --> 00:41:54,990
galaxy cluster called a bill 68 and a

983
00:41:59,960 --> 00:41:57,619
bell 68 is one of those gravitationally

984
00:42:01,820 --> 00:41:59,970
gravitational lensing clusters

985
00:42:05,000 --> 00:42:01,830
alright if you know will that know what

986
00:42:08,270 --> 00:42:05,010
that means Einstein's theory of general

987
00:42:10,670 --> 00:42:08,280
relativity tells us that mass warps

988
00:42:12,770 --> 00:42:10,680

space actually that's my favorite three

989
00:42:16,790 --> 00:42:12,780
word summary of general relativity mass

990
00:42:18,400 --> 00:42:16,800
warps space okay that's that's all you

991
00:42:22,190 --> 00:42:18,410
need to know about general relativity

992
00:42:25,010 --> 00:42:22,200
but in this case there is so much mass

993
00:42:27,620 --> 00:42:25,020
here in this cluster of galaxies that it

994
00:42:30,740 --> 00:42:27,630
warps space so much that the light

995
00:42:34,430 --> 00:42:30,750
passing through that space changes in

996
00:42:36,770 --> 00:42:34,440
diverges okay it acts like a lens and it

997
00:42:40,910 --> 00:42:36,780
redirects the light from galaxies that

998
00:42:43,190 --> 00:42:40,920
on the far side this cluster and there's

999
00:42:45,349 --> 00:42:43,200
a really cool effect of that happens you

1000
00:42:47,960 --> 00:42:45,359
can see they're a bunch of streaky

1001
00:42:50,030 --> 00:42:47,970
things around this cluster long thin

1002
00:42:51,470 --> 00:42:50,040
things that these are galaxies that are

1003
00:42:53,720 --> 00:42:51,480
behind the cluster whose light has been

1004
00:42:55,609 --> 00:42:53,730
stretched out into these long streaky

1005
00:43:00,230 --> 00:42:55,619
things by the gravitational lensing of

1006
00:43:02,359 --> 00:43:00,240
the cluster but there's also this object

1007
00:43:06,920 --> 00:43:02,369
right here that I put a box around okay

1008
00:43:12,849 --> 00:43:06,930
um and if we blow that guy up uh you can

1009
00:43:18,620 --> 00:43:15,920
matter of fact it doesn't belong in a

1010
00:43:22,520 --> 00:43:18,630
galaxy cluster it looks like it belongs

1011
00:43:29,510 --> 00:43:22,530
in a 1970s video game yeah I knew you're

1012
00:43:32,260 --> 00:43:29,520
going there definitely space invaders so

1013
00:43:35,450 --> 00:43:32,270

this week all the space invader galaxy

1014
00:43:37,760 --> 00:43:35,460
but of course it's not a space invader

1015
00:43:39,829 --> 00:43:37,770
galaxy this is not it's true shape it's

1016
00:43:42,109 --> 00:43:39,839
been gravitationally lens you can see

1017
00:43:44,420 --> 00:43:42,119
the two yellow dots that form the eyes

1018
00:43:47,210 --> 00:43:44,430
of the space invader right well that's

1019
00:43:49,430 --> 00:43:47,220
the same yellow dot but traveling to

1020
00:43:51,020 --> 00:43:49,440
different paths through the mass of the

1021
00:43:53,420 --> 00:43:51,030
cluster through this warped space around

1022
00:43:54,950 --> 00:43:53,430
this cluster it's doubly image so that

1023
00:43:58,940 --> 00:43:54,960
you can see there's sort of a mirror

1024
00:44:01,550 --> 00:43:58,950
reflection left to right of the the

1025
00:44:03,200 --> 00:44:01,560
features of this galaxy so the galaxies

1026
00:44:05,540 --> 00:44:03,210
features have been warped Stape and

1027
00:44:08,540 --> 00:44:05,550
changed and they've been mirrored so

1028
00:44:09,710 --> 00:44:08,550
that you see two mirror images of it and

1029
00:44:12,440 --> 00:44:09,720
then you get this beautiful space

1030
00:44:13,670 --> 00:44:12,450
invader I don't know if you ever saw a

1031
00:44:15,620 --> 00:44:13,680
movie in nineteen

1032
00:44:17,690 --> 00:44:15,630
he's called crawl it was this really

1033
00:44:20,600 --> 00:44:17,700
kind of cheesy fantasy movie looks like

1034
00:44:23,000 --> 00:44:20,610
a bad guy in that had really big really

1035
00:44:24,080 --> 00:44:23,010
big horns and got kinda looks like horn

1036
00:44:28,940 --> 00:44:24,090
sticking out of his head and everything

1037
00:44:31,730 --> 00:44:28,950
else I reminded me of that too okay well

1038
00:44:35,780 --> 00:44:31,740

you could definitely use this as a bad

1039
00:44:37,910 --> 00:44:35,790
guy to moving but a bell 68 has more

1040
00:44:39,950 --> 00:44:37,920
interesting features than this ad listen

1041
00:44:42,260 --> 00:44:39,960
there's another oddity in a bell 68 that

1042
00:44:44,180 --> 00:44:42,270
I wanted to point out so that one was

1043
00:44:47,060 --> 00:44:44,190
gravitational lensing but this one over

1044
00:44:49,160 --> 00:44:47,070
here in the upper right you can see this

1045
00:44:51,680 --> 00:44:49,170
galaxy here now let me pull that up and

1046
00:44:54,080 --> 00:44:51,690
big alright and you can see this is a

1047
00:44:56,750 --> 00:44:54,090
galaxy where it looks like it's raining

1048
00:45:00,170 --> 00:44:56,760
right you've got all these sort of

1049
00:45:03,200 --> 00:45:00,180
droplets coming down coming down from

1050
00:45:08,960 --> 00:45:03,210
the galaxy and we're looking at that I

1051
00:45:11,450 --> 00:45:08,970
have to mute my phone anyways um look

1052
00:45:13,600 --> 00:45:11,460
like it's raining down and then how that

1053
00:45:16,190 --> 00:45:13,610
looks really strange to that's an oddity

1054
00:45:19,670 --> 00:45:16,200
what's happening here is not

1055
00:45:21,440 --> 00:45:19,680
gravitational lensing instead the galaxy

1056
00:45:23,630 --> 00:45:21,450
is moving through the intracluster gas

1057
00:45:26,870 --> 00:45:23,640
there's lots of gas in between these

1058
00:45:30,230 --> 00:45:26,880
galaxies and that gas is actually Ram

1059
00:45:33,680 --> 00:45:30,240
pressure stripping material out of this

1060
00:45:35,780 --> 00:45:33,690
galaxy that's amazing yeah so what looks

1061
00:45:39,110 --> 00:45:35,790
like teardrops falling from this galaxy

1062
00:45:41,330 --> 00:45:39,120
this crying galaxy is actually material

1063
00:45:43,880 --> 00:45:41,340

just being stripped so as you're moving

1064
00:45:46,460 --> 00:45:43,890
through this dense intracluster medium

1065
00:45:47,840 --> 00:45:46,470
some of the gas is being stripped all

1066
00:45:50,540 --> 00:45:47,850
right and we're getting star formation

1067
00:45:53,840 --> 00:45:50,550
in that strip gas forming these

1068
00:45:55,490 --> 00:45:53,850
wonderful wonderful little raindrops

1069
00:45:57,890 --> 00:45:55,500
coming out of the galaxy or tears

1070
00:46:03,080 --> 00:45:57,900
flowing down from the galaxy it's a sad

1071
00:46:05,090 --> 00:46:03,090
GALEX so this is a really cool image

1072
00:46:09,740 --> 00:46:05,100
here in a bell 68 in that you get to see

1073
00:46:14,350 --> 00:46:09,750
both a gravitational lensing oddity as

1074
00:46:17,870 --> 00:46:14,360
well as a physics-based oddity okay so

1075
00:46:21,260 --> 00:46:17,880
with Hubble we're doing a study looking

1076
00:46:25,810 --> 00:46:21,270
at gravitational lensing clusters and in

1077
00:46:27,589 --> 00:46:25,820
one of the clusters they saw this and

1078
00:46:28,700 --> 00:46:27,599
here you can see this

1079
00:46:29,839 --> 00:46:28,710
is a cluster that's producing

1080
00:46:31,700 --> 00:46:29,849
gravitational lensing if you look

1081
00:46:33,019 --> 00:46:31,710
carefully you can see some streaks and

1082
00:46:37,009 --> 00:46:33,029
arching especially see this almost

1083
00:46:39,079 --> 00:46:37,019
circular grouping of streaks and arcs

1084
00:46:41,390 --> 00:46:39,089
around the central center of the cluster

1085
00:46:42,829 --> 00:46:41,400
and you say wow that's a lot of

1086
00:46:46,339 --> 00:46:42,839
gravitational lensing going on here

1087
00:46:49,759 --> 00:46:46,349
right yes so when you look in the center

1088
00:46:51,710 --> 00:46:49,769

and you see these blue crazy little are

1089
00:46:52,819 --> 00:46:51,720
key you know things you immediately

1090
00:46:56,589 --> 00:46:52,829
think well that's got to be

1091
00:46:59,569 --> 00:46:56,599
gravitational lensing right it's not

1092
00:47:01,640 --> 00:46:59,579
they did a study with another telescope

1093
00:47:03,859 --> 00:47:01,650
and within the radio telescope to look

1094
00:47:05,960 --> 00:47:03,869
forward to try and look at the the

1095
00:47:08,450 --> 00:47:05,970
details of it and they proved that it's

1096
00:47:12,079 --> 00:47:08,460
not gravitational lensing which makes

1097
00:47:14,359 --> 00:47:12,089
you go whoa okay now what are we going

1098
00:47:17,329 --> 00:47:14,369
to do this because where are you going

1099
00:47:22,299 --> 00:47:17,339
to get these bright blue sort of spiral

1100
00:47:25,789 --> 00:47:22,309
shapes really long elongated knots of

1101
00:47:27,289 --> 00:47:25,799
what looked like bright stars here okay

1102
00:47:29,630 --> 00:47:27,299
so let's just look at it

1103
00:47:31,729 --> 00:47:29,640
phenomenologically first okay this thing

1104
00:47:34,880 --> 00:47:31,739
is about a hundred thousand light years

1105
00:47:36,680 --> 00:47:34,890
long alright that's stretching from side

1106
00:47:39,009 --> 00:47:36,690
to side all the way across the Milky Way

1107
00:47:43,430 --> 00:47:39,019
galaxy so this is a galactic scale

1108
00:47:45,559 --> 00:47:43,440
streamer plus it's got some spirals

1109
00:47:47,630 --> 00:47:45,569
shape too it's got a little to a bit of

1110
00:47:50,599 --> 00:47:47,640
a coil shaped and it seems to be wrapped

1111
00:47:54,170 --> 00:47:50,609
in amongst these two colliding galaxies

1112
00:47:56,900 --> 00:47:54,180
so you've got a lot of this long thin

1113
00:47:58,729 --> 00:47:56,910

streamer with this spiraling shape

1114
00:48:01,549 --> 00:47:58,739
alright and then you've got these knots

1115
00:48:05,029 --> 00:48:01,559
along it and if you analyze those knots

1116
00:48:09,039 --> 00:48:05,039
they believe that these knots are star

1117
00:48:12,739 --> 00:48:09,049
clusters not just star clusters but

1118
00:48:14,450 --> 00:48:12,749
super star clusters like the big star

1119
00:48:21,019 --> 00:48:14,460
clusters that we saw in the antennae

1120
00:48:22,219 --> 00:48:21,029
galaxies so it's really kind of cool all

1121
00:48:24,739 --> 00:48:22,229
right that you've got this amazing

1122
00:48:26,479 --> 00:48:24,749
structure and they wanted to do an

1123
00:48:29,209 --> 00:48:26,489
analogy for it for the press release and

1124
00:48:31,519 --> 00:48:29,219
so they took the analogy well the

1125
00:48:34,459 --> 00:48:31,529
physical process behind this is what we

1126
00:48:37,999 --> 00:48:34,469
call the genes instability okay and the

1127
00:48:40,299 --> 00:48:38,009
genes instability governs when a a cloud

1128
00:48:41,420 --> 00:48:40,309
of gas becomes self-gravitating and

1129
00:48:44,480 --> 00:48:41,430
color

1130
00:48:48,440 --> 00:48:44,490
apps down to form stars or star clusters

1131
00:48:50,120 --> 00:48:48,450
okay and so when you get a jeans mass of

1132
00:48:52,730 --> 00:48:50,130
material then it can become

1133
00:48:57,559 --> 00:48:52,740
self-gravitating and unstable to forming

1134
00:49:00,950 --> 00:48:57,569
stars and clusters right but that's kind

1135
00:49:03,079 --> 00:49:00,960
of in this long thin in this long thin

1136
00:49:05,809 --> 00:49:03,089
streamer you would have separate regions

1137
00:49:07,940 --> 00:49:05,819
that reach green jeans mass criticality

1138
00:49:09,799 --> 00:49:07,950

and and then would start to start to

1139
00:49:13,280 --> 00:49:09,809
collapse and that's how you get these

1140
00:49:14,780 --> 00:49:13,290
knots along the streamer so the analogy

1141
00:49:17,299 --> 00:49:14,790
that theythey used in the press release

1142
00:49:20,780 --> 00:49:17,309
was with the water coming out of the

1143
00:49:24,380 --> 00:49:20,790
faucet in your kitchen sink if you have

1144
00:49:27,770 --> 00:49:24,390
a smooth very thin laminar flow leaving

1145
00:49:30,799 --> 00:49:27,780
your faucet at some point it's going to

1146
00:49:33,589 --> 00:49:30,809
collapse in upon itself and form water

1147
00:49:37,309 --> 00:49:33,599
droplets okay this is a well-known

1148
00:49:40,370 --> 00:49:37,319
physical effect and it has a similar

1149
00:49:42,530 --> 00:49:40,380
analogy of the physical effects as to

1150
00:49:46,099 --> 00:49:42,540
the formation of these clusters along

1151
00:49:47,870 --> 00:49:46,109
the long thin streamer of gas now I have

1152
00:49:49,819 --> 00:49:47,880
to be totally honest with you it's not

1153
00:49:52,099 --> 00:49:49,829
an exact analogy in terms of physics

1154
00:49:53,599 --> 00:49:52,109
because the water involves the

1155
00:49:56,539 --> 00:49:53,609
turbulence and within the water and the

1156
00:49:59,000 --> 00:49:56,549
Reynolds number as well as the surface

1157
00:50:01,870 --> 00:49:59,010
tension of the water also plays a very

1158
00:50:03,799 --> 00:50:01,880
important role and you've got a

1159
00:50:05,839 --> 00:50:03,809
gravitational field that that's within

1160
00:50:08,510 --> 00:50:05,849
so it's not a perfect analogy here but

1161
00:50:10,690 --> 00:50:08,520
it's a useful visual analogue for you to

1162
00:50:14,960 --> 00:50:10,700
understand that these physical processes

1163
00:50:19,450 --> 00:50:14,970

that happen in your kitchen sink can

1164
00:50:23,990 --> 00:50:19,460
also happen on scales of entire galaxies

1165
00:50:25,609 --> 00:50:24,000
and that's that's a lot of fun yeah was

1166
00:50:27,079 --> 00:50:25,619
I mean it was just a time when everybody

1167
00:50:28,910 --> 00:50:27,089
thought that everything happened up in

1168
00:50:31,010 --> 00:50:28,920
this guy was if the universe was very

1169
00:50:32,960 --> 00:50:31,020
static place had never changed much and

1170
00:50:34,609 --> 00:50:32,970
with tell over the past 25 years with

1171
00:50:35,960 --> 00:50:34,619
Hubble and even though you know so many

1172
00:50:38,720 --> 00:50:35,970
other instruments we're learning that

1173
00:50:41,240 --> 00:50:38,730
how the universe is like completely on

1174
00:50:44,030 --> 00:50:41,250
just fire it's just doing all kinds of

1175
00:50:46,460 --> 00:50:44,040
things and as far from static so you and

1176
00:50:49,819 --> 00:50:46,470
you know and educationally it's a

1177
00:50:52,309 --> 00:50:49,829
fundamental lesson of science that what

1178
00:50:54,349 --> 00:50:52,319
happens here on earth happens elsewhere

1179
00:50:55,040 --> 00:50:54,359
in the universe you know that's sort of

1180
00:50:57,230 --> 00:50:55,050
an assumption

1181
00:50:59,120 --> 00:50:57,240
we make in science but here's a skiff

1182
00:51:00,890 --> 00:50:59,130
this is the you know got to be the

1183
00:51:03,080 --> 00:51:00,900
biggest scale change one of the biggest

1184
00:51:04,880 --> 00:51:03,090
fail scale change possible going from

1185
00:51:07,550 --> 00:51:04,890
your kitchen sink all the way to the

1186
00:51:09,110 --> 00:51:07,560
scale of an entire galaxy using the same

1187
00:51:11,030 --> 00:51:09,120
sort of physics showing that they hate

1188
00:51:13,850 --> 00:51:11,040

the physics equations work here they

1189
00:51:16,460 --> 00:51:13,860
also work there that's uh that's that's

1190
00:51:17,990 --> 00:51:16,470
a nice perspective on the universe I

1191
00:51:19,490 --> 00:51:18,000
think it's amazing what did you say that

1192
00:51:23,930 --> 00:51:19,500
did you say with how far the way this

1193
00:51:26,840 --> 00:51:23,940
was I didn't hot I got the press release

1194
00:51:29,870 --> 00:51:26,850
in front of me here zoop zoop zoop zoop

1195
00:51:31,040 --> 00:51:29,880
zoop zoop i mean it's just not that

1196
00:51:33,230 --> 00:51:31,050
critical just trying to get a sense of

1197
00:51:36,200 --> 00:51:33,240
how far back you know after the Big Bang

1198
00:51:37,820 --> 00:51:36,210
this was so yeah it's not that far it's

1199
00:51:40,240 --> 00:51:37,830
not these aren't high redshift clusters

1200
00:51:42,770 --> 00:51:40,250
i will say i would say they're

1201
00:51:44,930 --> 00:51:42,780
definitely less than richest of a half

1202
00:51:45,980 --> 00:51:44,940
so there may be a couple built this is

1203
00:51:47,870 --> 00:51:45,990
probably a couple billion light-years

1204
00:51:49,400 --> 00:51:47,880
out there it's not to me it's not gonna

1205
00:51:51,230 --> 00:51:49,410
be 10 billion light years at maybe two

1206
00:51:52,400 --> 00:51:51,240
three billion light-years out there all

1207
00:51:54,370 --> 00:51:52,410
right I was just curious yeah it was

1208
00:51:57,890 --> 00:51:54,380
because the universe was a lot different

1209
00:52:00,650 --> 00:51:57,900
at high redshift than it is then in the

1210
00:52:02,780 --> 00:52:00,660
lower ones and so one can imagine maybe

1211
00:52:05,060 --> 00:52:02,790
things not working maybe analogy not

1212
00:52:06,260 --> 00:52:05,070
working out even more so back then but

1213
00:52:09,560 --> 00:52:06,270

it sounds like that's not the issue here

1214
00:52:11,150 --> 00:52:09,570
now this is roughly this is rough enough

1215
00:52:14,360 --> 00:52:11,160
to be considered a local universe okay

1216
00:52:17,690 --> 00:52:14,370
okay did you have another slide I had

1217
00:52:22,880 --> 00:52:17,700
actually just um one last question for

1218
00:52:26,270 --> 00:52:22,890
to pose about this okay why um how do

1219
00:52:29,360 --> 00:52:26,280
you get at galaxy no no no no no no how

1220
00:52:33,050 --> 00:52:29,370
do you get a 100,000 light year long

1221
00:52:34,490 --> 00:52:33,060
streamer of gas all right no matter what

1222
00:52:37,790 --> 00:52:34,500
its shape is no matter what it's done

1223
00:52:41,540 --> 00:52:37,800
how do you get that I'm gonna say black

1224
00:52:44,240 --> 00:52:41,550
holes that's my answer to everything I

1225
00:52:50,530 --> 00:52:44,250
don't understand all right up till the

1226
00:52:54,590 --> 00:52:53,240
there are three possibilities mentioned

1227
00:52:58,690 --> 00:52:54,600
in the press release none of them are

1228
00:53:01,460 --> 00:52:58,700
compelling okay how does material

1229
00:53:03,980 --> 00:53:01,470
collapse it you can come up with an idea

1230
00:53:06,170 --> 00:53:03,990
that material should cool down towards

1231
00:53:08,390 --> 00:53:06,180
the center of a cluster of galaxies but

1232
00:53:11,330 --> 00:53:08,400
that doesn't form it into a streamer

1233
00:53:13,070 --> 00:53:11,340
okay you could say that you know this is

1234
00:53:15,290 --> 00:53:13,080
maybe he's a title the remnant of a

1235
00:53:17,510 --> 00:53:15,300
title tail wrapped around these galaxies

1236
00:53:19,010 --> 00:53:17,520
but you know the kinematic so that

1237
00:53:21,610 --> 00:53:19,020
doesn't really quite work why is it

1238
00:53:23,780 --> 00:53:21,620

wrapped in between the galaxies and such

1239
00:53:25,610 --> 00:53:23,790
there's going to be a lot more study to

1240
00:53:27,080 --> 00:53:25,620
understand this way how sure are they

1241
00:53:29,750 --> 00:53:27,090
this is this is actually not some kind

1242
00:53:31,760 --> 00:53:29,760
of a loser II effect with it with you

1243
00:53:33,860 --> 00:53:31,770
know the line of sight or something how

1244
00:53:37,840 --> 00:53:33,870
do they sure these droplets or these

1245
00:53:40,430 --> 00:53:37,850
blue dots are in between intertwined I

1246
00:53:42,200 --> 00:53:40,440
would believe that the sense they are

1247
00:53:45,530 --> 00:53:42,210
star clusters they have emission lines

1248
00:53:46,580 --> 00:53:45,540
and they can rich if the bishop taking a

1249
00:53:48,260 --> 00:53:46,590
look at the road trip to the emission

1250
00:53:50,360 --> 00:53:48,270
lines they can look at the redshift of

1251
00:53:52,760 --> 00:53:50,370
the galaxies and make sure that they are

1252
00:53:55,640 --> 00:53:52,770
the same okay all right so they do have

1253
00:53:58,220 --> 00:53:55,650
sort of a 3d structure to this then by

1254
00:54:01,610 --> 00:53:58,230
looking at the specular so this is one

1255
00:54:03,920 --> 00:54:01,620
of my fun points to make is that we

1256
00:54:06,590 --> 00:54:03,930
don't know the answer and you know what

1257
00:54:09,230 --> 00:54:06,600
that's not bad that's actually really

1258
00:54:12,500 --> 00:54:09,240
good okay one its job security for us

1259
00:54:14,660 --> 00:54:12,510
right all right but to when you see

1260
00:54:16,970 --> 00:54:14,670
something like this it's your indication

1261
00:54:19,310 --> 00:54:16,980
that hey we don't know what's going on

1262
00:54:22,250 --> 00:54:19,320
there's something new to understand

1263
00:54:24,230 --> 00:54:22,260

about the universe we love and

1264
00:54:25,760 --> 00:54:24,240
confronting our ignorance because it

1265
00:54:27,920 --> 00:54:25,770
shows us there's something new to

1266
00:54:29,690 --> 00:54:27,930
understand okay yeah i think was it

1267
00:54:31,070 --> 00:54:29,700
George gamma for somebody back in the

1268
00:54:32,420 --> 00:54:31,080
day said that we know just about

1269
00:54:36,350 --> 00:54:32,430
everything there is to know or at least

1270
00:54:39,020 --> 00:54:36,360
we will and hug people have said that

1271
00:54:42,430 --> 00:54:39,030
over the centuries yeah always been so

1272
00:54:45,560 --> 00:54:42,440
wrong it out already we know most things

1273
00:54:47,210 --> 00:54:45,570
okay so i put up the slide that we we

1274
00:54:51,890 --> 00:54:47,220
said we would do about the upcoming

1275
00:54:53,270 --> 00:54:51,900
public lectures so go ahead the day just

1276
00:54:55,730 --> 00:54:53,280
wanted to point out to everybody that

1277
00:54:57,620 --> 00:54:55,740
this little hangout the Frank and I do

1278
00:54:59,630 --> 00:54:57,630
every month is in conjunction with the

1279
00:55:01,850 --> 00:54:59,640
Hubble public lecture series that we

1280
00:55:04,850 --> 00:55:01,860
have on the first Tuesday of every month

1281
00:55:07,730 --> 00:55:04,860
but Frank September 18th isn't the first

1282
00:55:12,500 --> 00:55:07,740
Tuesday not the first Tuesday we've got

1283
00:55:14,930 --> 00:55:12,510
a special lecture for you ray-j Ardana

1284
00:55:17,060 --> 00:55:14,940
from York University's coming in he's

1285
00:55:19,130 --> 00:55:17,070
giving a colloquium here a scientific

1286
00:55:21,620 --> 00:55:19,140
colloquium and he also agreed to give a

1287
00:55:22,380 --> 00:55:21,630
public lecture on that Thursday so I

1288
00:55:24,299 --> 00:55:22,390

said

1289
00:55:27,180 --> 00:55:24,309
eight will add you to the schedule and

1290
00:55:30,359 --> 00:55:27,190
we have a live an amazing talk on

1291
00:55:32,339 --> 00:55:30,369
nutrino hunters the ghostly particles of

1292
00:55:33,930 --> 00:55:32,349
neutrinos that you know you've got a

1293
00:55:36,269 --> 00:55:33,940
billion neutrinos passing through you

1294
00:55:39,359 --> 00:55:36,279
every second right now and you don't

1295
00:55:41,849 --> 00:55:39,369
feel anything but we can also use these

1296
00:55:45,359 --> 00:55:41,859
neutrinos to unlock cosmic secrets and

1297
00:55:46,829 --> 00:55:45,369
he will talk about that awesome and then

1298
00:55:48,870 --> 00:55:46,839
of course our regular one first Tuesday

1299
00:55:51,359 --> 00:55:48,880
of the month october seventh Greg Snyder

1300
00:55:54,509 --> 00:55:51,369
will talk about simulating the universe

1301
00:55:56,940 --> 00:55:54,519
the illustrious computational simulation

1302
00:56:00,180 --> 00:55:56,950
when the largest computer simulations of

1303
00:56:01,859 --> 00:56:00,190
how structure forms in the universe he

1304
00:56:04,079 --> 00:56:01,869
is part of that team and he will tell

1305
00:56:06,210 --> 00:56:04,089
you all sorts of secrets of how to make

1306
00:56:08,519 --> 00:56:06,220
a fake universe and see if it matches

1307
00:56:09,750 --> 00:56:08,529
the real universe yeah I'm really

1308
00:56:11,370 --> 00:56:09,760
excited about that one because if you

1309
00:56:13,769 --> 00:56:11,380
haven't heard of this do a search for

1310
00:56:15,750 --> 00:56:13,779
Don Gong Gong on Google and it'll come

1311
00:56:17,759 --> 00:56:15,760
up there's a youtube video that nature

1312
00:56:20,039 --> 00:56:17,769
put out that shows this simulation to

1313
00:56:21,210 --> 00:56:20,049

it's just amazing you've got to check

1314
00:56:23,490 --> 00:56:21,220
it's one of the neatest things I've ever

1315
00:56:25,109 --> 00:56:23,500
seen it all so in addition to checking

1316
00:56:27,269 --> 00:56:25,119
out the public lecture next month I

1317
00:56:28,880 --> 00:56:27,279
definitely do a search on that you'll be

1318
00:56:33,269 --> 00:56:28,890
haven't seen it yet it it's

1319
00:56:34,499 --> 00:56:33,279
mind-boggling so okay frankly a couple

1320
00:56:37,109 --> 00:56:34,509
of questions here I want to get to a few

1321
00:56:39,180 --> 00:56:37,119
things we're running out of time but

1322
00:56:42,089 --> 00:56:39,190
i'll start with an easy one this one's

1323
00:56:43,650 --> 00:56:42,099
from angel lights three how long does

1324
00:56:48,150 --> 00:56:43,660
the hubble take to do a complete

1325
00:56:51,539 --> 00:56:48,160
rotation around our mother earth okay

1326
00:56:54,870 --> 00:56:51,549
Hubble does orbits around Earth every

1327
00:56:58,349 --> 00:56:54,880
ninety seven minutes if you watch the

1328
00:57:01,440 --> 00:56:58,359
movie gravity they put it at like 90

1329
00:57:04,440 --> 00:57:01,450
minutes right yeah and it's actually 97

1330
00:57:06,630 --> 00:57:04,450
minutes at the the orbit of Hubble bear

1331
00:57:08,400 --> 00:57:06,640
i always say 90 minutes but yes Proxima

1332
00:57:10,259 --> 00:57:08,410
90 minutes so we've been talking for

1333
00:57:12,210 --> 00:57:10,269
almost an hour Hubble has completed two

1334
00:57:15,359 --> 00:57:12,220
thirds of an orbit around the earth

1335
00:57:17,880 --> 00:57:15,369
while we've been chatting here yeah good

1336
00:57:18,990 --> 00:57:17,890
question okay here's one from we're

1337
00:57:22,349 --> 00:57:19,000
getting some questions on this i'll

1338
00:57:25,460 --> 00:57:22,359

start with stargazer nation what's what

1339
00:57:28,950 --> 00:57:25,470
is next for the telescope any uploading

1340
00:57:30,660 --> 00:57:28,960
upcoming highlights I wonder how close

1341
00:57:32,460 --> 00:57:30,670
it would focus and are they going to see

1342
00:57:34,230 --> 00:57:32,470
siding spring there's a couple of

1343
00:57:36,000 --> 00:57:34,240
questions about that and if you had any

1344
00:57:42,180 --> 00:57:36,010
news on site

1345
00:57:43,860 --> 00:57:42,190
spring on that as well so okay first of

1346
00:57:47,670 --> 00:57:43,870
all Hubble will be observing comet

1347
00:57:50,510 --> 00:57:47,680
siding spring Hubble the comet siding

1348
00:57:53,370 --> 00:57:50,520
spring is going to pass close to mars

1349
00:57:58,140 --> 00:57:53,380
the information on comet siding spring

1350
00:58:02,040 --> 00:57:58,150
is that it is not its comas not growing

1351
00:58:05,220 --> 00:58:02,050
as fast as it one might have thought so

1352
00:58:06,570 --> 00:58:05,230
the coma of common siding spring which I

1353
00:58:08,190 --> 00:58:06,580
never thought was actually going to

1354
00:58:10,350 --> 00:58:08,200
encompass Mars doesn't look like it's

1355
00:58:11,760 --> 00:58:10,360
going to encompass Mars although you

1356
00:58:13,920 --> 00:58:11,770
know the density falls off very very

1357
00:58:16,050 --> 00:58:13,930
slowly so definitely some particles

1358
00:58:19,860 --> 00:58:16,060
traveling with comet siding Springs will

1359
00:58:23,160 --> 00:58:19,870
impact Mars but the risk to the Mars

1360
00:58:26,220 --> 00:58:23,170
orbiters etc is a little lower than we

1361
00:58:27,660 --> 00:58:26,230
have might have been feared calm Hubble

1362
00:58:29,910 --> 00:58:27,670
will be looking at the comment itself

1363
00:58:32,700 --> 00:58:29,920

because Hubble has the best resolution

1364
00:58:35,790 --> 00:58:32,710
of any telescope here located at earth

1365
00:58:37,470 --> 00:58:35,800
and so we can't see the full the the

1366
00:58:41,340 --> 00:58:37,480
size of deciding Springs it's so small

1367
00:58:43,020 --> 00:58:41,350
we will be able to see if any parts any

1368
00:58:45,030 --> 00:58:43,030
pieces of it break off anything

1369
00:58:47,070 --> 00:58:45,040
happening with the comet Hubble will be

1370
00:58:49,890 --> 00:58:47,080
monitoring it during the closest

1371
00:58:52,830 --> 00:58:49,900
approach and that it comes up in October

1372
00:58:56,250 --> 00:58:52,840
doesn't it I think so yes yeah okay and

1373
00:58:59,700 --> 00:58:56,260
that is also a Geneva Bevan also from

1374
00:59:02,250 --> 00:58:59,710
the Q&A app was asking about siding

1375
00:59:06,240 --> 00:59:02,260
spring so there you go folks thank good

1376
00:59:11,330 --> 00:59:06,250
questions and here's one from Eamon of

1377
00:59:17,100 --> 00:59:11,340
Brampton who's asking um where to go

1378
00:59:21,660 --> 00:59:17,110
then it went away uh come back okay all

1379
00:59:23,520 --> 00:59:21,670
right fine so so Janine I was also

1380
00:59:26,660 --> 00:59:23,530
saying all now I'm sitting in my desk

1381
00:59:31,230 --> 00:59:26,670
coming along to rubber ducky thanks guys

1382
00:59:36,780 --> 00:59:31,240
ducky or the one you may drag astronomy

1383
00:59:38,760 --> 00:59:36,790
so much fun that's right now all saying

1384
00:59:39,900 --> 00:59:38,770
thank you for that yes rubber duck okay

1385
00:59:41,790 --> 00:59:39,910
I don't know what happened to that

1386
00:59:43,920 --> 00:59:41,800
question it had to do with exoplanets

1387
00:59:46,290 --> 00:59:43,930
but it disappeared from my Q&A app I'm

1388
00:59:48,780 --> 00:59:46,300

really sorry about that I guess that'll

1389
00:59:49,860 --> 00:59:48,790
be so that is it for our time I don't

1390
00:59:52,830 --> 00:59:49,870
see any other

1391
00:59:56,430 --> 00:59:52,840
shins or comments that I should read out

1392
00:59:58,290 --> 00:59:56,440
thank you all for watching the four

1393
01:00:00,600 --> 00:59:58,300
participating during the Q&A app I

1394
01:00:03,990 --> 01:00:00,610
really appreciate that we will be back

1395
01:00:05,070 --> 01:00:04,000
again next month with Frank oh no no sep

1396
01:00:06,900 --> 01:00:05,080
tember we are we going to do this again

1397
01:00:09,000 --> 01:00:06,910
this month are we going to just wait

1398
01:00:10,560 --> 01:00:09,010
till October well we're already into

1399
01:00:12,560 --> 01:00:10,570
September this is sep tember i know we

1400
01:00:15,570 --> 01:00:12,570
had another public lecture so ah i

1401
01:00:18,260 --> 01:00:15,580
wanted to i wasn't planning on doing a

1402
01:00:20,280 --> 01:00:18,270
huge news summary for the September 18th

1403
01:00:22,680 --> 01:00:20,290
I'm alright and we won't worry about

1404
01:00:24,270 --> 01:00:22,690
that will diff if something amazing

1405
01:00:26,490 --> 01:00:24,280
happens with siding Springs or anything

1406
01:00:30,780 --> 01:00:26,500
we can jump in and do that actually I'll

1407
01:00:33,960 --> 01:00:30,790
be my son's going to color ok I'll

1408
01:00:37,020 --> 01:00:33,970
late-september so we'll have to do it in

1409
01:00:39,180 --> 01:00:37,030
October ok look yes so look back for for

1410
01:00:40,650 --> 01:00:39,190
the next episode of this with Frank I at

1411
01:00:42,120 --> 01:00:40,660
the beginning of October right after the

1412
01:00:44,010 --> 01:00:42,130
public lecture series we just talked

1413
01:00:45,660 --> 01:00:44,020

about I want to thank you Frank this was

1414
01:00:47,010 --> 01:00:45,670
awesome as always you've done an

1415
01:00:49,020 --> 01:00:47,020
excellent job bringing some awesome crow

1416
01:00:51,150 --> 01:00:49,030
stories to us so thank you very much

1417
01:00:54,290 --> 01:00:51,160
we're an excellent job of asking

1418
01:00:57,780 --> 01:00:54,300
questions and keeping me honest about it

1419
01:00:59,550 --> 01:00:57,790
my job as what I do all right all right