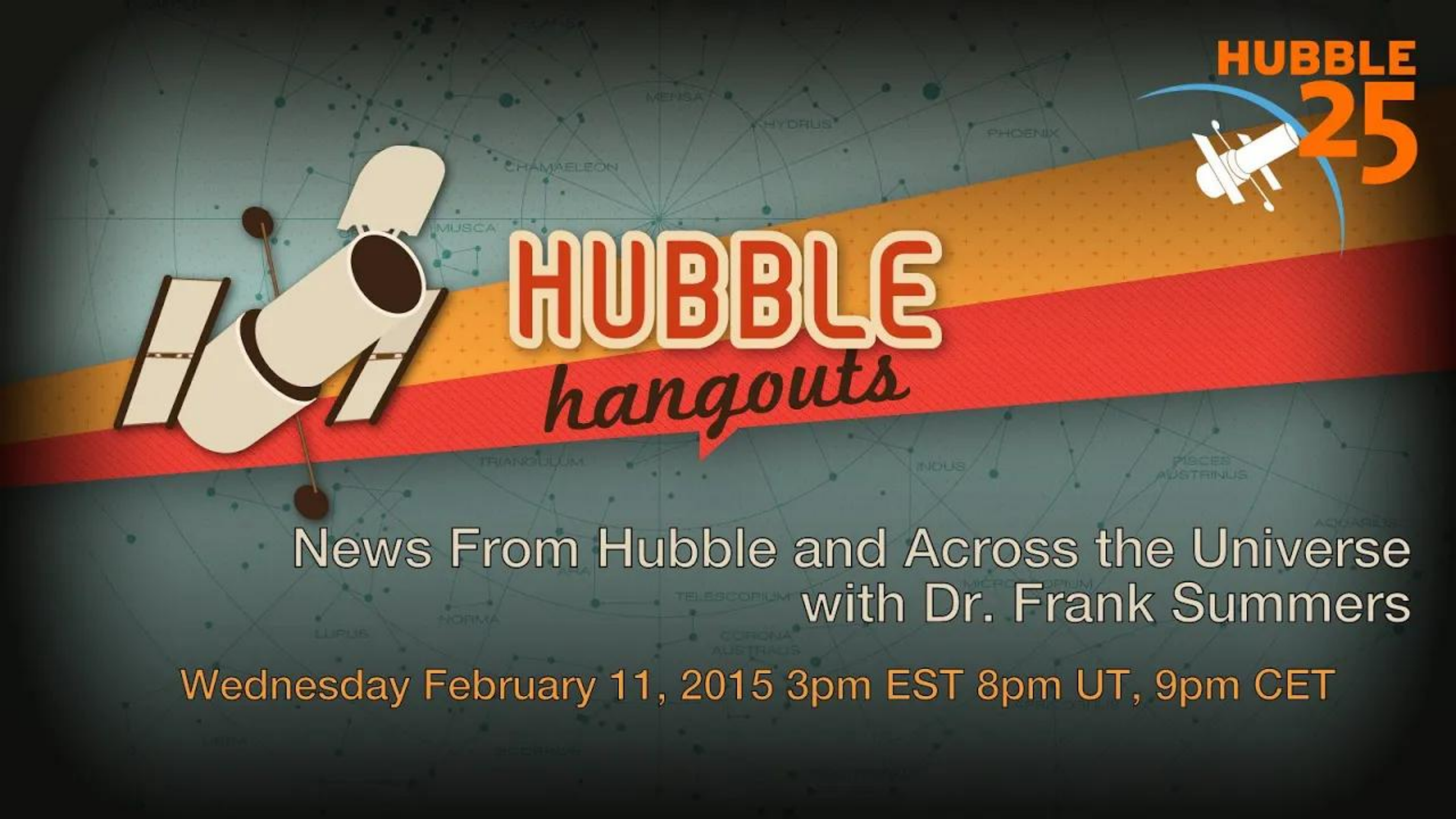
HUBBLE 25
HUBBLE
hangouts
News From Hubble and Across the Universe
with Dr. Frank Summers
Wednesday February 11, 2015 3pm EST 8pm UT, 9pm CET

1
00:00:08,999 --> 00:00:05,999
hello everybody it's time once again for

2
00:00:13,589 --> 00:00:09,009
news from space with doctor Frank

3
00:00:15,089 --> 00:00:13,599
summers I thought was really cool it's

4
00:00:16,440 --> 00:00:15,099
time once again when news from Hubble

5
00:00:18,150 --> 00:00:16,450
and across the universe we do this every

6
00:00:19,620 --> 00:00:18,160
month my name is Tony Darnell I work at

7
00:00:21,990 --> 00:00:19,630
the Space Telescope Science Institute

8
00:00:24,000 --> 00:00:22,000
and with me as he does he joins me most

9
00:00:26,160 --> 00:00:24,010
months is dr. Frank summers he's the

10
00:00:28,770 --> 00:00:26,170
outreach astrophysicist hey where's your

11
00:00:31,080 --> 00:00:28,780
lower third go oh that's because I had

12
00:00:35,189 --> 00:00:31,090
to reboot remember oh that's right ok

13
00:00:37,040 --> 00:00:35,199

I'll add it back in ok so we do this is

14
00:00:40,169 --> 00:00:37,050
a hangout we try to do each month where

15
00:00:42,569 --> 00:00:40,179
Frank does his astrophysicist due to

16
00:00:43,979 --> 00:00:42,579
duty and lets us know his all the

17
00:00:45,779 --> 00:00:43,989
interesting news that's going on not

18
00:00:47,369 --> 00:00:45,789
only with Hubble but elsewhere and other

19
00:00:49,139 --> 00:00:47,379
missions and in the field of astronomy

20
00:00:51,329 --> 00:00:49,149
and so he's going to fill us in on that

21
00:00:53,759 --> 00:00:51,339
today but before we get started let me

22
00:00:56,790 --> 00:00:53,769
invite you to interact with us we want

23
00:00:57,899 --> 00:00:56,800
to hear from you please use the Q&A app

24
00:00:59,189 --> 00:00:57,909
if you have any questions or comments

25
00:01:00,779 --> 00:00:59,199
it's right there should be a button

26
00:01:03,000 --> 00:01:00,789
right there on your screen to push and

27
00:01:04,740 --> 00:01:03,010
you can either comment or leave us a

28
00:01:07,370 --> 00:01:04,750
question and we'll take well take them

29
00:01:10,890 --> 00:01:07,380
as they come you can also alternatively

30
00:01:13,320 --> 00:01:10,900
comment on the YouTube pages of being

31
00:01:15,600 --> 00:01:13,330
broadcast on and the G+ event page which

32
00:01:18,240 --> 00:01:15,610
I'm also looking at and finally you can

33
00:01:21,240 --> 00:01:18,250
tweet at us using the Hubble hang out

34
00:01:23,790 --> 00:01:21,250
hashtag which I am also monitoring with

35
00:01:25,980 --> 00:01:23,800
all of my stuff so I'm the driver of the

36
00:01:28,260 --> 00:01:25,990
internet today usually a Scott Lewis but

37
00:01:30,420 --> 00:01:28,270
not the driver and Frank what do you got

38
00:01:32,190 --> 00:01:30,430

for us this month oh well we got some

39
00:01:34,560 --> 00:01:32,200
fun stuff remember I promised your last

40
00:01:36,390 --> 00:01:34,570
month we'd get to Andromeda because we

41
00:01:37,830 --> 00:01:36,400
spend so much time on the Eagle Nebula

42
00:01:39,240 --> 00:01:37,840
less that's right and have time to go

43
00:01:43,020 --> 00:01:39,250
for the other really big story of

44
00:01:45,270 --> 00:01:43,030
January which is in drama de and then we

45
00:01:46,560 --> 00:01:45,280
got we're going to go we're gonna go

46
00:01:48,780 --> 00:01:46,570
some different places we're going to

47
00:01:50,730 --> 00:01:48,790
start our Hubble 25 retrospective here

48
00:01:53,670 --> 00:01:50,740
tonight today ok ah speaking of which

49
00:01:55,920 --> 00:01:53,680
let me get it out to the there is a

50
00:01:57,180 --> 00:01:55,930
video contest for the Hubble 25th

51
00:01:59,400 --> 00:01:57,190
anniversary as you know we've got

52
00:02:01,080 --> 00:01:59,410
starting all year long this year this

53
00:02:03,750 --> 00:02:01,090
marks the 25th anniversary of the Hubble

54
00:02:05,340 --> 00:02:03,760
Space Telescope and many events going on

55
00:02:08,070 --> 00:02:05,350
in activities right now if you go to

56
00:02:11,369 --> 00:02:08,080
Space Telescope o RG you'll be able to

57
00:02:13,199 --> 00:02:11,379
that you learn about a and an ode to

58
00:02:14,040 --> 00:02:13,209
Hubble video contest which is open now

59
00:02:15,510 --> 00:02:14,050
you can

60
00:02:17,430 --> 00:02:15,520
create a video three minutes or less and

61
00:02:19,440 --> 00:02:17,440
say about anything you want about Hubble

62
00:02:21,510 --> 00:02:19,450
and enter it into the contest I'd left

63
00:02:24,120 --> 00:02:21,520

the link to that contest on the Google+

64
00:02:26,010 --> 00:02:24,130
event page and I'll also tweet it out

65
00:02:27,120 --> 00:02:26,020
here in just a little bit so I just

66
00:02:31,860 --> 00:02:27,130
wanted to get that out thanks Frank

67
00:02:34,140 --> 00:02:31,870
great great so let's go to the slides ok

68
00:02:36,770 --> 00:02:34,150
from Hubble and across the universe and

69
00:02:42,060 --> 00:02:36,780
if we can figure out to work in span

70
00:02:45,450 --> 00:02:42,070
right actually I work at these special

71
00:02:49,680 --> 00:02:45,460
scope Science Institute all right so

72
00:02:53,040 --> 00:02:49,690
what so ease in that yeah so uh februari

73
00:02:56,430 --> 00:02:53,050
and how ok oops I hit the wrong one I

74
00:03:01,110 --> 00:02:56,440
always do this there we go ok so our top

75
00:03:02,460 --> 00:03:01,120
story today is in your dreams bubble and

76
00:03:04,470 --> 00:03:02,470
in this case i'm not talking about

77
00:03:07,170 --> 00:03:04,480
Hubble telescope I'm talking about

78
00:03:12,270 --> 00:03:07,180
Hubble the astronomer now I found this

79
00:03:15,060 --> 00:03:12,280
wonderful image from 1901 the Yerkes

80
00:03:17,760 --> 00:03:15,070
Observatory an image of the great nebula

81
00:03:20,550 --> 00:03:17,770
in Andromeda as it was called back then

82
00:03:23,040 --> 00:03:20,560
because we didn't know what was a galaxy

83
00:03:24,510 --> 00:03:23,050
back then and so this actually is

84
00:03:28,229 --> 00:03:24,520
something I got from project gutenberg

85
00:03:29,729 --> 00:03:28,239
on the internet it was in a book that

86
00:03:31,020 --> 00:03:29,739
was published before copyright took

87
00:03:32,850 --> 00:03:31,030
effect in the United States so I was

88
00:03:35,310 --> 00:03:32,860

able to just pull it out but this is a

89
00:03:36,900 --> 00:03:35,320
really gorgeous image that shows you

90
00:03:40,050 --> 00:03:36,910
just you know the state of the art of

91
00:03:42,600 --> 00:03:40,060
astronomy observation a hundred years

92
00:03:44,370 --> 00:03:42,610
ago now your keys is a refractor

93
00:03:47,550 --> 00:03:44,380
telescope is that is that like a 20 inch

94
00:03:48,990 --> 00:03:47,560
telescope isn't like it could be the 40

95
00:03:51,120 --> 00:03:49,000
inch remember the largest refractor in

96
00:03:52,830 --> 00:03:51,130
the world was at Yerkes mistaken is it

97
00:03:54,420 --> 00:03:52,840
40 okay I wasn't sure of the diameter

98
00:03:57,360 --> 00:03:54,430
but yeah that for the longest time that

99
00:03:58,830 --> 00:03:57,370
was what it may even still be one of the

100
00:04:00,479 --> 00:03:58,840
largest reported well the 40 inch

101
00:04:03,300 --> 00:04:00,489
refractor wherever it is I think it's at

102
00:04:05,880 --> 00:04:03,310
Yerkes is the largest refractor in ever

103
00:04:07,170 --> 00:04:05,890
built simply because you build a piece

104
00:04:09,510 --> 00:04:07,180
of glass larger than about 40 inches

105
00:04:13,699 --> 00:04:09,520
across and it starts to sag in the

106
00:04:16,320 --> 00:04:13,709
center right if you only hold up the the

107
00:04:19,020 --> 00:04:16,330
glass by the edges the weight of the

108
00:04:22,770 --> 00:04:19,030
glass itself starts to to say get and

109
00:04:24,960 --> 00:04:22,780
bolted out of alignment anyway so that's

110
00:04:27,600 --> 00:04:24,970
we called it the great nebula in

111
00:04:32,219 --> 00:04:27,610
Andromeda in 1901

112
00:04:35,369 --> 00:04:32,229
well it became the great the galaxy in

113
00:04:37,499 --> 00:04:35,379

Andromeda about 20 years later and so

114
00:04:40,050 --> 00:04:37,509
this image here is from Edwin Hubble

115
00:04:43,469 --> 00:04:40,060
himself and you can see it's dated the

116
00:04:46,230 --> 00:04:43,479
sixth of October 1923 those ends in the

117
00:04:49,649 --> 00:04:46,240
center are stars that he believed were

118
00:04:52,290 --> 00:04:49,659
nove in this nebula though he was

119
00:04:54,839 --> 00:04:52,300
looking for stars it flashed and then

120
00:04:57,480 --> 00:04:54,849
went away so he's looking for no bay in

121
00:05:00,929 --> 00:04:57,490
this nebula and then you can see up near

122
00:05:03,300 --> 00:05:00,939
the top he has one isolated that he also

123
00:05:07,679 --> 00:05:03,310
has an N next to but then he's crossed

124
00:05:10,050 --> 00:05:07,689
out the end and put VAR ! it's not a

125
00:05:13,170 --> 00:05:10,060
nova it didn't just flash on once it

126
00:05:15,929 --> 00:05:13,180
actually recurred it's a variable star

127
00:05:18,179 --> 00:05:15,939
so this was his fantastic discovery

128
00:05:20,939 --> 00:05:18,189
discovering a variable star in the

129
00:05:22,800 --> 00:05:20,949
Andromeda nebula now why was that

130
00:05:25,140 --> 00:05:22,810
fantastic there's lots and lots of

131
00:05:26,909 --> 00:05:25,150
variable stars much closer to home the

132
00:05:29,309 --> 00:05:26,919
point is that when you have a variable

133
00:05:31,860 --> 00:05:29,319
star of a specific type it's called a

134
00:05:34,200 --> 00:05:31,870
Cepheid variable star then the

135
00:05:36,329 --> 00:05:34,210
brightness that it rises to and falls

136
00:05:38,790 --> 00:05:36,339
from the the front there the period at

137
00:05:41,850 --> 00:05:38,800
which it rises and falls rises and falls

138
00:05:45,059 --> 00:05:41,860

the timing of that period is related to

139
00:05:47,249 --> 00:05:45,069
its absolute brightness and so by

140
00:05:49,260 --> 00:05:47,259
measuring the timing of the period you

141
00:05:50,820 --> 00:05:49,270
could gauge its brightness and then

142
00:05:52,740 --> 00:05:50,830
comparing its absolute brightness

143
00:05:54,360 --> 00:05:52,750
against its apparent brightness the

144
00:05:56,999 --> 00:05:54,370
brightness it appears you could then

145
00:05:59,100 --> 00:05:57,009
engage its distance and when you do that

146
00:06:02,459 --> 00:05:59,110
you figure out that the nebula in

147
00:06:05,939 --> 00:06:02,469
Andromeda is well outside the Milky Way

148
00:06:08,309 --> 00:06:05,949
galaxy it's not a nebula it's a galaxy

149
00:06:09,839 --> 00:06:08,319
unto itself right right the example I

150
00:06:11,219 --> 00:06:09,849
always use for people for this is

151
00:06:12,779 --> 00:06:11,229
imagine if you know something's

152
00:06:14,189 --> 00:06:12,789
intrinsic brightness that is how bright

153
00:06:16,439 --> 00:06:14,199
it actually is if you were standing

154
00:06:18,959 --> 00:06:16,449
right next to it and then you measure

155
00:06:21,629 --> 00:06:18,969
how far you actually see it how bright

156
00:06:23,939 --> 00:06:21,639
it is at your when you look at it

157
00:06:25,290 --> 00:06:23,949
through a telescope didn't that's you

158
00:06:27,390 --> 00:06:25,300
can measure its distance because the

159
00:06:29,670 --> 00:06:27,400
brightness falls away as the inverse

160
00:06:31,230 --> 00:06:29,680
square of the distance and so I way to

161
00:06:33,570 --> 00:06:31,240
look at it directly as you take a candle

162
00:06:35,070 --> 00:06:33,580
put it really close to your like a few

163
00:06:37,620 --> 00:06:35,080

inches from your face don't burn your

164
00:06:39,200 --> 00:06:37,630
hair your eyeballs and then move it and

165
00:06:41,059 --> 00:06:39,210
put it on the other side of the room

166
00:06:43,100 --> 00:06:41,069
and then you know that that you can you

167
00:06:44,510 --> 00:06:43,110
could if you measure the brightness

168
00:06:46,370 --> 00:06:44,520
difference accurately enough you can

169
00:06:48,439 --> 00:06:46,380
measure how far away the candle is right

170
00:06:50,510 --> 00:06:48,449
we use this all the time when we're

171
00:06:52,309 --> 00:06:50,520
gauging how far away is a car at night

172
00:06:54,200 --> 00:06:52,319
you can only see the headlights and you

173
00:06:56,150 --> 00:06:54,210
know how bright headlights generally

174
00:06:58,070 --> 00:06:56,160
appear so you can tell whether they're

175
00:07:00,110 --> 00:06:58,080
bright and it's a natural thing that you

176
00:07:02,659 --> 00:07:00,120
actually do what we do it scientifically

177
00:07:04,610 --> 00:07:02,669
and so Hubble was able to measure that

178
00:07:06,950 --> 00:07:04,620
the Andromeda galaxy was its own galaxy

179
00:07:10,159 --> 00:07:06,960
proving for the first time that there

180
00:07:13,610 --> 00:07:10,169
were other galaxies in the universe okay

181
00:07:16,070 --> 00:07:13,620
well this this is amazing to me that it

182
00:07:17,719 --> 00:07:16,080
that it happened so recently that we you

183
00:07:20,600 --> 00:07:17,729
know that's not very far long ago that

184
00:07:22,730 --> 00:07:20,610
we didn't know there were other galaxies

185
00:07:24,320 --> 00:07:22,740
for about a hundred years we see we take

186
00:07:26,330 --> 00:07:24,330
them so much for granted these days but

187
00:07:29,779 --> 00:07:26,340
really it's only a hundred years no shun

188
00:07:34,339 --> 00:07:29,789

is a hundred years old or so ok so this

189
00:07:37,070 --> 00:07:34,349
sequence of four images is the star that

190
00:07:39,800 --> 00:07:37,080
Hubble found this is we call hv1 Hubble

191
00:07:41,749 --> 00:07:39,810
variable one and these are for images

192
00:07:43,909 --> 00:07:41,759
from the Hubble Space Telescope the

193
00:07:46,610 --> 00:07:43,919
namesake telescope showing it at the

194
00:07:47,960 --> 00:07:46,620
various brightnesses and you can't quite

195
00:07:49,820 --> 00:07:47,970
you can sort of see that they're the

196
00:07:52,219 --> 00:07:49,830
changes in brightness but on the next

197
00:07:53,839 --> 00:07:52,229
slide here I've got an animated gif I

198
00:07:57,709 --> 00:07:53,849
don't know how well this comes out

199
00:07:58,909 --> 00:07:57,719
across the Hangout I look how it exists

200
00:08:00,529 --> 00:07:58,919
coming out pretty good yeah yeah it's

201
00:08:02,300 --> 00:08:00,539
doing good all right definitely see the

202
00:08:04,129 --> 00:08:02,310
brightness changes right so you can see

203
00:08:05,990 --> 00:08:04,139
the brightness changing and you can see

204
00:08:08,300 --> 00:08:06,000
what Hubble did is measuring the

205
00:08:10,070 --> 00:08:08,310
variable the brightness changes others

206
00:08:11,480 --> 00:08:10,080
variable star in order to measure its

207
00:08:14,570 --> 00:08:11,490
distance and therefore the distance of

208
00:08:15,770 --> 00:08:14,580
the galaxy so what I'm showing you here

209
00:08:19,430 --> 00:08:15,780
the important thing I'm showing you here

210
00:08:21,499 --> 00:08:19,440
is Hubble the telescope can resolve the

211
00:08:25,189 --> 00:08:21,509
stars much much better than Hubble the

212
00:08:27,980 --> 00:08:25,199
astronomer matter of fact Hubble the

213
00:08:31,700 --> 00:08:27,990

telescope has looked in great detail at

214
00:08:36,019 --> 00:08:31,710
the Andromeda galaxy so this is an image

215
00:08:41,510 --> 00:08:36,029
from 2003 that we call the stellar Deep

216
00:08:44,240 --> 00:08:41,520
Field and this is an image of stars it's

217
00:08:46,850 --> 00:08:44,250
a star field basically but it's not in

218
00:08:50,720 --> 00:08:46,860
the Milky Way galaxy this is a star

219
00:08:52,100 --> 00:08:50,730
field in the Andromeda galaxy and let me

220
00:08:53,030 --> 00:08:52,110
zoom in on it because this is this is

221
00:08:55,100 --> 00:08:53,040
the whole field

222
00:08:57,980 --> 00:08:55,110
you know thousands of pixels across let

223
00:09:00,259 --> 00:08:57,990
me zoom in and show you you can see that

224
00:09:02,120 --> 00:09:00,269
bright star with a cross on it okay nuts

225
00:09:04,249 --> 00:09:02,130
that's going to be a star in the Milky

226
00:09:05,600 --> 00:09:04,259
Way galaxy that's a foreground store

227
00:09:07,370 --> 00:09:05,610
that's a foreground star in the Milky

228
00:09:08,569 --> 00:09:07,380
Way galaxy of course stars in the Milky

229
00:09:11,120 --> 00:09:08,579
Way are going to be between us and

230
00:09:15,650 --> 00:09:11,130
Andromeda but every other star that you

231
00:09:19,280 --> 00:09:15,660
see there is in the Andromeda galaxy two

232
00:09:23,150 --> 00:09:19,290
and a half million light-years away so

233
00:09:25,910 --> 00:09:23,160
we're seeing a star filled in Andromeda

234
00:09:30,319 --> 00:09:25,920
plus if you look carefully you'll see

235
00:09:33,110 --> 00:09:30,329
that there are these small galaxies they

236
00:09:35,389 --> 00:09:33,120
small uh yeah there are these small

237
00:09:38,059 --> 00:09:35,399
fuzzy blobs that are actually background

238
00:09:39,379 --> 00:09:38,069

galaxies you're seeing through Andromeda

239
00:09:42,139 --> 00:09:39,389
yeah there's a lot of them in there

240
00:09:45,829 --> 00:09:42,149
that's really cool and then what's even

241
00:09:49,100 --> 00:09:45,839
cooler is here I'm showing you a

242
00:09:52,939 --> 00:09:49,110
globular star cluster but this globular

243
00:09:56,629 --> 00:09:52,949
star cluster is in Andromeda mm-hmm

244
00:09:58,579 --> 00:09:56,639
Hubble can see the Andromeda galaxy was

245
00:10:01,009 --> 00:09:58,589
such good resolution not just he starts

246
00:10:03,259 --> 00:10:01,019
we can see star clusters and I'm always

247
00:10:04,850 --> 00:10:03,269
am sort of amazed at this this globular

248
00:10:07,460 --> 00:10:04,860
star cluster in Andromeda because i

249
00:10:09,290 --> 00:10:07,470
think it compared really well with this

250
00:10:11,210 --> 00:10:09,300
of your star cluster in our own Milky

251
00:10:12,769 --> 00:10:11,220
Way galaxy yeah they're the prettiest

252
00:10:14,660 --> 00:10:12,779
what the stars are pretty well resolved

253
00:10:16,280 --> 00:10:14,670
how far away is Andromeda are you going

254
00:10:18,370 --> 00:10:16,290
to get to that later Andromeda's two and

255
00:10:21,110 --> 00:10:18,380
a half million light-years away okay

256
00:10:23,960 --> 00:10:21,120
whereas the star cluster on the left is

257
00:10:26,000 --> 00:10:23,970
Messier 80 and I don't know the exact

258
00:10:28,850 --> 00:10:26,010
distance to Messier 80 but it's going to

259
00:10:30,530 --> 00:10:28,860
be on order 10,000 light-years right

260
00:10:32,389 --> 00:10:30,540
it's much closer sorry and so you get

261
00:10:35,960 --> 00:10:32,399
10,000 light-years two and a half

262
00:10:38,410 --> 00:10:35,970
million light-years it the the distance

263
00:10:41,780 --> 00:10:38,420

difference is around 200 factor of 250

264
00:10:44,059 --> 00:10:41,790
well I mean if also i mean it's it's

265
00:10:46,850 --> 00:10:44,069
obvious that the Andromeda star cluster

266
00:10:48,740 --> 00:10:46,860
is larger and so you can see that it's

267
00:10:51,499 --> 00:10:48,750
not as well resolved of course it

268
00:10:53,449 --> 00:10:51,509
shouldn't be but you can see it's really

269
00:10:56,179 --> 00:10:53,459
cool were able to study stars and star

270
00:10:57,889 --> 00:10:56,189
clusters in the Andromeda galaxy so

271
00:10:59,749 --> 00:10:57,899
Frank let me ask you a quick question on

272
00:11:02,300 --> 00:10:59,759
the the very the sea Fiat variable

273
00:11:03,679 --> 00:11:02,310
brightness technique how that was one of

274
00:11:05,449 --> 00:11:03,689
the ways in which they first figured out

275
00:11:05,990 --> 00:11:05,459
how this was really really far the

276
00:11:07,250 --> 00:11:06,000
Andromeda

277
00:11:10,160 --> 00:11:07,260
the far away how accurate is that

278
00:11:12,500 --> 00:11:10,170
technique of using see Fiat variables to

279
00:11:14,930 --> 00:11:12,510
measure distance well in Hubble's time

280
00:11:16,940 --> 00:11:14,940
it wasn't very accurate matter of fact

281
00:11:20,540 --> 00:11:16,950
he got the distance to Andromeda wrong

282
00:11:22,070 --> 00:11:20,550
by about a factor of five only does he

283
00:11:24,590 --> 00:11:22,080
think it was further away or closer

284
00:11:27,020 --> 00:11:24,600
closer all right there are two different

285
00:11:28,400 --> 00:11:27,030
types of Cepheid um some pronounced to

286
00:11:30,050 --> 00:11:28,410
see if you had some routes a Cepheid i

287
00:11:33,020 --> 00:11:30,060
pronounced a Cepheid i'm not sure

288
00:11:34,220 --> 00:11:33,030

exactly what which is correct a lot of

289
00:11:35,870 --> 00:11:34,230
these things I just don't care well I

290
00:11:37,400 --> 00:11:35,880
say see fee is because it you know

291
00:11:40,250 --> 00:11:37,410
actually I save Cepheus the

292
00:11:42,050 --> 00:11:40,260
constellation that's why I do it okay

293
00:11:44,720 --> 00:11:42,060
you know and it comes with kareena

294
00:11:47,120 --> 00:11:44,730
incurring a or you know Karina we will

295
00:11:48,910 --> 00:11:47,130
do a lot of those anyways corona there

296
00:11:52,010 --> 00:11:48,920
are two different types of them and

297
00:11:54,170 --> 00:11:52,020
Hubble chose the wrong type to compare

298
00:11:57,080 --> 00:11:54,180
against and got the got the distance is

299
00:11:59,660 --> 00:11:57,090
wrong the however it is a very accurate

300
00:12:01,490 --> 00:11:59,670
technique now because one of the key

301
00:12:04,630 --> 00:12:01,500
projects when the whole space telescope

302
00:12:07,520 --> 00:12:04,640
was first launched was to serve a nearby

303
00:12:09,050 --> 00:12:07,530
galaxies for these Cepheid variable

304
00:12:11,150 --> 00:12:09,060
stars as well as our hourly rate

305
00:12:13,730 --> 00:12:11,160
variable stars to look for variable

306
00:12:16,250 --> 00:12:13,740
stars in nearby galaxies measure their

307
00:12:18,980 --> 00:12:16,260
distances extremely carefully and from

308
00:12:22,790 --> 00:12:18,990
that measure of the Hubble law which is

309
00:12:25,250 --> 00:12:22,800
the local expansion of the universe so

310
00:12:27,800 --> 00:12:25,260
it is really it's accurate out to tens

311
00:12:29,390 --> 00:12:27,810
of millions of light-years these days so

312
00:12:31,760 --> 00:12:29,400
one of the original science questions

313
00:12:34,130 --> 00:12:31,770

Hubble was designed to answer was you

314
00:12:36,470 --> 00:12:34,140
know this this how getting this

315
00:12:38,870 --> 00:12:36,480
technique down more accurately exactly

316
00:12:41,090 --> 00:12:38,880
using this really good technique to then

317
00:12:46,070 --> 00:12:41,100
measure the local expansion rate of the

318
00:12:49,579 --> 00:12:46,080
universe ok thank him so that stellar

319
00:12:51,710 --> 00:12:49,589
Deep Field was in Andromeda but you can

320
00:12:55,280 --> 00:12:51,720
see from this illustration it was way

321
00:12:57,770 --> 00:12:55,290
out from the main body of Andromeda it's

322
00:13:00,829 --> 00:12:57,780
in what we call the halo of Andromeda

323
00:13:03,050 --> 00:13:00,839
now these galaxies most of the stars are

324
00:13:05,120 --> 00:13:03,060
in these disks as you soon see but

325
00:13:07,070 --> 00:13:05,130
there's a very large halo of stars

326
00:13:09,200 --> 00:13:07,080
orbiting around these galaxies

327
00:13:13,040 --> 00:13:09,210
relatively low we have the same sort of

328
00:13:14,750 --> 00:13:13,050
halo in our own Milky Way galaxy and we

329
00:13:16,880 --> 00:13:14,760
observed it in other galaxies but we

330
00:13:19,730 --> 00:13:16,890
can't see them in detail except for in

331
00:13:23,090 --> 00:13:19,740
the closest of galaxies Milky Way

332
00:13:24,770 --> 00:13:23,100
Andromeda so we're studying it in the

333
00:13:27,170 --> 00:13:24,780
halo so that we didn't have crowded

334
00:13:30,260 --> 00:13:27,180
confusion and we could you know really

335
00:13:32,990 --> 00:13:30,270
study the individual stars well what

336
00:13:36,320 --> 00:13:33,000
wouldn't it be really cool to study the

337
00:13:43,240 --> 00:13:36,330
main disk of Andromeda what if yes it

338
00:13:46,250 --> 00:13:43,250

would be cool yes yes dr. Frank well

339
00:13:48,470 --> 00:13:46,260
unfortunately you can see the size of a

340
00:13:49,850 --> 00:13:48,480
single Hubble image this is using

341
00:13:51,950 --> 00:13:49,860
advanced camera for surveys but why

342
00:13:53,570 --> 00:13:51,960
field camera 3 is about the same and you

343
00:13:55,700 --> 00:13:53,580
can see how many of those would it take

344
00:13:57,140 --> 00:13:55,710
to cover all of Andromeda that little

345
00:13:59,270 --> 00:13:57,150
green square there right yeah that

346
00:14:03,680 --> 00:13:59,280
little green square there too many you'd

347
00:14:06,670 --> 00:14:03,690
never get that much time but a project

348
00:14:11,210 --> 00:14:06,680
called the pen chromatic Hubble

349
00:14:13,580 --> 00:14:11,220
Andromeda Treasury program fat ph 80 did

350
00:14:17,660 --> 00:14:13,590
get enough time to cover about a third

351
00:14:19,760 --> 00:14:17,670
of that and drama to disk ok this is the

352
00:14:23,360 --> 00:14:19,770
one of the largest programs ever done on

353
00:14:27,200 --> 00:14:23,370
Hubble and it covers a tremendous amount

354
00:14:30,680 --> 00:14:27,210
of the Andromeda disk so they just

355
00:14:32,270 --> 00:14:30,690
completed the fat and they've got the

356
00:14:33,890 --> 00:14:32,280
data in hand they don't have all the

357
00:14:35,120 --> 00:14:33,900
science results ok I mean just say that

358
00:14:37,610 --> 00:14:35,130
you know the science results are still

359
00:14:40,220 --> 00:14:37,620
coming because this is a really whopping

360
00:14:42,590 --> 00:14:40,230
huge amount of data but this is the

361
00:14:45,020 --> 00:14:42,600
panchromatic Hubble Andromeda Treasury

362
00:14:47,420 --> 00:14:45,030
program and what you see in front of you

363
00:14:50,090 --> 00:14:47,430

is the what we call the uncropped image

364
00:14:51,650 --> 00:14:50,100
this is the image that shows you has the

365
00:14:54,800 --> 00:14:51,660
ragged edge shows you all the various

366
00:14:56,930 --> 00:14:54,810
pointings alright recognize that it is a

367
00:14:59,570 --> 00:14:56,940
hundred thousand pixels from side to

368
00:15:02,840 --> 00:14:59,580
side and about twenty or thirty thousand

369
00:15:07,870 --> 00:15:02,850
pixels high do the math this is several

370
00:15:09,950 --> 00:15:07,880
billion pixels of the Andromeda galaxy

371
00:15:11,840 --> 00:15:09,960
largest mosaic we've ever put together

372
00:15:13,570 --> 00:15:11,850
as you can see from the stats at the

373
00:15:16,660 --> 00:15:13,580
bottom it took three years to do it over

374
00:15:19,910 --> 00:15:16,670
seven thousand different exposures

375
00:15:22,340 --> 00:15:19,920
pointing it 411 different places in

376
00:15:26,810 --> 00:15:22,350
Andromeda and then mosaicing them all

377
00:15:29,990 --> 00:15:26,820
together how big is this well on this

378
00:15:32,060 --> 00:15:30,000
image here well right on the left you

379
00:15:33,290 --> 00:15:32,070
see that the rectangle is the outline of

380
00:15:35,389 --> 00:15:33,300
the cropped image

381
00:15:38,870 --> 00:15:35,399
but on the right you see that circle

382
00:15:42,590 --> 00:15:38,880
half circle that's the apparent diameter

383
00:15:45,699 --> 00:15:42,600
of the full moon on our sky half a

384
00:15:49,759 --> 00:15:45,709
degree across okay it's bigger than that

385
00:15:51,740 --> 00:15:49,769
dude so the width of this image is about

386
00:15:55,509 --> 00:15:51,750
you know two and a half full moons

387
00:15:58,910 --> 00:15:55,519
across all rights it's a huge huge image

388
00:16:01,280 --> 00:15:58,920

and also down in the lower right you see

389
00:16:03,980 --> 00:16:01,290
that rectangle that's got a line down

390
00:16:08,480 --> 00:16:03,990
the center of it that is the footprint

391
00:16:10,400 --> 00:16:08,490
of one Hubble observation with wide

392
00:16:12,710 --> 00:16:10,410
field camera on the sky so you can

393
00:16:15,019 --> 00:16:12,720
really start to see the 411 various

394
00:16:16,519 --> 00:16:15,029
pointing signals okay and while you're

395
00:16:18,590 --> 00:16:16,529
talking I want to tell everybody that I

396
00:16:20,509 --> 00:16:18,600
just posted a link to where you can get

397
00:16:22,759 --> 00:16:20,519
these images yourself on the grievant

398
00:16:24,560 --> 00:16:22,769
page so check it out yeah but let me

399
00:16:27,769 --> 00:16:24,570
warn you you cannot get the two billion

400
00:16:29,720 --> 00:16:27,779
pixel version okay I think we've got a

401
00:16:31,509 --> 00:16:29,730
500 million pixel version up there but

402
00:16:35,030 --> 00:16:31,519
the two billion pixel version actually

403
00:16:37,670 --> 00:16:35,040
is so large it violates a 32-bit

404
00:16:40,400 --> 00:16:37,680
addressing that's in the normal tiff

405
00:16:42,500 --> 00:16:40,410
file and so it's only available in a

406
00:16:44,660 --> 00:16:42,510
special file format that uses 64 bit of

407
00:16:47,600 --> 00:16:44,670
dressing so we haven't publicly released

408
00:16:49,460 --> 00:16:47,610
that isn't but the I mean maybe this is

409
00:16:51,920 --> 00:16:49,470
a little off topic but aren't there

410
00:16:54,019 --> 00:16:51,930
zoomable jpeg images we actually do

411
00:16:56,780 --> 00:16:54,029
believe yes and that correct I believe

412
00:16:59,180 --> 00:16:56,790
on the website they do have a zoomable

413
00:17:00,650 --> 00:16:59,190

version of this okay good but if you

414
00:17:02,780 --> 00:17:00,660
want to try and download every stall

415
00:17:04,280 --> 00:17:02,790
pixels in one file you need a special

416
00:17:06,350 --> 00:17:04,290
file format because they're just too

417
00:17:08,600 --> 00:17:06,360
many pixels and in terms of the the

418
00:17:11,569 --> 00:17:08,610
addressing internal to the file format

419
00:17:15,140 --> 00:17:11,579
okay alright so let's take a look in

420
00:17:16,130 --> 00:17:15,150
some detail okay so what is the science

421
00:17:18,380 --> 00:17:16,140
we're going to get out of this well the

422
00:17:21,230 --> 00:17:18,390
very first thing about science is that

423
00:17:24,620 --> 00:17:21,240
we're going to look in great detail at

424
00:17:27,409 --> 00:17:24,630
the stellar populations in the various

425
00:17:29,510 --> 00:17:27,419
parts of the galaxy one of the problems

426
00:17:32,150 --> 00:17:29,520
about living in the Milky Way is that

427
00:17:35,049 --> 00:17:32,160
we're inside it and you've got this disk

428
00:17:38,570 --> 00:17:35,059
of material in your way that's a problem

429
00:17:40,130 --> 00:17:38,580
that's a great thing but if you want to

430
00:17:42,950 --> 00:17:40,140
actually look at the center of the

431
00:17:43,940 --> 00:17:42,960
galaxy and then i'll say i get my Sh my

432
00:17:45,530 --> 00:17:43,950
hand if you want to the center of the

433
00:17:45,919 --> 00:17:45,540
galaxy and further out and further and

434
00:17:48,169 --> 00:17:45,929
further

435
00:17:50,600 --> 00:17:48,179
out if you're inside it it's kind of

436
00:17:53,330 --> 00:17:50,610
hard to hard to do so all right you got

437
00:17:56,239 --> 00:17:53,340
a lot of junk in your way Andromeda is

438
00:17:57,889 --> 00:17:56,249

the nearest large galaxy and we can as

439
00:18:00,289 --> 00:17:57,899
I've labeled here look in the central

440
00:18:03,710 --> 00:18:00,299
region I've labeled one getting further

441
00:18:05,480 --> 00:18:03,720
out into the dust lanes to this new

442
00:18:07,430 --> 00:18:05,490
star-forming regions this label 3 and

443
00:18:10,279 --> 00:18:07,440
all the way out to the edge of the disk

444
00:18:12,379 --> 00:18:10,289
in that region I've labeled for okay so

445
00:18:15,889 --> 00:18:12,389
we'll be able to look at the stellar

446
00:18:19,070 --> 00:18:15,899
populations and how they change fraught

447
00:18:21,109 --> 00:18:19,080
with the environment within a galaxy so

448
00:18:24,619 --> 00:18:21,119
let's take a look at that first one one

449
00:18:27,919 --> 00:18:24,629
down at the very core and if you've got

450
00:18:30,289 --> 00:18:27,929
a high-resolution screen you still don't

451
00:18:34,220 --> 00:18:30,299
see the individual stars it is so

452
00:18:37,789 --> 00:18:34,230
crowded here it's just this milky white

453
00:18:41,210 --> 00:18:37,799
glow with the the the shadows of the

454
00:18:44,389 --> 00:18:41,220
dust in front of it what you see that

455
00:18:48,049 --> 00:18:44,399
may look like stars these clumps right

456
00:18:49,609 --> 00:18:48,059
here are actually star clusters all of

457
00:18:52,340 --> 00:18:49,619
those white dots that sort of look like

458
00:18:55,009 --> 00:18:52,350
they could be stars are really star

459
00:18:57,440 --> 00:18:55,019
clusters the stars themselves are so

460
00:18:59,720 --> 00:18:57,450
dense and so packed together they just

461
00:19:02,570 --> 00:18:59,730
form this almost uniform white glow in

462
00:19:04,730 --> 00:19:02,580
the background so very dense a stellar

463
00:19:09,070 --> 00:19:04,740

feed stellar field in the center of the

464
00:19:12,039 --> 00:19:09,080
galaxy we move on out toward the US

465
00:19:14,659 --> 00:19:12,049
regions where I called the dust lanes

466
00:19:17,539 --> 00:19:14,669
now you start to see though that the the

467
00:19:20,720 --> 00:19:17,549
populate the number of stars is greatly

468
00:19:24,109 --> 00:19:20,730
reduced and you also can see the clouds

469
00:19:26,749 --> 00:19:24,119
of material so these big dark clouds

470
00:19:29,960 --> 00:19:26,759
material again the big white things that

471
00:19:32,779 --> 00:19:29,970
you see are going to be star clusters in

472
00:19:36,230 --> 00:19:32,789
just the initial analysis of this image

473
00:19:40,549 --> 00:19:36,240
of this billion pixel image they were

474
00:19:42,109 --> 00:19:40,559
able to identify almost 3,000 new star

475
00:19:44,419 --> 00:19:42,119
clusters that they'd never seen before

476
00:19:45,950 --> 00:19:44,429
so how do they do that Frank I mean that

477
00:19:47,629 --> 00:19:45,960
sounds like a lot of work I mean I

478
00:19:50,419 --> 00:19:47,639
there's up people doing this will hire a

479
00:19:52,669 --> 00:19:50,429
lot of graduates to know I started

480
00:19:57,139 --> 00:19:52,679
that's not right don't scare them off

481
00:19:59,810 --> 00:19:57,149
now you of course do it by computers

482
00:20:02,630 --> 00:19:59,820
right but the hard part is telling the

483
00:20:08,180 --> 00:20:02,640
computer what it's looking for you have

484
00:20:10,310 --> 00:20:08,190
to describe in mathematical terms the

485
00:20:13,160 --> 00:20:10,320
brightness profile of what you expect a

486
00:20:15,200 --> 00:20:13,170
star cluster to look like well and and

487
00:20:17,870 --> 00:20:15,210
then once you once the computer says

488
00:20:19,850 --> 00:20:17,880

here I think I found something then you

489
00:20:22,550 --> 00:20:19,860
need a human to come in and look at

490
00:20:24,920 --> 00:20:22,560
every single one of them this is the so

491
00:20:26,720 --> 00:20:24,930
the so the computer would go in and you

492
00:20:28,700 --> 00:20:26,730
would design an algorithm to try and

493
00:20:30,410 --> 00:20:28,710
find these star clusters then the

494
00:20:32,180 --> 00:20:30,420
computer would then pop up on screen

495
00:20:34,430 --> 00:20:32,190
okay here the star clusters I think I

496
00:20:35,870 --> 00:20:34,440
found and you have to go through every

497
00:20:38,810 --> 00:20:35,880
single one of them somebody has to look

498
00:20:40,490 --> 00:20:38,820
at it to check the computer because the

499
00:20:42,950 --> 00:20:40,500
computers only do what you tell them to

500
00:20:44,240 --> 00:20:42,960
do and unfortunately we aren't perfect

501
00:20:46,340 --> 00:20:44,250
people that telling computers to do

502
00:20:48,080 --> 00:20:46,350
exactly what we want to do no but they

503
00:20:50,240 --> 00:20:48,090
do do a pretty good job I mean there's a

504
00:20:51,770 --> 00:20:50,250
I'm they can even even tell the

505
00:20:53,540 --> 00:20:51,780
difference between stars and galaxies a

506
00:20:55,430 --> 00:20:53,550
lot of times or whether sometimes even

507
00:20:57,440 --> 00:20:55,440
if two galaxies are superimposed on each

508
00:20:59,090 --> 00:20:57,450
other one may be way farther away than

509
00:21:00,170 --> 00:20:59,100
the other so they do a pretty good job

510
00:21:02,390 --> 00:21:00,180
but I didn't want to talk about that

511
00:21:04,040 --> 00:21:02,400
briefly because it's it used to be back

512
00:21:06,890 --> 00:21:04,050
in the day like in clyde tombaugh stay

513
00:21:09,170 --> 00:21:06,900

and Hubble's day yeah you didn't do it

514
00:21:10,730 --> 00:21:09,180
all manually write a parrot or and all

515
00:21:13,130 --> 00:21:10,740
that kind of guess I mean when you think

516
00:21:17,210 --> 00:21:13,140
about what clyde tombaugh did to

517
00:21:21,040 --> 00:21:17,220
discover pluto unbelievable i don't the

518
00:21:24,230 --> 00:21:21,050
man had patience is so easy these days

519
00:21:27,320 --> 00:21:24,240
ok so moving on to region 3 which

520
00:21:29,450 --> 00:21:27,330
identified as a cluster of newborn stars

521
00:21:30,770 --> 00:21:29,460
it's not just one cluster of newborn

522
00:21:35,090 --> 00:21:30,780
stars this is a region where you can see

523
00:21:36,830 --> 00:21:35,100
a lot of bright blue stars here now one

524
00:21:39,310 --> 00:21:36,840
problem with this fat image that we

525
00:21:41,840 --> 00:21:39,320
released is we're only using two colors

526
00:21:45,440 --> 00:21:41,850
we're using a blue light and we're using

527
00:21:48,920 --> 00:21:45,450
a near-infrared red light we're not

528
00:21:50,990 --> 00:21:48,930
however using something that would

529
00:21:53,000 --> 00:21:51,000
identify the star-forming regions with

530
00:21:55,100 --> 00:21:53,010
that pink glow that for example you see

531
00:21:56,600 --> 00:21:55,110
in the Whirlpool Galaxy Iraq over my

532
00:21:58,550 --> 00:21:56,610
left shoulder here right there that's

533
00:22:01,940 --> 00:21:58,560
the Whirlpool Galaxy over my left

534
00:22:03,860 --> 00:22:01,950
shoulder and we have a lot of pink star

535
00:22:06,230 --> 00:22:03,870
forming regions that we see in those

536
00:22:09,110 --> 00:22:06,240
galaxies but those are called out

537
00:22:11,540 --> 00:22:09,120
because we use hydrogen alpha filters to

538
00:22:13,490 --> 00:22:11,550

bring out that reddish glow in the star

539
00:22:15,110 --> 00:22:13,500
for images we

540
00:22:18,740 --> 00:22:15,120
don't have the hydrogen alpha filter I

541
00:22:21,080 --> 00:22:18,750
in this observation only two filters

542
00:22:22,760 --> 00:22:21,090
were used here so you can't identify the

543
00:22:25,640 --> 00:22:22,770
star-forming regions by their pink glow

544
00:22:28,780 --> 00:22:25,650
but you can identify the young newborn

545
00:22:31,580 --> 00:22:28,790
stars by their bright blue go glow the

546
00:22:34,610 --> 00:22:31,590
blue stars are the hottest stars and

547
00:22:37,580 --> 00:22:34,620
these hottest stars only live for tens

548
00:22:40,550 --> 00:22:37,590
of millions of years so this you know

549
00:22:44,780 --> 00:22:40,560
that these are regions of new new star

550
00:22:46,730 --> 00:22:44,790
formation yeah all right finally let's

551
00:22:49,580 --> 00:22:46,740
take it on to the outer regions of the

552
00:22:51,740 --> 00:22:49,590
of the galaxy all right and so this

553
00:22:55,250 --> 00:22:51,750
starts to look a little bit like what we

554
00:22:56,990 --> 00:22:55,260
saw in the stellar Deep Field the one

555
00:22:59,210 --> 00:22:57,000
the observation is out in the halo of

556
00:23:01,550 --> 00:22:59,220
Andromeda but if you've got a high res

557
00:23:03,740 --> 00:23:01,560
monitor and it comes up they can really

558
00:23:07,430 --> 00:23:03,750
start to see the individual stars here

559
00:23:09,860 --> 00:23:07,440
that you can understand why the first in

560
00:23:12,020 --> 00:23:09,870
their first deep field that stole the

561
00:23:13,610 --> 00:23:12,030
appeal was done in a halo so that you

562
00:23:17,180 --> 00:23:13,620
could really get a handle on the

563
00:23:19,220 --> 00:23:17,190

individual stars but up in the spot and

564
00:23:21,890 --> 00:23:19,230
the spiral disk of the galaxy you still

565
00:23:23,540 --> 00:23:21,900
have an amazing number of stars well out

566
00:23:25,400 --> 00:23:23,550
from the center all the way out to the

567
00:23:28,850 --> 00:23:25,410
edges of this and you can see the

568
00:23:30,230 --> 00:23:28,860
amazing details you got here okay so

569
00:23:32,960 --> 00:23:30,240
let's take it and do a sort of a

570
00:23:34,610 --> 00:23:32,970
continuum of this we released this image

571
00:23:36,640 --> 00:23:34,620
as part of our press release too short

572
00:23:39,770 --> 00:23:36,650
of show you some of the various things

573
00:23:42,380 --> 00:23:39,780
you can see the Milky Way star just

574
00:23:44,360 --> 00:23:42,390
below into the right of Center you can

575
00:23:45,710 --> 00:23:44,370
see some background galaxies you can see

576
00:23:48,140 --> 00:23:45,720
the stellar clusters that I've pulled

577
00:23:50,510 --> 00:23:48,150
out and they've got a region that they

578
00:23:53,210 --> 00:23:50,520
call the star-forming region all right

579
00:23:55,910 --> 00:23:53,220
and let me just outline that you see

580
00:23:58,820 --> 00:23:55,920
that I do what you are looking at here

581
00:24:00,140 --> 00:23:58,830
is like a tenth of the resolution all

582
00:24:02,480 --> 00:24:00,150
right I'm going to go into that star

583
00:24:05,480 --> 00:24:02,490
forming region area at full resolution

584
00:24:06,680 --> 00:24:05,490
full billion pixel resolution I have to

585
00:24:09,050 --> 00:24:06,690
say those four regions that I went

586
00:24:11,210 --> 00:24:09,060
through that was only quarter resolution

587
00:24:13,670 --> 00:24:11,220
okay so one pixel really should be

588
00:24:17,570 --> 00:24:13,680

replaced by 16 pixels in those here it

589
00:24:20,570 --> 00:24:17,580
is at full resolution okay you get down

590
00:24:23,840 --> 00:24:20,580
and you can I had just the immense

591
00:24:25,550 --> 00:24:23,850
number of stars so that's really where I

592
00:24:26,960 --> 00:24:25,560
want to leave you with is that they

593
00:24:30,560 --> 00:24:26,970
identified over a

594
00:24:33,980 --> 00:24:30,570
hundred and seventy million stars in the

595
00:24:36,110 --> 00:24:33,990
Andromeda galaxy with this survey and it

596
00:24:38,750 --> 00:24:36,120
will be analyzing it and studied how

597
00:24:41,180 --> 00:24:38,760
those stellar types change how the

598
00:24:43,250 --> 00:24:41,190
populations of stars in different

599
00:24:45,770 --> 00:24:43,260
regions change as a function of distance

600
00:24:48,520 --> 00:24:45,780
from the center what is the variation

601
00:24:51,380 --> 00:24:48,530
and really get a great handle on

602
00:24:54,770 --> 00:24:51,390
understanding the star formation history

603
00:24:57,350 --> 00:24:54,780
in galaxies because we see galaxies as

604
00:25:00,049 --> 00:24:57,360
they are today but you know the ages of

605
00:25:02,180 --> 00:25:00,059
the stars can tell you how long ago they

606
00:25:04,700 --> 00:25:02,190
formed which tells you some on gives you

607
00:25:06,500 --> 00:25:04,710
some understanding of when stars formed

608
00:25:09,409 --> 00:25:06,510
at different places within this galaxy

609
00:25:11,840 --> 00:25:09,419
and get a good understanding of how the

610
00:25:13,250 --> 00:25:11,850
galaxy got to be the way it is which is

611
00:25:15,649 --> 00:25:13,260
of course one of the major things we try

612
00:25:18,740 --> 00:25:15,659
to answer in astronomy how things get to

613
00:25:21,039 --> 00:25:18,750

way they are what are the wavelengths

614
00:25:25,130 --> 00:25:21,049
that were used to make this mosaic uh

615
00:25:29,120 --> 00:25:25,140
let's see I believe it's the 814 also

616
00:25:32,090 --> 00:25:29,130
814 nanometers which is just outside the

617
00:25:35,000 --> 00:25:32,100
visible light into the 94 red near-ir um

618
00:25:38,270 --> 00:25:35,010
and then it was a blue filter which is

619
00:25:41,000 --> 00:25:38,280
that what's 450 to 500 nanometers

620
00:25:44,750 --> 00:25:41,010
something in there I don't remember the

621
00:25:47,750 --> 00:25:44,760
exact so between 450 500 I believe okay

622
00:25:50,330 --> 00:25:47,760
mm-hmm they do that two wavelengths in

623
00:25:53,720 --> 00:25:50,340
two wavelengths yes no crime okay they

624
00:25:56,659 --> 00:25:53,730
do of course have more more filters but

625
00:25:57,950 --> 00:25:56,669
only two were put together and creating

626
00:26:00,230 --> 00:25:57,960
this amazing mosaic right this was

627
00:26:02,990 --> 00:26:00,240
already big enough and adding what would

628
00:26:05,090 --> 00:26:03,000
have been really that's a huge project

629
00:26:06,680 --> 00:26:05,100
yeah coming years I actually expect we

630
00:26:08,180 --> 00:26:06,690
will get the other way thanks

631
00:26:09,620 --> 00:26:08,190
incorporated into large mosaics like

632
00:26:12,049 --> 00:26:09,630
yeah I was just thinking about the UV

633
00:26:13,549 --> 00:26:12,059
are wondering what some of this whatever

634
00:26:15,140 --> 00:26:13,559
you'd see in some of that especially

635
00:26:16,820 --> 00:26:15,150
these star forming regions right I mean

636
00:26:19,159 --> 00:26:16,830
then we have more yeah we have just

637
00:26:21,020 --> 00:26:19,169
begun to delve into this Andromeda image

638
00:26:22,190 --> 00:26:21,030

I'm sure we'll be hearing a lot from it

639
00:26:25,130 --> 00:26:22,200
over the year of the next coming years

640
00:26:26,990 --> 00:26:25,140
as the analysis goes on and the day

641
00:26:28,430 --> 00:26:27,000
taking is done now let's go to the

642
00:26:33,340 --> 00:26:28,440
analysis phase is going to take several

643
00:26:36,020 --> 00:26:33,350
years as well alright our second story

644
00:26:38,600 --> 00:26:36,030
moonshadows that sounds like a cat

645
00:26:40,970 --> 00:26:38,610
Steven song or whether it is

646
00:26:42,770 --> 00:26:40,980
name is didn't change the name Joseph

647
00:26:48,700 --> 00:26:42,780
Mohammed or something like that anyway

648
00:26:54,470 --> 00:26:48,710
so no I'm not singing I won't say either

649
00:26:56,840 --> 00:26:54,480
uh in april twenty first of 2014 and we

650
00:26:59,960 --> 00:26:56,850
saw a ganna me shadow on the Great Red

651
00:27:03,890 --> 00:26:59,970
Spot now you may remember we released

652
00:27:05,390 --> 00:27:03,900
this last Halloween right so we released

653
00:27:07,640 --> 00:27:05,400
this last Halloween where Ganymede

654
00:27:10,130 --> 00:27:07,650
shadow passed over the Great Red Spot it

655
00:27:13,430 --> 00:27:10,140
was kind of cute and I think we did this

656
00:27:15,260 --> 00:27:13,440
at a hangout that somebody took this and

657
00:27:17,000 --> 00:27:15,270
a photoshopped it and they doubled the

658
00:27:21,919 --> 00:27:17,010
double the Great Red Spot and they

659
00:27:24,850 --> 00:27:21,929
turned it into that yeah so we've shown

660
00:27:29,330 --> 00:27:24,860
you a shadow on Jupiter with Ganymede

661
00:27:32,840 --> 00:27:29,340
but we just got a chance to a triple

662
00:27:36,140 --> 00:27:32,850
shadow on Jupiter on january twenty

663
00:27:39,650 --> 00:27:36,150

fourth of this year so on january twenty

664
00:27:42,560 --> 00:27:39,660
fourth of 2015 hubble ellos allocated

665
00:27:45,440 --> 00:27:42,570
one orbit which is about 45 minutes of

666
00:27:49,010 --> 00:27:45,450
observing time to look at jupiter and

667
00:27:52,940 --> 00:27:49,020
see the passage of several shadows so

668
00:27:55,340 --> 00:27:52,950
you can see at 628 UT Europa shadow is

669
00:27:58,250 --> 00:27:55,350
lower left Calista shadows above center

670
00:28:00,980 --> 00:27:58,260
and then I of shadow is above and right

671
00:28:04,549 --> 00:28:00,990
of that alright three shadows passing

672
00:28:07,100 --> 00:28:04,559
across it now Hubble has taking pictures

673
00:28:08,870 --> 00:28:07,110
of Jupiter's actually pretty easy it

674
00:28:11,960 --> 00:28:08,880
doesn't require a long exposure time

675
00:28:14,659 --> 00:28:11,970
they could be done in seconds so you

676
00:28:17,210 --> 00:28:14,669
don't need to you know have multiple

677
00:28:18,919 --> 00:28:17,220
orbits so one orbit was allocated so

678
00:28:22,490 --> 00:28:18,929
they got about 40 minutes of good

679
00:28:24,710 --> 00:28:22,500
observing time for looking at Jupiter so

680
00:28:29,990 --> 00:28:24,720
they took a series of two dozen pictures

681
00:28:33,200 --> 00:28:30,000
from 628 UT up until this image here at

682
00:28:35,690 --> 00:28:33,210
seven ten UT and you can see that I Oh

683
00:28:37,789 --> 00:28:35,700
shadow has moved off Callisto shadow is

684
00:28:40,460 --> 00:28:37,799
still there Europa shadow and now

685
00:28:42,650 --> 00:28:40,470
Callisto and Europa are both in the

686
00:28:44,870 --> 00:28:42,660
frame so it was kind of cool we're

687
00:28:48,470 --> 00:28:44,880
looking at this and I put together an

688
00:28:50,180 --> 00:28:48,480

animated gift for this so this is what

689
00:28:52,810 --> 00:28:50,190
we released is just the black and white

690
00:28:55,100 --> 00:28:52,820
of the two dozen images

691
00:28:57,380 --> 00:28:55,110
in between those two images I just

692
00:28:59,660 --> 00:28:57,390
showed you taking a color image of

693
00:29:01,490 --> 00:28:59,670
course requires that you get red green

694
00:29:05,900 --> 00:29:01,500
and blue filters so you have to take

695
00:29:08,870 --> 00:29:05,910
three three exposures whereas to get the

696
00:29:12,050 --> 00:29:08,880
the animation they just took single

697
00:29:14,390 --> 00:29:12,060
filter images at these 24 times during

698
00:29:17,720 --> 00:29:14,400
that orbit so I guess that means there's

699
00:29:19,550 --> 00:29:17,730
about 30 images taken right and so here

700
00:29:23,480 --> 00:29:19,560
you can see the 24 images in the

701
00:29:25,310 --> 00:29:23,490
animated gif with Io Europa I think and

702
00:29:27,680 --> 00:29:25,320
it's kind of nice kind of kind of cool

703
00:29:30,860 --> 00:29:27,690
it's a that's a cute little thing the

704
00:29:32,630 --> 00:29:30,870
public loves planetary stuff so when

705
00:29:35,870 --> 00:29:32,640
every release a planetary press release

706
00:29:37,850 --> 00:29:35,880
they get it they respond really well but

707
00:29:39,370 --> 00:29:37,860
scientifically it's like okay it's a

708
00:29:42,110 --> 00:29:39,380
nice curiosity what's going on here

709
00:29:45,110 --> 00:29:42,120
however since you are talking to me

710
00:29:51,080 --> 00:29:45,120
today you thought of the extra story

711
00:29:53,540 --> 00:29:51,090
okay so in addition to the video that we

712
00:29:55,190 --> 00:29:53,550
showed just showing what Hubble sees we

713
00:29:58,310 --> 00:29:55,200

wanted to give you all the 3d

714
00:30:00,110 --> 00:29:58,320
perspective of it so Greg bacon and I

715
00:30:02,470 --> 00:30:00,120
work together on creating a

716
00:30:05,900 --> 00:30:02,480
visualization to show the 3d perspective

717
00:30:10,160 --> 00:30:05,910
so here is Jupiter isle Europa Ganymede

718
00:30:12,620 --> 00:30:10,170
and Callisto the four Galilean moons as

719
00:30:14,120 --> 00:30:12,630
showing you their orbits you can see the

720
00:30:15,920 --> 00:30:14,130
three of the four of them are almost in

721
00:30:17,780 --> 00:30:15,930
a line to the right exactly we're going

722
00:30:20,570 --> 00:30:17,790
to get there we're going to show you

723
00:30:24,140 --> 00:30:20,580
that in the next frame so what we did

724
00:30:26,840 --> 00:30:24,150
however is because this has a very very

725
00:30:29,870 --> 00:30:26,850
exact alignment we needed to get the

726
00:30:31,790 --> 00:30:29,880
very very exact positions of all of the

727
00:30:33,740 --> 00:30:31,800
actors in this we need to get the the

728
00:30:35,840 --> 00:30:33,750
correct positions for Jupiter IO Europa

729
00:30:37,490 --> 00:30:35,850
close to and Ganymede also the correct

730
00:30:39,590 --> 00:30:37,500
position of Earth and the correct

731
00:30:42,110 --> 00:30:39,600
position of the Sun all relative to

732
00:30:44,180 --> 00:30:42,120
where Jupiter is so one of the cool

733
00:30:46,820 --> 00:30:44,190
things that you can do is you can go to

734
00:30:48,560 --> 00:30:46,830
the Jet Propulsion Laboratory and they

735
00:30:51,860 --> 00:30:48,570
have an ephemeris service they call it

736
00:30:54,260 --> 00:30:51,870
horizons and you can put in what objects

737
00:30:58,130 --> 00:30:54,270
you're looking for what time frame

738
00:31:00,680 --> 00:30:58,140

you're looking for and what and what's

739
00:31:02,630 --> 00:31:00,690
what Center you want to look want to

740
00:31:05,480 --> 00:31:02,640
have for your objects and it will give

741
00:31:08,750 --> 00:31:05,490
you the positions of those objects

742
00:31:11,000 --> 00:31:08,760
for those times so I was able to go to

743
00:31:13,340 --> 00:31:11,010
the JPL ephemeris site and get the exact

744
00:31:16,970 --> 00:31:13,350
positions download them as text files

745
00:31:18,680 --> 00:31:16,980
and import them into our 3d software so

746
00:31:21,169 --> 00:31:18,690
these are this is dumb done in the

747
00:31:23,540 --> 00:31:21,179
software Maya and so these are the

748
00:31:25,880 --> 00:31:23,550
correct positions so we during this

749
00:31:29,090 --> 00:31:25,890
visualization we zoom in now notice

750
00:31:30,950 --> 00:31:29,100
we've got these white dots for the for

751
00:31:32,150 --> 00:31:30,960
representing the moon's and as Tony

752
00:31:33,740 --> 00:31:32,160
pointed out you've got three of the

753
00:31:36,230 --> 00:31:33,750
moon's pretty much on the same line

754
00:31:38,750 --> 00:31:36,240
Ganymede is out of the way but hey we

755
00:31:42,890 --> 00:31:38,760
saw a Ganymede shadow for Halloween oh

756
00:31:45,080 --> 00:31:42,900
you saw that one all right so now as the

757
00:31:48,799 --> 00:31:45,090
camera poles in we fade out those white

758
00:31:50,570 --> 00:31:48,809
dots and can you see the planets you

759
00:31:53,330 --> 00:31:50,580
look really carefully you might be able

760
00:31:56,390 --> 00:31:53,340
to see them right I'll I put some arrows

761
00:31:58,370 --> 00:31:56,400
up oh there we go yes okay so there's

762
00:32:01,790 --> 00:31:58,380
Callisto there's Europa and there's I oh

763
00:32:04,250 --> 00:32:01,800

right and that that's that's where they

764
00:32:06,710 --> 00:32:04,260
are as we're zooming in and then the

765
00:32:08,450 --> 00:32:06,720
camera pulls in to sort of show you what

766
00:32:10,310 --> 00:32:08,460
it looks like and you've got the shadow

767
00:32:12,620 --> 00:32:10,320
of the three shadows moving across and

768
00:32:16,160 --> 00:32:12,630
then we continue to let time pass and

769
00:32:18,020 --> 00:32:16,170
the shadows move across however Tony

770
00:32:20,840 --> 00:32:18,030
here's your challenge for the day

771
00:32:24,950 --> 00:32:20,850
alright oh no I'm being cut where's

772
00:32:28,700 --> 00:32:24,960
Callisto I don't see it's out of the

773
00:32:30,470 --> 00:32:28,710
front of the field of view okay so here

774
00:32:33,020 --> 00:32:30,480
it here here's your challenge for the

775
00:32:36,710 --> 00:32:33,030
today so on the right is the Hubble

776
00:32:39,890 --> 00:32:36,720
observation at 7-10 UT and on the left

777
00:32:41,780 --> 00:32:39,900
is the visualization approximately the

778
00:32:44,570 --> 00:32:41,790
same time and you can see that the

779
00:32:48,640 --> 00:32:44,580
Callisto shadow and Europa shadow line

780
00:32:51,680 --> 00:32:48,650
up yes iowa's in at the same position

781
00:32:53,419 --> 00:32:51,690
Callisto isn't up here and your rope is

782
00:32:56,810 --> 00:32:53,429
still off-screen it hasn't gotten off

783
00:32:59,090 --> 00:32:56,820
screen now I told you that we got the

784
00:33:01,370 --> 00:32:59,100
exact positions from the ephemeris and

785
00:33:02,630 --> 00:33:01,380
matter of fact that positions have to be

786
00:33:06,860 --> 00:33:02,640
right because those shadows are being

787
00:33:10,100 --> 00:33:06,870
cast in the 3d software so what is it

788
00:33:14,120 --> 00:33:10,110

that we couldn't do right and the thing

789
00:33:16,909 --> 00:33:14,130
is we couldn't get a camera to have the

790
00:33:19,100 --> 00:33:16,919
same tiny tiny tiny tiny tiny field of

791
00:33:21,680 --> 00:33:19,110
view as Hubble

792
00:33:24,410 --> 00:33:21,690
ah the visualization software that we

793
00:33:25,610 --> 00:33:24,420
use we try to extend the focal length of

794
00:33:27,110 --> 00:33:25,620
the camera so that the field of view

795
00:33:29,810 --> 00:33:27,120
gets smaller and smaller and smaller and

796
00:33:31,820 --> 00:33:29,820
smaller but it appears it has a limit

797
00:33:35,120 --> 00:33:31,830
and that its smallest field of view is

798
00:33:36,590 --> 00:33:35,130
only a degree across whereas Hubble's

799
00:33:39,410 --> 00:33:36,600
field of view if you remember is about

800
00:33:41,660 --> 00:33:39,420
three arc minutes across and a fact

801
00:33:44,360 --> 00:33:41,670
Jupiter is even smaller than that yeah

802
00:33:46,160 --> 00:33:44,370
so it was kind of funky guy I knew going

803
00:33:47,720 --> 00:33:46,170
into this that all right well it's going

804
00:33:49,760 --> 00:33:47,730
to be difficult to try and exactly

805
00:33:52,240 --> 00:33:49,770
reproduce the Hubble how the Hubble view

806
00:33:54,500 --> 00:33:52,250
is your camera has to be you know almost

807
00:33:57,620 --> 00:33:54,510
orthographic camera almost up a plane

808
00:33:59,450 --> 00:33:57,630
parallel camera but it was funky that we

809
00:34:01,580 --> 00:33:59,460
couldn't that week that this software

810
00:34:02,990 --> 00:34:01,590
only had a limitation yeah well you

811
00:34:04,039 --> 00:34:03,000
could kind of see that in the disk of

812
00:34:07,370 --> 00:34:04,049
Jupiter I mean you can see you've got

813
00:34:09,889 --> 00:34:07,380

all of the disk in the in the frame and

814
00:34:13,580 --> 00:34:09,899
your simulation but the Hubble image has

815
00:34:15,619 --> 00:34:13,590
it cropped out so yeah so the field of

816
00:34:17,869 --> 00:34:15,629
view isn't as big their infield views if

817
00:34:19,520 --> 00:34:17,879
he isn't quite quite big I mean but also

818
00:34:23,359 --> 00:34:19,530
I mean we just couldn't get the camera

819
00:34:25,639 --> 00:34:23,369
the the the the software camera to

820
00:34:26,960 --> 00:34:25,649
reproduce the Hubble camera images and

821
00:34:29,210 --> 00:34:26,970
so what I think I figured out as i was

822
00:34:31,190 --> 00:34:29,220
going to lunch today as I was prepping

823
00:34:34,129 --> 00:34:31,200
this talk I said well you know we could

824
00:34:35,629 --> 00:34:34,139
do we could do a one degree camera but

825
00:34:37,790 --> 00:34:35,639
then put in tons and tons and tons of

826
00:34:39,980 --> 00:34:37,800
pixels in the image and then only do the

827
00:34:42,830 --> 00:34:39,990
very very smallest things but that would

828
00:34:45,440 --> 00:34:42,840
be really uh you didn't do that you gave

829
00:34:48,020 --> 00:34:45,450
you a delete it be lunch is now occult

830
00:34:49,790 --> 00:34:48,030
and be monstrously difficult so Greg

831
00:34:51,980 --> 00:34:49,800
bacon and I actually discussed all right

832
00:34:54,349 --> 00:34:51,990
let's see if we can fake a Hubble camera

833
00:34:57,050 --> 00:34:54,359
I can force the hot software to do what

834
00:34:59,450 --> 00:34:57,060
we think it was so this will be fun to

835
00:35:01,040 --> 00:34:59,460
play with but I just wanted to show you

836
00:35:04,700 --> 00:35:01,050
that some of the things is that because

837
00:35:06,260 --> 00:35:04,710
Hubble has such a tiny feel of you if we

838
00:35:07,609 --> 00:35:06,270

want to try and reproduce these things

839
00:35:09,440 --> 00:35:07,619
we've got to be able to reduce

840
00:35:11,750 --> 00:35:09,450
everything in the visualization software

841
00:35:13,580 --> 00:35:11,760
and sometimes it it's built for

842
00:35:15,410 --> 00:35:13,590
Hollywood make movies and they don't

843
00:35:19,450 --> 00:35:15,420
really have these tiny tiny tiny field

844
00:35:21,590 --> 00:35:19,460
of youth like we do yeah yeah it's uh

845
00:35:22,910 --> 00:35:21,600
that that that's the software they use

846
00:35:24,950 --> 00:35:22,920
for like making special effects and

847
00:35:26,450 --> 00:35:24,960
stuff right and exactly Maya's used on

848
00:35:29,390 --> 00:35:26,460
most every Hollywood film you've ever

849
00:35:31,700 --> 00:35:29,400
seen alright so that was just how the

850
00:35:32,210 --> 00:35:31,710
way of adding a special insight on that

851
00:35:35,210 --> 00:35:32,220
one

852
00:35:37,490 --> 00:35:35,220
cool let me finally get to art Hubble

853
00:35:39,950 --> 00:35:37,500
retrospective because we're doing a lot

854
00:35:43,460 --> 00:35:39,960
of things for 25 years of help where r

855
00:35:45,440 --> 00:35:43,470
Hubble's 25th anniversary and one of the

856
00:35:47,599 --> 00:35:45,450
things that I'm responsible for is sort

857
00:35:50,570 --> 00:35:47,609
of looking over the history of Hubble

858
00:35:53,060 --> 00:35:50,580
and trying to go through what is Hubble

859
00:35:56,330 --> 00:35:53,070
done specifically in certain subject

860
00:35:58,609 --> 00:35:56,340
areas so the first thing I just the

861
00:36:01,280 --> 00:35:58,619
first thing I hit well I pulled together

862
00:36:03,890 --> 00:36:01,290
some slides of what Hubble has observed

863
00:36:06,670 --> 00:36:03,900

in the area of supernovae so supernova

864
00:36:11,570 --> 00:36:06,680
explosions just in case you didn't know

865
00:36:14,330 --> 00:36:11,580
supernova is when a star explodes ok and

866
00:36:16,700 --> 00:36:14,340
there's a couple ways that it can do it

867
00:36:20,089 --> 00:36:16,710
can do so I've one can be a very massive

868
00:36:22,250 --> 00:36:20,099
star reaches the end of its life and it

869
00:36:26,750 --> 00:36:22,260
has a Thurman appear catastrophe on the

870
00:36:29,960 --> 00:36:26,760
inside and explodes another way is that

871
00:36:32,330 --> 00:36:29,970
when a white dwarf star as mass added on

872
00:36:34,640 --> 00:36:32,340
to it it can go go over what we call the

873
00:36:37,820 --> 00:36:34,650
Chandrasekhar limit and it could also

874
00:36:40,609 --> 00:36:37,830
then explode all right so this is a

875
00:36:43,579 --> 00:36:40,619
picture of a star that has exploded on

876
00:36:46,040 --> 00:36:43,589
the left is the before image and on the

877
00:36:50,180 --> 00:36:46,050
right is the after image this is

878
00:36:56,060 --> 00:36:50,190
supernova 1987a which was observed in

879
00:36:59,210 --> 00:36:56,070
January of 1987 and this star is a star

880
00:37:01,010 --> 00:36:59,220
in these large magellanic cloud and you

881
00:37:03,589 --> 00:37:01,020
can see that it brightens up by a

882
00:37:05,329 --> 00:37:03,599
concern out well when it does that

883
00:37:08,570 --> 00:37:05,339
explosion and the large reg Atlanta

884
00:37:10,760 --> 00:37:08,580
cloud is a dwarf galaxy that is right

885
00:37:12,890 --> 00:37:10,770
next right next door to us one of our

886
00:37:14,450 --> 00:37:12,900
neighboring galaxies right next door we

887
00:37:15,940 --> 00:37:14,460
talked about in Andromeda galaxy beam

888
00:37:19,550 --> 00:37:15,950

two and a half million light-years away

889
00:37:21,530 --> 00:37:19,560
so the lmc is about a hundred and

890
00:37:24,290 --> 00:37:21,540
seventy-five thousand light-years away

891
00:37:25,700 --> 00:37:24,300
and if you happen to be lucky enough to

892
00:37:27,500 --> 00:37:25,710
live in the southern hemisphere you get

893
00:37:29,450 --> 00:37:27,510
to see it all the time right now all the

894
00:37:31,400 --> 00:37:29,460
time but with this up in the sky

895
00:37:32,630 --> 00:37:31,410
unfortunately I can say I've never never

896
00:37:34,670 --> 00:37:32,640
been down the southern hemisphere and

897
00:37:37,520 --> 00:37:34,680
being able to see the large or small

898
00:37:43,430 --> 00:37:37,530
small Magellanic Clouds I have laa laa

899
00:37:45,590 --> 00:37:43,440
laa la cera to Lulu I saw it and of

900
00:37:49,010 --> 00:37:45,600
course that means that although

901
00:37:52,100 --> 00:37:49,020
we saw this light in 1987 the star

902
00:37:53,960 --> 00:37:52,110
itself actually exploded about 175,000

903
00:37:56,000 --> 00:37:53,970
years ago and it's the light that has

904
00:37:58,880 --> 00:37:56,010
been traveling 10 75,000 years across

905
00:38:02,170 --> 00:37:58,890
space until we observed it in 1987

906
00:38:04,580 --> 00:38:02,180
there's always that space time

907
00:38:06,890 --> 00:38:04,590
calculation of speed of light land but

908
00:38:08,570 --> 00:38:06,900
at least a couple call an 87 a because

909
00:38:11,450 --> 00:38:08,580
when we observed it is of course the way

910
00:38:13,520 --> 00:38:11,460
we talk about these things ok so when

911
00:38:17,780 --> 00:38:13,530
Hubble this was before Hubble launched

912
00:38:19,520 --> 00:38:17,790
1987 Hubble launched in 1990 Hubble did

913
00:38:21,530 --> 00:38:19,530

look at it while there was the silver

914
00:38:23,510 --> 00:38:21,540
flan amira but i'm going to show the

915
00:38:27,560 --> 00:38:23,520
next one I'm going to jump to is 1994

916
00:38:31,370 --> 00:38:27,570
and this is the image that Hubble got of

917
00:38:33,410 --> 00:38:31,380
supernova 1987a in 1994 after they

918
00:38:36,740 --> 00:38:33,420
repair mission so this is with the fixed

919
00:38:37,940 --> 00:38:36,750
camera and it's important because you

920
00:38:41,290 --> 00:38:37,950
can see that when they've got these

921
00:38:43,790 --> 00:38:41,300
rings here okay these very faint rings

922
00:38:45,170 --> 00:38:43,800
all right let me just talk you through

923
00:38:47,990 --> 00:38:45,180
the image let's start in the very center

924
00:38:51,140 --> 00:38:48,000
that's dot right in there is the

925
00:38:52,850 --> 00:38:51,150
supernova where the star exploded it's

926
00:38:56,240 --> 00:38:52,860
no longer a star there it's now a

927
00:38:59,150 --> 00:38:56,250
supernova remnant a gas cloud and that

928
00:39:02,300 --> 00:38:59,160
gas cloud is expanding at millions of

929
00:39:04,450 --> 00:39:02,310
miles an hour all right then you have

930
00:39:07,550 --> 00:39:04,460
this yellow ring around the center

931
00:39:09,530 --> 00:39:07,560
obviously this yellow ring did not come

932
00:39:12,340 --> 00:39:09,540
from the supernova explosion it was

933
00:39:16,130 --> 00:39:12,350
there in advance this was a blowout

934
00:39:18,410 --> 00:39:16,140
material blown out from the star before

935
00:39:20,810 --> 00:39:18,420
it explodes one of the interesting

936
00:39:23,360 --> 00:39:20,820
things about supernova is to study what

937
00:39:25,940 --> 00:39:23,370
happens in these precursor phases before

938
00:39:28,610 --> 00:39:25,950

the explosion happens we see a lot of

939
00:39:30,290 --> 00:39:28,620
blowouts we see things at the inn in

940
00:39:32,150 --> 00:39:30,300
Ocarina we see things in other places

941
00:39:35,000 --> 00:39:32,160
that there's evidence that there's uh

942
00:39:38,270 --> 00:39:35,010
there's unstable phases before the

943
00:39:41,030 --> 00:39:38,280
actual explosion and so with 87a we see

944
00:39:43,400 --> 00:39:41,040
evidence of definitely a ring that was a

945
00:39:45,110 --> 00:39:43,410
pre-existing that pre-existing before

946
00:39:47,060 --> 00:39:45,120
the supernova must have been blonde in

947
00:39:49,760 --> 00:39:47,070
previous phase now is it true that you

948
00:39:52,760 --> 00:39:49,770
could take the width of that circle or

949
00:39:54,500 --> 00:39:52,770
how far away it is from the star where

950
00:39:57,440 --> 00:39:54,510
it actually exploded and get a sense of

951
00:39:58,859 --> 00:39:57,450
how much earlier it went off prior to

952
00:40:01,660 --> 00:39:58,869
the supernova

953
00:40:04,239 --> 00:40:01,670
only a thon the ring only if you knew

954
00:40:07,420 --> 00:40:04,249
the velocity right which is expanding

955
00:40:09,970 --> 00:40:07,430
okay and so we don't know that I guess

956
00:40:13,150 --> 00:40:09,980
yeah but we will know that in a minute

957
00:40:14,470 --> 00:40:13,160
okay we're gonna know we don't know it

958
00:40:16,660 --> 00:40:14,480
now we're gonna know something's there I

959
00:40:17,920 --> 00:40:16,670
guess I 1984 or we did all right and

960
00:40:21,940 --> 00:40:17,930
then the other cool thing one of these

961
00:40:24,099 --> 00:40:21,950
big red thin rings okay now I notice the

962
00:40:25,720 --> 00:40:24,109
two white dots those are just stars they

963
00:40:27,309 --> 00:40:25,730

happen to be a long line of sight they

964
00:40:29,950 --> 00:40:27,319
have nothing to do with supernova okay

965
00:40:33,999 --> 00:40:29,960
all right but you got these big thin red

966
00:40:36,069 --> 00:40:34,009
rings which are way outside the the

967
00:40:38,680 --> 00:40:36,079
inner yellow ring and the supernova

968
00:40:41,259 --> 00:40:38,690
remnant in the center and these were

969
00:40:42,729 --> 00:40:41,269
kind of puzzling at first because I

970
00:40:44,440 --> 00:40:42,739
don't know I can sort of imagine a TIE

971
00:40:48,729 --> 00:40:44,450
fighter from Star Wars or something here

972
00:40:51,009 --> 00:40:48,739
or look at this gun and so the idea was

973
00:40:53,589 --> 00:40:51,019
that maybe there was a jet from the star

974
00:40:55,599 --> 00:40:53,599
in this pre supernova phase and the jet

975
00:40:57,910 --> 00:40:55,609
goes out in opposite direction and then

976
00:41:01,660 --> 00:40:57,920
rotates around you got a spinning jet

977
00:41:06,339 --> 00:41:01,670
that could illuminate gas and create

978
00:41:08,620 --> 00:41:06,349
these rings way away okay so just really

979
00:41:10,120 --> 00:41:08,630
cool structures that we sort of hadn't

980
00:41:11,589 --> 00:41:10,130
expected to see so I'm you see a

981
00:41:13,089 --> 00:41:11,599
rotating jet are you talking about

982
00:41:14,970 --> 00:41:13,099
something that's kind of doing this kind

983
00:41:18,279 --> 00:41:14,980
of thing where it's making a circle

984
00:41:20,829 --> 00:41:18,289
mm-hmm kind of like that okay yeah I was

985
00:41:23,559 --> 00:41:20,839
doing it on my video as well taking you

986
00:41:25,120 --> 00:41:23,569
know uh you know in a spinning top right

987
00:41:27,460 --> 00:41:25,130
and if it's standing up straight it's is

988
00:41:29,829 --> 00:41:27,470

doing but once it wobbles right in the

989
00:41:32,769 --> 00:41:29,839
spinning top wobbles and that wobbling

990
00:41:36,160 --> 00:41:32,779
motion well certain scribe a circle so

991
00:41:40,390 --> 00:41:36,170
that jet could illuminate material based

992
00:41:41,620 --> 00:41:40,400
upon a five by its waddle okay yeah what

993
00:41:44,829 --> 00:41:41,630
so what wavelengths are we looking at

994
00:41:48,339 --> 00:41:44,839
here oh I don't remember this is 1994

995
00:41:49,839 --> 00:41:48,349
before i came to Apple oh okay no I

996
00:41:55,120 --> 00:41:49,849
didn't look I'm sorry I didn't that's

997
00:41:57,700 --> 00:41:55,130
alright that's cool okay so then we

998
00:41:59,710 --> 00:41:57,710
started looking at that inner ring over

999
00:42:02,859 --> 00:41:59,720
and over and over again and so this is

1000
00:42:08,170 --> 00:42:02,869
an amazing image that shows you the how

1001
00:42:11,830 --> 00:42:08,180
it looks from 1994 through to 2003 now

1002
00:42:15,340 --> 00:42:11,840
as there's a star at about what

1003
00:42:16,810 --> 00:42:15,350
at four o'clock four or five o'clock on

1004
00:42:19,960 --> 00:42:16,820
it that that doesn't have anything to do

1005
00:42:21,820 --> 00:42:19,970
it which is just pre-existing okay okay

1006
00:42:24,850 --> 00:42:21,830
so that's just a bright spot but as you

1007
00:42:27,820 --> 00:42:24,860
go across the top row not much happens

1008
00:42:30,550 --> 00:42:27,830
as you go to the second row you start to

1009
00:42:32,290 --> 00:42:30,560
see another bright spot up here and then

1010
00:42:34,540 --> 00:42:32,300
you know towards the end more bright

1011
00:42:36,250 --> 00:42:34,550
spots appear and then as you come

1012
00:42:39,010 --> 00:42:36,260
through the bottom row you're seeing

1013
00:42:43,120 --> 00:42:39,020

lots and lots of bright spots up here in

1014
00:42:45,540 --> 00:42:43,130
this ring what's happening the shock

1015
00:42:50,590 --> 00:42:45,550
wave from the supernova explosion is

1016
00:42:53,070 --> 00:42:50,600
expanding and reaching that ring you're

1017
00:42:56,670 --> 00:42:53,080
seeing the shock wave from the supernova

1018
00:43:01,270 --> 00:42:56,680
interacting with this projected ring

1019
00:43:03,430 --> 00:43:01,280
really cool that is cool plus you are

1020
00:43:07,270 --> 00:43:03,440
seeing that inner supernova remnant that

1021
00:43:09,570 --> 00:43:07,280
gas cloud also blow out so on this next

1022
00:43:12,520 --> 00:43:09,580
image from 2011 eight years after that

1023
00:43:14,950 --> 00:43:12,530
you can clearly see the ring is lit up

1024
00:43:17,290 --> 00:43:14,960
by the shock wave passing through it as

1025
00:43:19,590 --> 00:43:17,300
well as that supernova explosion

1026
00:43:21,940 --> 00:43:19,600
supernova remnant is blowing out

1027
00:43:24,090 --> 00:43:21,950
although I gotta say when you look at

1028
00:43:29,860 --> 00:43:24,100
that supernova road what do you see ah

1029
00:43:32,050 --> 00:43:29,870
blurry myths I see Homer Simpson oh now

1030
00:43:40,120 --> 00:43:32,060
I do actually see the profile of Homer

1031
00:43:42,130 --> 00:43:40,130
Simpson there's haha I guess so well

1032
00:43:45,100 --> 00:43:42,140
anyways so what's really cool about

1033
00:43:46,960 --> 00:43:45,110
superdome 87a and I'll finish with his

1034
00:43:48,820 --> 00:43:46,970
last image of it with is really small is

1035
00:43:51,550 --> 00:43:48,830
that we've been able to watch the

1036
00:43:54,340 --> 00:43:51,560
development Isis renova on over the

1037
00:43:57,070 --> 00:43:54,350
course of 20 years not many things

1038
00:43:58,510 --> 00:43:57,080

change on human timescales but were able

1039
00:44:00,730 --> 00:43:58,520
to watch the birth of a supernova

1040
00:44:05,080 --> 00:44:00,740
remnant from it's very beginning and

1041
00:44:09,300 --> 00:44:05,090
that's kind of cool now we also looked

1042
00:44:12,940 --> 00:44:09,310
at other supernovae and in john july 4th

1043
00:44:15,280 --> 00:44:12,950
1054 there was a guest star in the night

1044
00:44:18,670 --> 00:44:15,290
sky it was observed by chinese

1045
00:44:21,100 --> 00:44:18,680
astronomers and this here is what they

1046
00:44:24,460 --> 00:44:21,110
call it petrol graph it's in Chaco

1047
00:44:25,250 --> 00:44:24,470
Canyon National Park and they believe it

1048
00:44:28,340 --> 00:44:25,260
may be a ver

1049
00:44:31,070 --> 00:44:28,350
hoarding of that new star appearing in

1050
00:44:35,420 --> 00:44:31,080
the sky you know what we call that star

1051
00:44:36,320 --> 00:44:35,430
today we call it the Crab Nebula okay

1052
00:44:40,450 --> 00:44:36,330
don't know if you want me to give it

1053
00:44:44,150 --> 00:44:40,460
away or not you can give it away please

1054
00:44:46,250 --> 00:44:44,160
the Anasazi may have seen the Crab

1055
00:44:49,340 --> 00:44:46,260
Nebula explosion a thousand years ago

1056
00:44:53,510 --> 00:44:49,350
what Hubble sees today is this image

1057
00:44:56,500 --> 00:44:53,520
this is the Crab Nebula basically the

1058
00:44:59,680 --> 00:44:56,510
guts of a star just blown out into space

1059
00:45:03,800 --> 00:44:59,690
and what we're looking at here are the

1060
00:45:05,780 --> 00:45:03,810
emissions from oxygen and sulfur there's

1061
00:45:08,240 --> 00:45:05,790
neutral neutral oxygen and doubly

1062
00:45:10,850 --> 00:45:08,250
ionized oxygen we're seeing looking at

1063
00:45:13,280 --> 00:45:10,860

the very particular the elements that

1064
00:45:15,170 --> 00:45:13,290
the the very particular wavelengths that

1065
00:45:17,870 --> 00:45:15,180
that emitted by those elements but you

1066
00:45:20,120 --> 00:45:17,880
can see the amazing no detail this is a

1067
00:45:22,460 --> 00:45:20,130
30 million pixel image if you go to

1068
00:45:24,500 --> 00:45:22,470
Hubble site and download you can see the

1069
00:45:27,380 --> 00:45:24,510
structure of the material just throw it

1070
00:45:31,370 --> 00:45:27,390
out this is a thousand years after the

1071
00:45:34,040 --> 00:45:31,380
stars exploded so it's super over 87a we

1072
00:45:36,100 --> 00:45:34,050
get to watch a star that's just in the

1073
00:45:39,350 --> 00:45:36,110
first few decades of its explosion and

1074
00:45:41,150 --> 00:45:39,360
it is here into the Crab Nebula were

1075
00:45:43,850 --> 00:45:41,160
able to see a star that's that exploded

1076
00:45:46,610 --> 00:45:43,860
a thousand years ago we looked at a

1077
00:45:50,420 --> 00:45:46,620
couple other supernova remnants this one

1078
00:45:52,400 --> 00:45:50,430
is Cassiopeia A and I thought this was

1079
00:45:54,440 --> 00:45:52,410
an old supernova remnant in fact I gave

1080
00:45:56,030 --> 00:45:54,450
a talk a couple weeks ago and i said i

1081
00:45:58,360 --> 00:45:56,040
think it's about ten thousand thirty

1082
00:46:01,700 --> 00:45:58,370
thousand years old and i'm totally wrong

1083
00:46:04,730 --> 00:46:01,710
okay why are you wrong I was totally

1084
00:46:06,740 --> 00:46:04,740
wrong do you mark the date yeah this one

1085
00:46:09,260 --> 00:46:06,750
is the youngest supernova remnant we

1086
00:46:10,970 --> 00:46:09,270
know of you can see how broad and

1087
00:46:14,300 --> 00:46:10,980
dispersed it is and I that's what maybe

1088
00:46:16,310 --> 00:46:14,310

think it was really old um it looks like

1089
00:46:18,020 --> 00:46:16,320
it's you know at that they got that

1090
00:46:20,210 --> 00:46:18,030
crowd supernova remnant is a thousand

1091
00:46:21,740 --> 00:46:20,220
years old and then this is diffused away

1092
00:46:23,990 --> 00:46:21,750
and it looks like it's tens of thousands

1093
00:46:26,240 --> 00:46:24,000
of years old I they tell me that this is

1094
00:46:28,910 --> 00:46:26,250
only three hundred and forty years old

1095
00:46:31,220 --> 00:46:28,920
wow it's also very strong in the radio I

1096
00:46:32,810 --> 00:46:31,230
only know that because I was learning

1097
00:46:33,920 --> 00:46:32,820
how to use radio telescope once and that

1098
00:46:36,980 --> 00:46:33,930
was a point source we could easily

1099
00:46:38,480 --> 00:46:36,990
identify so that is why is called

1100
00:46:40,460 --> 00:46:38,490
Cassiopeia A

1101
00:46:42,109 --> 00:46:40,470
because that a means that it's the

1102
00:46:45,890 --> 00:46:42,119
brightest source in the Sun

1103
00:46:48,620 --> 00:46:45,900
constellation Cassiopeia and so this is

1104
00:46:50,450 --> 00:46:48,630
this is the cool image of that and you

1105
00:46:53,330 --> 00:46:50,460
can see it also has that fractured

1106
00:46:56,690 --> 00:46:53,340
appearance that we see in the Crab

1107
00:46:59,810 --> 00:46:56,700
Nebula well we also have looked at this

1108
00:47:01,820 --> 00:46:59,820
image that this supernova remnant this

1109
00:47:03,440 --> 00:47:01,830
is another supernova in the Large

1110
00:47:10,820 --> 00:47:03,450
Magellanic Cloud and it's supernova

1111
00:47:14,150 --> 00:47:10,830
remnant 0509 dash 67.5 oh yeah we call

1112
00:47:18,200 --> 00:47:14,160
0509 for short right it doesn't have a

1113
00:47:20,720 --> 00:47:18,210

fun named funding to it this one is also

1114
00:47:23,510 --> 00:47:20,730
about 400 years old but you can see it's

1115
00:47:28,300 --> 00:47:23,520
roughly circular and the reason for that

1116
00:47:31,520 --> 00:47:28,310
may be that it is a supernova type 1a a

1117
00:47:34,580 --> 00:47:31,530
explosion of a white dwarf whereas the

1118
00:47:36,770 --> 00:47:34,590
crab supernova is a explosion of a

1119
00:47:38,780 --> 00:47:36,780
massive star I told you there are two

1120
00:47:41,660 --> 00:47:38,790
different types of supernovae when a

1121
00:47:44,510 --> 00:47:41,670
massive stars explode versus the white

1122
00:47:46,490 --> 00:47:44,520
dwarfs explode this remarkable symmetry

1123
00:47:48,320 --> 00:47:46,500
that we see here may be due to the fact

1124
00:47:51,050 --> 00:47:48,330
that it's a white dwarf explosion

1125
00:47:52,580 --> 00:47:51,060
instead of massive star explosion all

1126
00:47:55,609 --> 00:47:52,590
right I got one more supernova to go to

1127
00:47:57,470 --> 00:47:55,619
and here is where we see that Hubble

1128
00:48:00,380 --> 00:47:57,480
doesn't always have the prettiest image

1129
00:48:04,099 --> 00:48:00,390
okay so this is what we call Kepler

1130
00:48:07,010 --> 00:48:04,109
supernova supernova of 1604 observed by

1131
00:48:10,010 --> 00:48:07,020
Johannes Kepler and you can see just a

1132
00:48:13,490 --> 00:48:10,020
little bit of stuff in the Hubble image

1133
00:48:16,280 --> 00:48:13,500
on the left the Hubble image just shows

1134
00:48:18,020 --> 00:48:16,290
a little bit of stuff this is again 1604

1135
00:48:19,880 --> 00:48:18,030
so this is another four hundred year old

1136
00:48:22,430 --> 00:48:19,890
I don't know why we have three of these

1137
00:48:24,920 --> 00:48:22,440
that are you know on a year old

1138
00:48:26,540 --> 00:48:24,930

supernova remnants why do we don't have

1139
00:48:28,460 --> 00:48:26,550
that some hundred year old ones five

1140
00:48:30,260 --> 00:48:28,470
minutes it's really frustrating that

1141
00:48:32,090 --> 00:48:30,270
since the invention of the telescope you

1142
00:48:35,030 --> 00:48:32,100
haven't seen a really good supernova in

1143
00:48:38,000 --> 00:48:35,040
our own galaxy a7 a is the closest since

1144
00:48:39,859 --> 00:48:38,010
they know telescope all right but you

1145
00:48:42,230 --> 00:48:39,869
can see there's Hubble on the left which

1146
00:48:44,359 --> 00:48:42,240
doesn't see that much Spitzer in the

1147
00:48:46,940 --> 00:48:44,369
center observes an infrared and you can

1148
00:48:50,510 --> 00:48:46,950
seize them the warm gas in the infrared

1149
00:48:52,190 --> 00:48:50,520
but as you said the x-rays are often the

1150
00:48:54,230 --> 00:48:52,200
most exciting for these

1151
00:48:56,270 --> 00:48:54,240
supernova remnants so here on the right

1152
00:48:58,880 --> 00:48:56,280
you see the Chandra x-ray Observatory

1153
00:49:01,819 --> 00:48:58,890
observing an x rays you can see all that

1154
00:49:04,730 --> 00:49:01,829
hot gas hundred thousand million degree

1155
00:49:07,130 --> 00:49:04,740
gasps that's filling that entire bubble

1156
00:49:10,370 --> 00:49:07,140
of the supernova explosion here in

1157
00:49:14,000 --> 00:49:10,380
Kepler's supernova remnant so combining

1158
00:49:16,460 --> 00:49:14,010
Hubble with infrared with x-rays and all

1159
00:49:20,030 --> 00:49:16,470
this history you can see we get to look

1160
00:49:22,040 --> 00:49:20,040
at young supernova some decades old some

1161
00:49:23,990 --> 00:49:22,050
hundreds of years old some thousands of

1162
00:49:26,240 --> 00:49:24,000
years old and there are others that are

1163
00:49:27,680 --> 00:49:26,250

tens of thousands of years old Hubble

1164
00:49:30,710 --> 00:49:27,690
has been able to contribute to our

1165
00:49:33,020 --> 00:49:30,720
knowledge of supernovae both in its own

1166
00:49:36,079 --> 00:49:33,030
observations and in comparison to our

1167
00:49:38,000 --> 00:49:36,089
other great observatories also that you

1168
00:49:40,730 --> 00:49:38,010
bring up an interesting point what is

1169
00:49:43,010 --> 00:49:40,740
the supernova rate do we have an idea

1170
00:49:46,760 --> 00:49:43,020
how often supernova explode in our

1171
00:49:48,710 --> 00:49:46,770
galaxy we do we pretend we do okay what

1172
00:49:51,470 --> 00:49:48,720
do we what do we feel we go and we like

1173
00:49:52,400 --> 00:49:51,480
to think that in a large galaxies like

1174
00:49:54,650 --> 00:49:52,410
the Milky Way there should be

1175
00:49:57,710 --> 00:49:54,660
approximately one supernova every

1176
00:50:02,780 --> 00:49:57,720
hundred years okay okay so we're kind of

1177
00:50:05,000 --> 00:50:02,790
so working on K 1 because of 1987a was

1178
00:50:08,150 --> 00:50:05,010
was in our galaxy in our galaxy it's in

1179
00:50:11,359 --> 00:50:08,160
the lmc oh sorry your kid and we can

1180
00:50:13,640 --> 00:50:11,369
write your hundred years we are 30 and I

1181
00:50:18,530 --> 00:50:13,650
guess we said that the the Cassiopeia A

1182
00:50:20,900 --> 00:50:18,540
wasn't visible and you know why we

1183
00:50:23,150 --> 00:50:20,910
didn't seek a supe 340 years ago I don't

1184
00:50:24,410 --> 00:50:23,160
know but we haven't had a good one in

1185
00:50:26,240 --> 00:50:24,420
the last hundred years when we got these

1186
00:50:28,730 --> 00:50:26,250
really great telescopes to look at it

1187
00:50:31,010 --> 00:50:28,740
although 87a is the best we've got so

1188
00:50:32,599 --> 00:50:31,020

far cool okay well so we are dude that's

1189
00:50:33,950 --> 00:50:32,609
good to know all right let me get to

1190
00:50:38,450 --> 00:50:33,960
some we got some comments and questions

1191
00:50:41,059 --> 00:50:38,460
lined up here I wanna go so Daniel

1192
00:50:43,700 --> 00:50:41,069
Masato is is commenting super Noda

1193
00:50:47,210 --> 00:50:43,710
supernova 1987a does look like a TIE

1194
00:50:49,730 --> 00:50:47,220
fighter or the eye of sauron so I have

1195
00:50:52,550 --> 00:50:49,740
to disagree the eye of sauron is from a

1196
00:50:54,790 --> 00:50:52,560
lot okay os from yeah we do have when

1197
00:50:57,410 --> 00:50:54,800
actually we actually called it um and

1198
00:50:59,300 --> 00:50:57,420
causal Joe is commenting in the Q&A app

1199
00:51:01,309 --> 00:50:59,310
I really enjoyed looking through the

1200
00:51:03,230 --> 00:51:01,319
Andromeda image using the zoom tool I

1201
00:51:05,960 --> 00:51:03,240
can see the star density change with

1202
00:51:08,010 --> 00:51:05,970
distance from the center it's amazing

1203
00:51:09,809 --> 00:51:08,020
that's really what we'd love for you to

1204
00:51:12,930 --> 00:51:09,819
be able to do that self-directed

1205
00:51:14,789 --> 00:51:12,940
expiration using the zoom tool is a way

1206
00:51:17,640 --> 00:51:14,799
you really really learn and really

1207
00:51:19,620 --> 00:51:17,650
understand right and so thank you thank

1208
00:51:22,650 --> 00:51:19,630
you call till Joe that's a great handle

1209
00:51:25,620 --> 00:51:22,660
two so let's go Adam synergy has a

1210
00:51:28,020 --> 00:51:25,630
question has a supermassive black hole

1211
00:51:32,339 --> 00:51:28,030
been identified at the center of

1212
00:51:34,049 --> 00:51:32,349
Andromeda yes it has and one of the

1213
00:51:35,250 --> 00:51:34,059

contributions Hubble made was actually

1214
00:51:38,099 --> 00:51:35,260
identifying where the center of

1215
00:51:40,980 --> 00:51:38,109
Andromeda is and looking in detail at

1216
00:51:43,319 --> 00:51:40,990
the motions of stars around the center

1217
00:51:45,390 --> 00:51:43,329
of Andromeda and measuring the mass of

1218
00:51:48,990 --> 00:51:45,400
the supermassive black hole which I

1219
00:51:51,839 --> 00:51:49,000
believe was on the order of 4 4 to 6

1220
00:51:53,430 --> 00:51:51,849
million solar masses we've got about a 2

1221
00:51:56,069 --> 00:51:53,440
million solar mass black hole center of

1222
00:51:57,480 --> 00:51:56,079
our galaxy the one in Andromeda is like

1223
00:51:59,819 --> 00:51:57,490
4 to 6 million if I remember correctly

1224
00:52:01,950 --> 00:51:59,829
and it's a physically larger galaxy than

1225
00:52:04,140 --> 00:52:01,960
ours too yeah it's about twenty thirty

1226
00:52:05,760 --> 00:52:04,150
percent larger than ours right so good

1227
00:52:08,609 --> 00:52:05,770
question Adam and welcome back it's good

1228
00:52:10,829 --> 00:52:08,619
to have you back Andrew planet I keep

1229
00:52:12,420 --> 00:52:10,839
wanting to eat 10 I know I feel like I

1230
00:52:16,200 --> 00:52:12,430
know you know I want to call you Andy I

1231
00:52:18,420 --> 00:52:16,210
hope you they're mad so he's asking if

1232
00:52:20,460 --> 00:52:18,430
galactic nuclei aren't spherically

1233
00:52:22,950 --> 00:52:20,470
shaped doesn't that mean that the forces

1234
00:52:25,549 --> 00:52:22,960
creating them are indicative of their

1235
00:52:28,079 --> 00:52:25,559
form therefore gravitationally uneven

1236
00:52:31,740 --> 00:52:28,089
has that possibility anything to do with

1237
00:52:33,569 --> 00:52:31,750
dark matter so galactic nuclei aren't

1238
00:52:35,250 --> 00:52:33,579

spherically shaped doesn't that mean

1239
00:52:37,589 --> 00:52:35,260
that the forces creating them are

1240
00:52:39,720 --> 00:52:37,599
indicative of there being some kind of

1241
00:52:42,030 --> 00:52:39,730
inhomogeneities in the gravitational

1242
00:52:44,579 --> 00:52:42,040
field okay so it sort of depends on what

1243
00:52:46,770 --> 00:52:44,589
you mean by eclectic nucleus if you're

1244
00:52:49,020 --> 00:52:46,780
looking at an average galaxy then

1245
00:52:52,140 --> 00:52:49,030
nucleus what you see is really this

1246
00:52:54,750 --> 00:52:52,150
bulge of stars okay so if you're looking

1247
00:52:57,180 --> 00:52:54,760
at that a large scale of a galaxy the

1248
00:52:59,190 --> 00:52:57,190
the central region is as a bulge of

1249
00:53:02,400 --> 00:52:59,200
stars in the plant in it right around

1250
00:53:04,730 --> 00:53:02,410
the center and that shape of that is

1251
00:53:08,690 --> 00:53:04,740
indicative of the orbits of those stars

1252
00:53:10,829 --> 00:53:08,700
those stars aren't always randomized a

1253
00:53:13,260 --> 00:53:10,839
lot of times they are randomizing it's

1254
00:53:15,120 --> 00:53:13,270
roughly spherical but it can also have

1255
00:53:16,829 --> 00:53:15,130
an elongated shape what we call it more

1256
00:53:19,140 --> 00:53:16,839
of a bar shape simply due to

1257
00:53:19,770 --> 00:53:19,150
gravitational resonances that pull those

1258
00:53:22,520 --> 00:53:19,780
stars into

1259
00:53:26,280 --> 00:53:22,530
orbitz that create an elongated shape

1260
00:53:28,380 --> 00:53:26,290
and it can also have oftentimes it also

1261
00:53:30,450 --> 00:53:28,390
has a sort of flattened spheroid an

1262
00:53:32,940 --> 00:53:30,460
oblate spheroid where it's wider it at

1263
00:53:36,180 --> 00:53:32,950

the at the center axis than it is

1264
00:53:38,040 --> 00:53:36,190
straight up and down and that of course

1265
00:53:40,380 --> 00:53:38,050
again would be due to the gravitational

1266
00:53:43,110 --> 00:53:40,390
forces of the disc and other material

1267
00:53:44,490 --> 00:53:43,120
pressing on it so the stars in the

1268
00:53:47,550 --> 00:53:44,500
central region their shapes are

1269
00:53:51,870 --> 00:53:47,560
definitely governed by the gravitational

1270
00:53:53,490 --> 00:53:51,880
forces the galactic nucleus itself is

1271
00:53:55,020 --> 00:53:53,500
generally the supermassive black hole

1272
00:53:57,060 --> 00:53:55,030
and then there's tons of tons of things

1273
00:53:59,280 --> 00:53:57,070
going on there but we don't actually

1274
00:54:01,170 --> 00:53:59,290
have I don't really think I would say I

1275
00:54:02,940 --> 00:54:01,180
know what the shape of a supermassive

1276
00:54:04,290 --> 00:54:02,950
black hole and the stuff around it looks

1277
00:54:07,610 --> 00:54:04,300
like there's no typical shape for that

1278
00:54:10,770 --> 00:54:07,620
right and what dark matter is related to

1279
00:54:14,340 --> 00:54:10,780
galatic alex e rotations though one of

1280
00:54:16,410 --> 00:54:14,350
the one of the ways we think it existed

1281
00:54:19,110 --> 00:54:16,420
one of the strongest indicators that it

1282
00:54:21,180 --> 00:54:19,120
might be there was the rate the way in

1283
00:54:24,510 --> 00:54:21,190
which galaxies rotated didn't match what

1284
00:54:26,340 --> 00:54:24,520
we saw with the visible matter so we

1285
00:54:29,090 --> 00:54:26,350
inferred there must be something else

1286
00:54:31,740 --> 00:54:29,100
out there causing these rotational

1287
00:54:33,090 --> 00:54:31,750
behaviors of galaxies so dark matter of

1288
00:54:36,060 --> 00:54:33,100

course would play a role in that as well

1289
00:54:38,880 --> 00:54:36,070
so good question and finally I have

1290
00:54:41,010 --> 00:54:38,890
something else from causal joe is it

1291
00:54:45,240 --> 00:54:41,020
possible to measure the axis of rotation

1292
00:54:46,710 --> 00:54:45,250
of stars in the Andromeda galaxy are we

1293
00:54:50,520 --> 00:54:46,720
that good at it can we can we measure

1294
00:54:52,650 --> 00:54:50,530
the stars themselves rotating well the

1295
00:54:55,890 --> 00:54:52,660
rotation of a star in an individual star

1296
00:54:57,330 --> 00:54:55,900
no I don't believe so the rotation of

1297
00:54:59,790 --> 00:54:57,340
all the stars around the center of

1298
00:55:02,070 --> 00:54:59,800
Andromeda yes of course we can do that

1299
00:55:03,960 --> 00:55:02,080
but right again it's that's kind of easy

1300
00:55:05,220 --> 00:55:03,970
you've got a disk and if things are

1301
00:55:06,810 --> 00:55:05,230
going to stay in a disk well then

1302
00:55:08,760 --> 00:55:06,820
there's a there's a center to the disk

1303
00:55:10,800 --> 00:55:08,770
and even rotation axis is going to be

1304
00:55:12,780 --> 00:55:10,810
perpendicular to that disk but the

1305
00:55:15,240 --> 00:55:12,790
ending the rotation of an individual

1306
00:55:18,270 --> 00:55:15,250
star is difficult even within our own

1307
00:55:19,950 --> 00:55:18,280
Milky Way galaxy trying to gather in

1308
00:55:21,630 --> 00:55:19,960
fact if we if we didn't we weren't able

1309
00:55:22,800 --> 00:55:21,640
to see features on our own Sun we'd have

1310
00:55:25,590 --> 00:55:22,810
a heck of a time trying to its

1311
00:55:27,570 --> 00:55:25,600
reflective exactly have to figure out is

1312
00:55:30,720 --> 00:55:27,580
there some sort there needs to be some

1313
00:55:32,880 --> 00:55:30,730

sort of in homogeneity okay some bright

1314
00:55:33,509 --> 00:55:32,890
spot emerged from something and so there

1315
00:55:35,519 --> 00:55:33,519
are some still

1316
00:55:38,370 --> 00:55:35,529
ours that have these very large star

1317
00:55:40,739 --> 00:55:38,380
spots correlation us on spots which we

1318
00:55:42,599 --> 00:55:40,749
can actually resolve the spots but we

1319
00:55:44,519 --> 00:55:42,609
can say oh it gets brighter and paint

1320
00:55:48,089 --> 00:55:44,529
and dimmer brighter and dimmer due to

1321
00:55:50,639 --> 00:55:48,099
the rotation and from that we can infer

1322
00:55:53,639 --> 00:55:50,649
the rotation axis in the rotation rate

1323
00:55:55,649 --> 00:55:53,649
of the of those stars awesome okay yep

1324
00:55:57,509 --> 00:55:55,659
Thank You causal Joe good question as it

1325
00:55:59,279 --> 00:55:57,519
has a wonderful question so we only have

1326
00:56:00,509 --> 00:55:59,289
a few minutes left and it looks like

1327
00:56:03,059 --> 00:56:00,519
Frank you want to talk about upcoming

1328
00:56:05,519 --> 00:56:03,069
events I have a couple events i'd like

1329
00:56:08,459 --> 00:56:05,529
to mention we always like to mention our

1330
00:56:09,870 --> 00:56:08,469
next public lecture and this one is

1331
00:56:11,959 --> 00:56:09,880
going to be a special event it's a joint

1332
00:56:15,539 --> 00:56:11,969
lecture with a baltimore museum of art

1333
00:56:19,259 --> 00:56:15,549
da da robledo is a nationally renowned

1334
00:56:21,839 --> 00:56:19,269
artist and he has a exhibited get in the

1335
00:56:24,929 --> 00:56:21,849
gallery in the contemporary wig at the

1336
00:56:26,729 --> 00:56:24,939
VMA he is going to come over and talk

1337
00:56:29,399 --> 00:56:26,739
about his exhibits home which was

1338
00:56:31,769 --> 00:56:29,409

inspired by hubble some of which was

1339
00:56:36,749 --> 00:56:31,779
also inspired by the Golden Record on

1340
00:56:38,449 --> 00:56:36,759
Voyager he has a very insightful way of

1341
00:56:40,649 --> 00:56:38,459
thinking about his art and

1342
00:56:43,169 --> 00:56:40,659
representative and multiple layers

1343
00:56:44,939 --> 00:56:43,179
within his art so I just called his talk

1344
00:56:47,639 --> 00:56:44,949
inside since the interplay of science

1345
00:56:49,620 --> 00:56:47,649
and art but more it's going to be a

1346
00:56:53,429 --> 00:56:49,630
conversation between Dario robledo and

1347
00:56:55,679 --> 00:56:53,439
myself to discuss the way he represents

1348
00:56:57,449 --> 00:56:55,689
Hubble in art and then I will play I

1349
00:56:58,859 --> 00:56:57,459
provide the counterpoint to say well

1350
00:57:00,359 --> 00:56:58,869
here's how we think about those things

1351
00:57:02,879 --> 00:57:00,369
in science and we'll have a great

1352
00:57:05,189 --> 00:57:02,889
conversation with a baltimore museum or

1353
00:57:07,349 --> 00:57:05,199
and that will also be on youtube folks

1354
00:57:08,579 --> 00:57:07,359
and i'll create the G+ event for leading

1355
00:57:10,949 --> 00:57:08,589
up to it so you'll be able to watch it

1356
00:57:13,139 --> 00:57:10,959
that way also as always special thanks

1357
00:57:15,809 --> 00:57:13,149
to Tony for putting those on YouTube

1358
00:57:18,779 --> 00:57:15,819
second thing I want to let anybody who's

1359
00:57:21,299 --> 00:57:18,789
a teacher out there or tell your tell

1360
00:57:23,009 --> 00:57:21,309
your kids teachers are on april twenty

1361
00:57:24,870 --> 00:57:23,019
fourth which is the 25th anniversary of

1362
00:57:27,779 --> 00:57:24,880
Hubble we're going we're doing what we

1363
00:57:30,539 --> 00:57:27,789

call a national teachin so we want to

1364
00:57:32,819 --> 00:57:30,549
present Hubble and it's 25 years and all

1365
00:57:35,089 --> 00:57:32,829
the cool things that it's done directly

1366
00:57:38,189 --> 00:57:35,099
to classrooms through a Hubble hangout

1367
00:57:40,109 --> 00:57:38,199
and so we have this we're planning and

1368
00:57:43,169 --> 00:57:40,119
organizing this Hubble 25 national

1369
00:57:46,559 --> 00:57:43,179
teachin at 1pm Eastern so that's 10 a.m.

1370
00:57:47,400 --> 00:57:46,569
pacific and if you would like email

1371
00:57:50,490 --> 00:57:47,410
information

1372
00:57:52,859 --> 00:57:50,500
email amazing heightened space STScI

1373
00:57:56,069 --> 00:57:52,869
well I guess that should be at sts yet a

1374
00:57:57,480 --> 00:57:56,079
tu isn't that uh there yet because

1375
00:57:59,970 --> 00:57:57,490
that's not an email address that's not

1376
00:58:02,539 --> 00:57:59,980
an email email address I'm sorry about

1377
00:58:08,819 --> 00:58:02,549
that I throw amazing hyphen space at

1378
00:58:10,470 --> 00:58:08,829
stsci edu all right ok cool oh there's a

1379
00:58:12,779 --> 00:58:10,480
really good really good question here I

1380
00:58:14,520 --> 00:58:12,789
went about we're almost out of time but

1381
00:58:16,020 --> 00:58:14,530
I want to hear your answer to this

1382
00:58:19,859 --> 00:58:16,030
question because I've noticed this too

1383
00:58:21,750 --> 00:58:19,869
Marco Pudge from the QA app sorry if I

1384
00:58:25,200 --> 00:58:21,760
messed your name up how many stars are

1385
00:58:27,059 --> 00:58:25,210
in the Milky Way galaxy and sun and some

1386
00:58:29,190 --> 00:58:27,069
documentaries they say hundred billion

1387
00:58:31,470 --> 00:58:29,200
and some two hundred and in some other

1388
00:58:34,140 --> 00:58:31,480

ones 400 billion and I've encountered

1389
00:58:36,170 --> 00:58:34,150
this too so which one which one is it

1390
00:58:41,539 --> 00:58:36,180
Frank how many stars are the Milky Way

1391
00:58:47,180 --> 00:58:41,549
ok um oh look at that slide back oh um

1392
00:58:50,010 --> 00:58:47,190
yeah we don't know for sure ok the

1393
00:58:53,039 --> 00:58:50,020
numbers of stars in mcquay has to be an

1394
00:58:55,740 --> 00:58:53,049
estimate because you are looking at

1395
00:58:59,069 --> 00:58:55,750
representative regions this guy counting

1396
00:59:01,799 --> 00:58:59,079
and then multiplying to see how many as

1397
00:59:03,240 --> 00:59:01,809
you saw with Andromeda if you just count

1398
00:59:05,430 --> 00:59:03,250
the stars in the disk you're going to

1399
00:59:07,019 --> 00:59:05,440
get one answer you count the disk and

1400
00:59:09,359 --> 00:59:07,029
then the stars and the halo you're going

1401
00:59:12,150 --> 00:59:09,369
to get another answer how far out does

1402
00:59:14,190 --> 00:59:12,160
that halo actually extend well you don't

1403
00:59:15,930 --> 00:59:14,200
know you need a good density function

1404
00:59:18,900 --> 00:59:15,940
for that and we can only have such good

1405
00:59:20,849 --> 00:59:18,910
so it's hundreds of billions of stars as

1406
00:59:22,920 --> 00:59:20,859
you point out could it be a hundred

1407
00:59:27,960 --> 00:59:22,930
billion yeah could it be 200 billion

1408
00:59:29,789 --> 00:59:27,970
yeah it could be 400 billion yeah we are

1409
00:59:33,269 --> 00:59:29,799
this is one place where we don't know

1410
00:59:35,279 --> 00:59:33,279
within a factor of two so take the 200

1411
00:59:38,010 --> 00:59:35,289
billion number as as a reasonable

1412
00:59:40,349 --> 00:59:38,020
estimate and if you want to drop it down

1413
00:59:41,849 --> 00:59:40,359

to we could be off by it we would have

1414
00:59:44,400 --> 00:59:41,859
twice as many or we could only have half

1415
00:59:46,589 --> 00:59:44,410
as many it's really not an easy number

1416
00:59:49,559 --> 00:59:46,599
to get exact right when I was taking my

1417
00:59:52,140 --> 00:59:49,569
cosmology course at in the mid-90s my a

1418
00:59:53,400 --> 00:59:52,150
thing my professor said in cosmology if

1419
00:59:55,710 --> 00:59:53,410
we know anything do within twenty

1420
00:59:57,210 --> 00:59:55,720
percent were happy now of course this

1421
00:59:58,410 --> 00:59:57,220
was the 90s and we're a lot better now

1422
01:00:01,319 --> 00:59:58,420
we live in an age where we could do

1423
01:00:04,079 --> 01:00:01,329
precision cosmology but so factors of

1424
01:00:07,289 --> 01:00:04,089
for that's pretty darn good I would say

1425
01:00:09,539 --> 01:00:07,299
so anyway you remember the 1990s when we

1426
01:00:11,459 --> 01:00:09,549
did cosmology we didn't know the Hubble

1427
01:00:12,449 --> 01:00:11,469
constant and what could have been 50

1428
01:00:15,209 --> 01:00:12,459
kilometers per second per megaparsec

1429
01:00:17,039 --> 01:00:15,219
right like a mega parsec that's one of

1430
01:00:19,859 --> 01:00:17,049
the things that you know in when Hubble

1431
01:00:23,640 --> 01:00:19,869
got it down to 70 plus or minus five it

1432
01:00:25,650 --> 01:00:23,650
was a very cool you know so yeah okay

1433
01:00:27,329 --> 01:00:25,660
well thank you for that great ? oh well

1434
01:00:29,819 --> 01:00:27,339
I've wondered the same thing myself and

1435
01:00:31,650 --> 01:00:29,829
Andrew or Andy thank you for the kind

1436
01:00:34,620 --> 01:00:31,660
comments or leaving it I do feel like we

1437
01:00:35,940 --> 01:00:34,630
actually know each other and i look

1438
01:00:37,680 --> 01:00:35,950

forward to thank you for all your

1439
01:00:39,180 --> 01:00:37,690
attending your and attending all of our

1440
01:00:41,640 --> 01:00:39,190
hangouts I really means a lot to me and

1441
01:00:42,930 --> 01:00:41,650
so thank you very much well I guess

1442
01:00:45,479 --> 01:00:42,940
we're going to stop there that's it for

1443
01:00:46,799 --> 01:00:45,489
this that's it for today tomorrow pretty

1444
01:00:49,199 --> 01:00:46,809
I hope you'll join us for our hangout

1445
01:00:52,559 --> 01:00:49,209
where we're going to go over 25 years of

1446
01:00:55,410 --> 01:00:52,569
Hubble images represented in 25

1447
01:00:58,079 --> 01:00:55,420
different images that we've selected to

1448
01:00:59,789 --> 01:00:58,089
sort of celebrate the the anniversary of

1449
01:01:02,279 --> 01:00:59,799
Hubble carol scott and i'll be talking

1450
01:01:05,009 --> 01:01:02,289
about those tomorrow so i hope you'll

1451
01:01:08,689 --> 01:01:05,019
join us there same bat-time same hubble

1452
01:01:12,479 --> 01:01:08,699
time three o'clock eastern standard time

1453
01:01:14,400 --> 01:01:12,489
tomorrow so hope to see you there Frank

1454
01:01:15,959 --> 01:01:14,410
thanks once again another great another

1455
01:01:17,729 --> 01:01:15,969
great episode I appreciate you joining

1456
01:01:20,729 --> 01:01:17,739
us this this month and we'll see you

1457
01:01:22,979 --> 01:01:20,739
back on in early March right definitely

1458
01:01:26,549 --> 01:01:22,989
we can have to do it uh what is it gonna

1459
01:01:28,709 --> 01:01:26,559
be in March 9th again all right ok Mario

1460
01:01:31,910 --> 01:01:28,719
know it mean it would be much 11th March

1461
01:01:34,049 --> 01:01:31,920
11 is 28 days this year so we march 11th

1462
01:01:36,120 --> 01:01:34,059
just before we go up to the South by

1463
01:01:37,859 --> 01:01:36,130

Southwest sounds good look forward to

1464
01:01:39,719 --> 01:01:37,869
talking oh all right thank you guys