

1
00:00:03,450 --> 00:00:09,009
hello everybody it's time once again for

2
00:00:06,009 --> 00:00:13,599
news from space with doctor Frank

3
00:00:09,009 --> 00:00:15,099
summers I thought was really cool it's

4
00:00:13,599 --> 00:00:16,449
time once again when news from Hubble

5
00:00:15,099 --> 00:00:18,160
and across the universe we do this every

6
00:00:16,449 --> 00:00:19,629
month my name is Tony Darnell I work at

7
00:00:18,160 --> 00:00:22,000
the Space Telescope Science Institute

8
00:00:19,629 --> 00:00:24,009
and with me as he does he joins me most

9
00:00:22,000 --> 00:00:26,170
months is dr. Frank summers he's the

10
00:00:24,010 --> 00:00:28,780
outreach astrophysicist hey where's your

11
00:00:26,170 --> 00:00:31,090
lower third go oh that's because I had

12
00:00:28,780 --> 00:00:35,198
to reboot remember oh that's right ok

13
00:00:31,089 --> 00:00:37,049
I'll add it back in ok so we do this is

14
00:00:35,198 --> 00:00:40,179
a hangout we try to do each month where

15
00:00:37,049 --> 00:00:42,578
Frank does his astrophysicist due to

16
00:00:40,179 --> 00:00:43,989
duty and lets us know his all the

17
00:00:42,579 --> 00:00:45,789
interesting news that's going on not

18
00:00:43,988 --> 00:00:47,378
only with Hubble but elsewhere and other

19
00:00:45,789 --> 00:00:49,149
missions and in the field of astronomy

20
00:00:47,378 --> 00:00:51,338
and so he's going to fill us in on that

21
00:00:49,149 --> 00:00:53,768
today but before we get started let me

22
00:00:51,338 --> 00:00:56,799
invite you to interact with us we want

23
00:00:53,768 --> 00:00:57,908
to hear from you please use the Q&A app

24
00:00:56,799 --> 00:00:59,198
if you have any questions or comments

25
00:00:57,908 --> 00:01:00,789
it's right there should be a button

26
00:00:59,198 --> 00:01:03,009
right there on your screen to push and

27
00:01:00,789 --> 00:01:04,750
you can either comment or leave us a

28
00:01:03,009 --> 00:01:07,379
question and we'll take well take them

29

00:01:04,750 --> 00:01:10,900
as they come you can also alternatively

30
00:01:07,379 --> 00:01:13,329
comment on the YouTube pages of being

31
00:01:10,900 --> 00:01:15,609
broadcast on and the G+ event page which

32
00:01:13,329 --> 00:01:18,250
I'm also looking at and finally you can

33
00:01:15,609 --> 00:01:21,250
tweet at us using the Hubble hang out

34
00:01:18,250 --> 00:01:23,799
hashtag which I am also monitoring with

35
00:01:21,250 --> 00:01:25,989
all of my stuff so I'm the driver of the

36
00:01:23,799 --> 00:01:28,269
internet today usually a Scott Lewis but

37
00:01:25,989 --> 00:01:30,429
not the driver and Frank what do you got

38
00:01:28,269 --> 00:01:32,200
for us this month oh well we got some

39
00:01:30,430 --> 00:01:34,570
fun stuff remember I promised your last

40
00:01:32,200 --> 00:01:36,400
month we'd get to Andromeda because we

41
00:01:34,569 --> 00:01:37,839
spend so much time on the Eagle Nebula

42
00:01:36,400 --> 00:01:39,250
less that's right and have time to go

43
00:01:37,840 --> 00:01:43,030

for the other really big story of

44

00:01:39,250 --> 00:01:45,280

January which is in drama de and then we

45

00:01:43,030 --> 00:01:46,570

got we're going to go we're gonna go

46

00:01:45,280 --> 00:01:48,790

some different places we're going to

47

00:01:46,569 --> 00:01:50,739

start our Hubble 25 retrospective here

48

00:01:48,790 --> 00:01:53,680

tonight today ok ah speaking of which

49

00:01:50,739 --> 00:01:55,929

let me get it out to the there is a

50

00:01:53,680 --> 00:01:57,190

video contest for the Hubble 25th

51

00:01:55,930 --> 00:01:59,410

anniversary as you know we've got

52

00:01:57,189 --> 00:02:01,090

starting all year long this year this

53

00:01:59,409 --> 00:02:03,759

marks the 25th anniversary of the Hubble

54

00:02:01,090 --> 00:02:05,350

Space Telescope and many events going on

55

00:02:03,760 --> 00:02:08,080

in activities right now if you go to

56

00:02:05,349 --> 00:02:11,378

Space Telescope o RG you'll be able to

57

00:02:08,080 --> 00:02:13,209

that you learn about a and an ode to

58
00:02:11,378 --> 00:02:14,049
Hubble video contest which is open now

59
00:02:13,209 --> 00:02:15,520
you can

60
00:02:14,050 --> 00:02:17,439
create a video three minutes or less and

61
00:02:15,520 --> 00:02:19,450
say about anything you want about Hubble

62
00:02:17,439 --> 00:02:21,520
and enter it into the contest I'd left

63
00:02:19,449 --> 00:02:24,129
the link to that contest on the Google+

64
00:02:21,520 --> 00:02:26,020
event page and I'll also tweet it out

65
00:02:24,129 --> 00:02:27,129
here in just a little bit so I just

66
00:02:26,020 --> 00:02:31,870
wanted to get that out thanks Frank

67
00:02:27,129 --> 00:02:34,150
great great so let's go to the slides ok

68
00:02:31,870 --> 00:02:36,780
from Hubble and across the universe and

69
00:02:34,150 --> 00:02:42,069
if we can figure out to work in span

70
00:02:36,780 --> 00:02:45,460
right actually I work at these special

71
00:02:42,069 --> 00:02:49,689
scope Science Institute all right so

72
00:02:45,460 --> 00:02:53,050
what so ease in that yeah so uh februari

73
00:02:49,689 --> 00:02:56,439
and how ok oops I hit the wrong one I

74
00:02:53,050 --> 00:03:01,120
always do this there we go ok so our top

75
00:02:56,439 --> 00:03:02,469
story today is in your dreams bubble and

76
00:03:01,120 --> 00:03:04,480
in this case i'm not talking about

77
00:03:02,469 --> 00:03:07,180
Hubble telescope I'm talking about

78
00:03:04,479 --> 00:03:12,280
Hubble the astronomer now I found this

79
00:03:07,180 --> 00:03:15,069
wonderful image from 1901 the Yerkes

80
00:03:12,280 --> 00:03:17,770
Observatory an image of the great nebula

81
00:03:15,069 --> 00:03:20,560
in Andromeda as it was called back then

82
00:03:17,770 --> 00:03:23,050
because we didn't know what was a galaxy

83
00:03:20,560 --> 00:03:24,520
back then and so this actually is

84
00:03:23,050 --> 00:03:28,239
something I got from project gutenberg

85
00:03:24,520 --> 00:03:29,739
on the internet it was in a book that

86

00:03:28,239 --> 00:03:31,030
was published before copyright took

87
00:03:29,739 --> 00:03:32,860
effect in the United States so I was

88
00:03:31,030 --> 00:03:35,319
able to just pull it out but this is a

89
00:03:32,860 --> 00:03:36,910
really gorgeous image that shows you

90
00:03:35,319 --> 00:03:40,060
just you know the state of the art of

91
00:03:36,909 --> 00:03:42,609
astronomy observation a hundred years

92
00:03:40,060 --> 00:03:44,379
ago now your keys is a refractor

93
00:03:42,610 --> 00:03:47,560
telescope is that is that like a 20 inch

94
00:03:44,379 --> 00:03:49,000
telescope isn't like it could be the 40

95
00:03:47,560 --> 00:03:51,129
inch remember the largest refractor in

96
00:03:49,000 --> 00:03:52,840
the world was at Yerkes mistaken is it

97
00:03:51,129 --> 00:03:54,430
40 okay I wasn't sure of the diameter

98
00:03:52,840 --> 00:03:57,370
but yeah that for the longest time that

99
00:03:54,430 --> 00:03:58,840
was what it may even still be one of the

100
00:03:57,370 --> 00:04:00,489

largest reported well the 40 inch

101

00:03:58,840 --> 00:04:03,310

refractor wherever it is I think it's at

102

00:04:00,489 --> 00:04:05,890

Yerkes is the largest refractor in ever

103

00:04:03,310 --> 00:04:07,180

built simply because you build a piece

104

00:04:05,889 --> 00:04:09,519

of glass larger than about 40 inches

105

00:04:07,180 --> 00:04:13,709

across and it starts to sag in the

106

00:04:09,520 --> 00:04:16,329

center right if you only hold up the the

107

00:04:13,709 --> 00:04:19,030

glass by the edges the weight of the

108

00:04:16,329 --> 00:04:22,779

glass itself starts to to say get and

109

00:04:19,029 --> 00:04:24,969

bolted out of alignment anyway so that's

110

00:04:22,779 --> 00:04:27,609

we called it the great nebula in

111

00:04:24,970 --> 00:04:32,229

Andromeda in 1901

112

00:04:27,610 --> 00:04:35,379

well it became the great the galaxy in

113

00:04:32,228 --> 00:04:37,508

Andromeda about 20 years later and so

114

00:04:35,379 --> 00:04:40,060

this image here is from Edwin Hubble

115
00:04:37,509 --> 00:04:43,479
himself and you can see it's dated the

116
00:04:40,060 --> 00:04:46,240
sixth of October 1923 those ends in the

117
00:04:43,478 --> 00:04:49,658
center are stars that he believed were

118
00:04:46,240 --> 00:04:52,300
nova in this nebula though he was

119
00:04:49,658 --> 00:04:54,848
looking for stars it flashed and then

120
00:04:52,300 --> 00:04:57,490
went away so he's looking for no bay in

121
00:04:54,848 --> 00:05:00,938
this nebula and then you can see up near

122
00:04:57,490 --> 00:05:03,310
the top he has one isolated that he also

123
00:05:00,939 --> 00:05:07,689
has an N next to but then he's crossed

124
00:05:03,310 --> 00:05:10,060
out the end and put VAR ! it's not a

125
00:05:07,689 --> 00:05:13,180
nova it didn't just flash on once it

126
00:05:10,060 --> 00:05:15,939
actually recurred it's a variable star

127
00:05:13,180 --> 00:05:18,189
so this was his fantastic discovery

128
00:05:15,939 --> 00:05:20,949
discovering a variable star in the

129
00:05:18,189 --> 00:05:22,810
Andromeda nebula now why was that

130
00:05:20,949 --> 00:05:25,150
fantastic there's lots and lots of

131
00:05:22,810 --> 00:05:26,918
variable stars much closer to home the

132
00:05:25,149 --> 00:05:29,318
point is that when you have a variable

133
00:05:26,918 --> 00:05:31,870
star of a specific type it's called a

134
00:05:29,319 --> 00:05:34,210
Cepheid variable star then the

135
00:05:31,870 --> 00:05:36,338
brightness that it rises to and falls

136
00:05:34,209 --> 00:05:38,799
from the the front there the period at

137
00:05:36,338 --> 00:05:41,860
which it rises and falls rises and falls

138
00:05:38,800 --> 00:05:45,069
the timing of that period is related to

139
00:05:41,860 --> 00:05:47,259
its absolute brightness and so by

140
00:05:45,069 --> 00:05:49,270
measuring the timing of the period you

141
00:05:47,259 --> 00:05:50,830
could gauge its brightness and then

142
00:05:49,269 --> 00:05:52,750
comparing its absolute brightness

143

00:05:50,829 --> 00:05:54,370
against its apparent brightness the

144
00:05:52,750 --> 00:05:57,009
brightness it appears you could then

145
00:05:54,370 --> 00:05:59,110
engage its distance and when you do that

146
00:05:57,009 --> 00:06:02,468
you figure out that the nebula in

147
00:05:59,110 --> 00:06:05,949
Andromeda is well outside the Milky Way

148
00:06:02,468 --> 00:06:08,319
galaxy it's not a nebula it's a galaxy

149
00:06:05,949 --> 00:06:09,848
unto itself right right the example I

150
00:06:08,319 --> 00:06:11,229
always use for people for this is

151
00:06:09,848 --> 00:06:12,788
imagine if you know something's

152
00:06:11,228 --> 00:06:14,199
intrinsic brightness that is how bright

153
00:06:12,788 --> 00:06:16,449
it actually is if you were standing

154
00:06:14,199 --> 00:06:18,968
right next to it and then you measure

155
00:06:16,449 --> 00:06:21,639
how far you actually see it how bright

156
00:06:18,968 --> 00:06:23,949
it is at your when you look at it

157
00:06:21,639 --> 00:06:25,300

through a telescope didn't that's you

158

00:06:23,949 --> 00:06:27,400

can measure its distance because the

159

00:06:25,300 --> 00:06:29,680

brightness falls away as the inverse

160

00:06:27,399 --> 00:06:31,239

square of the distance and so I way to

161

00:06:29,680 --> 00:06:33,579

look at it directly as you take a candle

162

00:06:31,240 --> 00:06:35,079

put it really close to your like a few

163

00:06:33,579 --> 00:06:37,629

inches from your face don't burn your

164

00:06:35,079 --> 00:06:39,209

hair your eyeballs and then move it and

165

00:06:37,629 --> 00:06:41,069

put it on the other side of the room

166

00:06:39,209 --> 00:06:43,109

and then you know that that you can you

167

00:06:41,069 --> 00:06:44,520

could if you measure the brightness

168

00:06:43,110 --> 00:06:46,379

difference accurately enough you can

169

00:06:44,519 --> 00:06:48,448

measure how far away the candle is right

170

00:06:46,379 --> 00:06:50,519

we use this all the time when we're

171

00:06:48,449 --> 00:06:52,319

gauging how far away is a car at night

172
00:06:50,519 --> 00:06:54,209
you can only see the headlights and you

173
00:06:52,319 --> 00:06:56,160
know how bright headlights generally

174
00:06:54,209 --> 00:06:58,079
appear so you can tell whether they're

175
00:06:56,160 --> 00:07:00,120
bright and it's a natural thing that you

176
00:06:58,079 --> 00:07:02,668
actually do what we do it scientifically

177
00:07:00,120 --> 00:07:04,620
and so Hubble was able to measure that

178
00:07:02,668 --> 00:07:06,959
the Andromeda galaxy was its own galaxy

179
00:07:04,620 --> 00:07:10,168
proving for the first time that there

180
00:07:06,959 --> 00:07:13,620
were other galaxies in the universe okay

181
00:07:10,168 --> 00:07:16,079
well this this is amazing to me that it

182
00:07:13,620 --> 00:07:17,728
that it happened so recently that we you

183
00:07:16,079 --> 00:07:20,609
know that's not very far long ago that

184
00:07:17,728 --> 00:07:22,740
we didn't know there were other galaxies

185
00:07:20,610 --> 00:07:24,330
for about a hundred years we see we take

186
00:07:22,740 --> 00:07:26,340
them so much for granted these days but

187
00:07:24,329 --> 00:07:29,788
really it's only a hundred years no shun

188
00:07:26,339 --> 00:07:34,348
is a hundred years old or so ok so this

189
00:07:29,788 --> 00:07:37,079
sequence of four images is the star that

190
00:07:34,348 --> 00:07:39,810
Hubble found this is we call hv1 Hubble

191
00:07:37,079 --> 00:07:41,758
variable one and these are for images

192
00:07:39,810 --> 00:07:43,918
from the Hubble Space Telescope the

193
00:07:41,759 --> 00:07:46,620
namesake telescope showing it at the

194
00:07:43,918 --> 00:07:47,969
various brightnesses and you can't quite

195
00:07:46,620 --> 00:07:49,829
you can sort of see that they're the

196
00:07:47,970 --> 00:07:52,229
changes in brightness but on the next

197
00:07:49,829 --> 00:07:53,848
slide here I've got an animated gif I

198
00:07:52,228 --> 00:07:57,718
don't know how well this comes out

199
00:07:53,848 --> 00:07:58,918
across the Hangout I look how it exists

200

00:07:57,718 --> 00:08:00,538
coming out pretty good yeah yeah it's

201
00:07:58,918 --> 00:08:02,310
doing good all right definitely see the

202
00:08:00,538 --> 00:08:04,139
brightness changes right so you can see

203
00:08:02,310 --> 00:08:06,000
the brightness changing and you can see

204
00:08:04,139 --> 00:08:08,310
what Hubble did is measuring the

205
00:08:06,000 --> 00:08:10,079
variable the brightness changes others

206
00:08:08,310 --> 00:08:11,490
variable star in order to measure its

207
00:08:10,079 --> 00:08:14,579
distance and therefore the distance of

208
00:08:11,490 --> 00:08:15,780
the galaxy so what I'm showing you here

209
00:08:14,579 --> 00:08:19,439
the important thing I'm showing you here

210
00:08:15,779 --> 00:08:21,508
is Hubble the telescope can resolve the

211
00:08:19,439 --> 00:08:25,199
stars much much better than Hubble the

212
00:08:21,509 --> 00:08:27,990
astronomer matter of fact Hubble the

213
00:08:25,199 --> 00:08:31,710
telescope has looked in great detail at

214
00:08:27,990 --> 00:08:36,028

the Andromeda galaxy so this is an image

215

00:08:31,709 --> 00:08:41,519

from 2003 that we call the stellar Deep

216

00:08:36,028 --> 00:08:44,250

Field and this is an image of stars it's

217

00:08:41,519 --> 00:08:46,860

a star field basically but it's not in

218

00:08:44,250 --> 00:08:50,730

the Milky Way galaxy this is a star

219

00:08:46,860 --> 00:08:52,110

field in the Andromeda galaxy and let me

220

00:08:50,730 --> 00:08:53,039

zoom in on it because this is this is

221

00:08:52,110 --> 00:08:55,110

the whole field

222

00:08:53,039 --> 00:08:57,990

you know thousands of pixels across let

223

00:08:55,110 --> 00:09:00,269

me zoom in and show you you can see that

224

00:08:57,990 --> 00:09:02,129

bright star with a cross on it okay nuts

225

00:09:00,269 --> 00:09:04,259

that's going to be a star in the Milky

226

00:09:02,129 --> 00:09:05,610

Way galaxy that's a foreground store

227

00:09:04,259 --> 00:09:07,379

that's a foreground star in the Milky

228

00:09:05,610 --> 00:09:08,579

Way galaxy of course stars in the Milky

229
00:09:07,379 --> 00:09:11,129
Way are going to be between us and

230
00:09:08,578 --> 00:09:15,659
Andromeda but every other star that you

231
00:09:11,129 --> 00:09:19,289
see there is in the Andromeda galaxy two

232
00:09:15,659 --> 00:09:23,159
and a half million light-years away so

233
00:09:19,289 --> 00:09:25,919
we're seeing a star filled in Andromeda

234
00:09:23,159 --> 00:09:30,328
plus if you look carefully you'll see

235
00:09:25,919 --> 00:09:33,120
that there are these small galaxies they

236
00:09:30,328 --> 00:09:35,399
small uh yeah there are these small

237
00:09:33,120 --> 00:09:38,068
fuzzy blobs that are actually background

238
00:09:35,399 --> 00:09:39,389
galaxies you're seeing through Andromeda

239
00:09:38,068 --> 00:09:42,149
yeah there's a lot of them in there

240
00:09:39,389 --> 00:09:45,839
that's really cool and then what's even

241
00:09:42,149 --> 00:09:49,110
cooler is here I'm showing you a

242
00:09:45,839 --> 00:09:52,949
globular star cluster but this globular

243
00:09:49,110 --> 00:09:56,639
star cluster is in Andromeda mm-hmm

244
00:09:52,948 --> 00:09:58,588
Hubble can see the Andromeda galaxy was

245
00:09:56,639 --> 00:10:01,019
such good resolution not just he starts

246
00:09:58,589 --> 00:10:03,269
we can see star clusters and I'm always

247
00:10:01,019 --> 00:10:04,860
am sort of amazed at this this globular

248
00:10:03,269 --> 00:10:07,470
star cluster in Andromeda because i

249
00:10:04,860 --> 00:10:09,300
think it compared really well with this

250
00:10:07,470 --> 00:10:11,220
of your star cluster in our own Milky

251
00:10:09,299 --> 00:10:12,778
Way galaxy yeah they're the prettiest

252
00:10:11,220 --> 00:10:14,670
what the stars are pretty well resolved

253
00:10:12,778 --> 00:10:16,289
how far away is Andromeda are you going

254
00:10:14,669 --> 00:10:18,379
to get to that later Andromeda's two and

255
00:10:16,289 --> 00:10:21,120
a half million light-years away okay

256
00:10:18,379 --> 00:10:23,970
whereas the star cluster on the left is

257

00:10:21,120 --> 00:10:26,009
Messier 80 and I don't know the exact

258
00:10:23,970 --> 00:10:28,860
distance to Messier 80 but it's going to

259
00:10:26,009 --> 00:10:30,539
be on order 10,000 light-years right

260
00:10:28,860 --> 00:10:32,399
it's much closer sorry and so you get

261
00:10:30,539 --> 00:10:35,969
10,000 light-years two and a half

262
00:10:32,399 --> 00:10:38,419
million light-years it the the distance

263
00:10:35,970 --> 00:10:41,790
difference is around 200 factor of 250

264
00:10:38,419 --> 00:10:44,068
well I mean if also i mean it's it's

265
00:10:41,789 --> 00:10:46,860
obvious that the Andromeda star cluster

266
00:10:44,068 --> 00:10:48,750
is larger and so you can see that it's

267
00:10:46,860 --> 00:10:51,509
not as well resolved of course it

268
00:10:48,750 --> 00:10:53,458
shouldn't be but you can see it's really

269
00:10:51,509 --> 00:10:56,188
cool were able to study stars and star

270
00:10:53,458 --> 00:10:57,899
clusters in the Andromeda galaxy so

271
00:10:56,188 --> 00:10:59,759

Frank let me ask you a quick question on

272

00:10:57,899 --> 00:11:02,309

the the very the sea Fiat variable

273

00:10:59,759 --> 00:11:03,688

brightness technique how that was one of

274

00:11:02,309 --> 00:11:05,458

the ways in which they first figured out

275

00:11:03,688 --> 00:11:06,000

how this was really really far the

276

00:11:05,458 --> 00:11:07,259

Andromeda

277

00:11:06,000 --> 00:11:10,169

the far away how accurate is that

278

00:11:07,259 --> 00:11:12,509

technique of using see Fiat variables to

279

00:11:10,169 --> 00:11:14,939

measure distance well in Hubble's time

280

00:11:12,509 --> 00:11:16,950

it wasn't very accurate matter of fact

281

00:11:14,940 --> 00:11:20,550

he got the distance to Andromeda wrong

282

00:11:16,950 --> 00:11:22,080

by about a factor of five only does he

283

00:11:20,549 --> 00:11:24,599

think it was further away or closer

284

00:11:22,080 --> 00:11:27,030

closer all right there are two different

285

00:11:24,600 --> 00:11:28,409

types of Cepheid um some pronounced to

286
00:11:27,029 --> 00:11:30,059
see if you had some routes a Cepheid i

287
00:11:28,409 --> 00:11:33,029
pronounced a Cepheid i'm not sure

288
00:11:30,059 --> 00:11:34,229
exactly what which is correct a lot of

289
00:11:33,029 --> 00:11:35,879
these things I just don't care well I

290
00:11:34,230 --> 00:11:37,409
say see fee is because it you know

291
00:11:35,879 --> 00:11:40,259
actually I save Cepheus the

292
00:11:37,409 --> 00:11:42,059
constellation that's why I do it okay

293
00:11:40,259 --> 00:11:44,730
you know and it comes with kareena

294
00:11:42,059 --> 00:11:47,129
incurring a or you know Karina we will

295
00:11:44,730 --> 00:11:48,920
do a lot of those anyways corona there

296
00:11:47,129 --> 00:11:52,019
are two different types of them and

297
00:11:48,919 --> 00:11:54,179
Hubble chose the wrong type to compare

298
00:11:52,019 --> 00:11:57,090
against and got the got the distance is

299
00:11:54,179 --> 00:11:59,669
wrong the however it is a very accurate

300
00:11:57,090 --> 00:12:01,500
technique now because one of the key

301
00:11:59,669 --> 00:12:04,639
projects when the whole space telescope

302
00:12:01,500 --> 00:12:07,529
was first launched was to serve a nearby

303
00:12:04,639 --> 00:12:09,059
galaxies for these Cepheid variable

304
00:12:07,529 --> 00:12:11,159
stars as well as our hourly rate

305
00:12:09,059 --> 00:12:13,739
variable stars to look for variable

306
00:12:11,159 --> 00:12:16,259
stars in nearby galaxies measure their

307
00:12:13,740 --> 00:12:18,990
distances extremely carefully and from

308
00:12:16,259 --> 00:12:22,799
that measure of the Hubble law which is

309
00:12:18,990 --> 00:12:25,259
the local expansion of the universe so

310
00:12:22,799 --> 00:12:27,809
it is really it's accurate out to tens

311
00:12:25,259 --> 00:12:29,399
of millions of light-years these days so

312
00:12:27,809 --> 00:12:31,769
one of the original science questions

313
00:12:29,399 --> 00:12:34,139
Hubble was designed to answer was you

314

00:12:31,769 --> 00:12:36,480
know this this how getting this

315
00:12:34,139 --> 00:12:38,879
technique down more accurately exactly

316
00:12:36,480 --> 00:12:41,100
using this really good technique to then

317
00:12:38,879 --> 00:12:46,080
measure the local expansion rate of the

318
00:12:41,100 --> 00:12:49,589
universe ok thank him so that stellar

319
00:12:46,080 --> 00:12:51,720
Deep Field was in Andromeda but you can

320
00:12:49,589 --> 00:12:55,290
see from this illustration it was way

321
00:12:51,720 --> 00:12:57,779
out from the main body of Andromeda it's

322
00:12:55,289 --> 00:13:00,838
in what we call the halo of Andromeda

323
00:12:57,779 --> 00:13:03,059
now these galaxies most of the stars are

324
00:13:00,839 --> 00:13:05,130
in these disks as you soon see but

325
00:13:03,059 --> 00:13:07,079
there's a very large halo of stars

326
00:13:05,129 --> 00:13:09,210
orbiting around these galaxies

327
00:13:07,080 --> 00:13:13,050
relatively low we have the same sort of

328
00:13:09,210 --> 00:13:14,759

halo in our own Milky Way galaxy and we

329

00:13:13,049 --> 00:13:16,889

observed it in other galaxies but we

330

00:13:14,759 --> 00:13:19,740

can't see them in detail except for in

331

00:13:16,889 --> 00:13:23,100

the closest of galaxies Milky Way

332

00:13:19,740 --> 00:13:24,779

Andromeda so we're studying it in the

333

00:13:23,100 --> 00:13:27,180

halo so that we didn't have crowded

334

00:13:24,779 --> 00:13:30,269

confusion and we could you know really

335

00:13:27,179 --> 00:13:33,000

study the individual stars well what

336

00:13:30,269 --> 00:13:36,329

wouldn't it be really cool to study the

337

00:13:33,000 --> 00:13:43,250

main disk of Andromeda what if yes it

338

00:13:36,330 --> 00:13:46,259

would be cool yes yes dr. Frank well

339

00:13:43,250 --> 00:13:48,480

unfortunately you can see the size of a

340

00:13:46,259 --> 00:13:49,860

single Hubble image this is using

341

00:13:48,480 --> 00:13:51,960

advanced camera for surveys but why

342

00:13:49,860 --> 00:13:53,580

field camera 3 is about the same and you

343
00:13:51,960 --> 00:13:55,710
can see how many of those would it take

344
00:13:53,580 --> 00:13:57,150
to cover all of Andromeda that little

345
00:13:55,710 --> 00:13:59,280
green square there right yeah that

346
00:13:57,149 --> 00:14:03,689
little green square there too many you'd

347
00:13:59,279 --> 00:14:06,679
never get that much time but a project

348
00:14:03,690 --> 00:14:11,220
called the pen chromatic Hubble

349
00:14:06,679 --> 00:14:13,589
Andromeda Treasury program fat ph 80 did

350
00:14:11,220 --> 00:14:17,670
get enough time to cover about a third

351
00:14:13,590 --> 00:14:19,769
of that and drama to disk ok this is the

352
00:14:17,669 --> 00:14:23,370
one of the largest programs ever done on

353
00:14:19,769 --> 00:14:27,210
Hubble and it covers a tremendous amount

354
00:14:23,370 --> 00:14:30,690
of the Andromeda disk so they just

355
00:14:27,210 --> 00:14:32,280
completed the fat and they've got the

356
00:14:30,690 --> 00:14:33,900
data in hand they don't have all the

357
00:14:32,279 --> 00:14:35,129
science results ok I mean just say that

358
00:14:33,899 --> 00:14:37,620
you know the science results are still

359
00:14:35,129 --> 00:14:40,230
coming because this is a really whopping

360
00:14:37,620 --> 00:14:42,600
huge amount of data but this is the

361
00:14:40,230 --> 00:14:45,029
panchromatic Hubble Andromeda Treasury

362
00:14:42,600 --> 00:14:47,430
program and what you see in front of you

363
00:14:45,029 --> 00:14:50,100
is the what we call the uncropped image

364
00:14:47,429 --> 00:14:51,659
this is the image that shows you has the

365
00:14:50,100 --> 00:14:54,810
ragged edge shows you all the various

366
00:14:51,659 --> 00:14:56,939
pointings alright recognize that it is a

367
00:14:54,809 --> 00:14:59,579
hundred thousand pixels from side to

368
00:14:56,940 --> 00:15:02,850
side and about twenty or thirty thousand

369
00:14:59,580 --> 00:15:07,879
pixels high do the math this is several

370
00:15:02,850 --> 00:15:09,960
billion pixels of the Andromeda galaxy

371

00:15:07,879 --> 00:15:11,850
largest mosaic we've ever put together

372
00:15:09,960 --> 00:15:13,580
as you can see from the stats at the

373
00:15:11,850 --> 00:15:16,670
bottom it took three years to do it over

374
00:15:13,580 --> 00:15:19,920
seven thousand different exposures

375
00:15:16,669 --> 00:15:22,349
pointing it 411 different places in

376
00:15:19,919 --> 00:15:26,819
Andromeda and then mosaicing them all

377
00:15:22,350 --> 00:15:30,000
together how big is this well on this

378
00:15:26,820 --> 00:15:32,070
image here well right on the left you

379
00:15:30,000 --> 00:15:33,299
see that the rectangle is the outline of

380
00:15:32,070 --> 00:15:35,399
the cropped image

381
00:15:33,299 --> 00:15:38,879
but on the right you see that circle

382
00:15:35,399 --> 00:15:42,600
half circle that's the apparent diameter

383
00:15:38,879 --> 00:15:45,708
of the full moon on our sky half a

384
00:15:42,600 --> 00:15:49,769
degree across okay it's bigger than that

385
00:15:45,708 --> 00:15:51,750

dude so the width of this image is about

386

00:15:49,769 --> 00:15:55,519

you know two and a half full moons

387

00:15:51,750 --> 00:15:58,919

across all rights it's a huge huge image

388

00:15:55,519 --> 00:16:01,289

and also down in the lower right you see

389

00:15:58,919 --> 00:16:03,990

that rectangle that's got a line down

390

00:16:01,289 --> 00:16:08,490

the center of it that is the footprint

391

00:16:03,990 --> 00:16:10,409

of one Hubble observation with wide

392

00:16:08,490 --> 00:16:12,720

field camera on the sky so you can

393

00:16:10,409 --> 00:16:15,028

really start to see the 411 various

394

00:16:12,720 --> 00:16:16,528

pointing signals okay and while you're

395

00:16:15,028 --> 00:16:18,600

talking I want to tell everybody that I

396

00:16:16,528 --> 00:16:20,519

just posted a link to where you can get

397

00:16:18,600 --> 00:16:22,769

these images yourself on the grievant

398

00:16:20,519 --> 00:16:24,570

page so check it out yeah but let me

399

00:16:22,769 --> 00:16:27,778

warn you you cannot get the two billion

400
00:16:24,570 --> 00:16:29,730
pixel version okay I think we've got a

401
00:16:27,778 --> 00:16:31,519
500 million pixel version up there but

402
00:16:29,730 --> 00:16:35,039
the two billion pixel version actually

403
00:16:31,519 --> 00:16:37,679
is so large it violates a 32-bit

404
00:16:35,039 --> 00:16:40,409
addressing that's in the normal tiff

405
00:16:37,679 --> 00:16:42,509
file and so it's only available in a

406
00:16:40,409 --> 00:16:44,669
special file format that uses 64 bit of

407
00:16:42,509 --> 00:16:47,610
dressing so we haven't publicly released

408
00:16:44,669 --> 00:16:49,469
that isn't but the I mean maybe this is

409
00:16:47,610 --> 00:16:51,930
a little off topic but aren't there

410
00:16:49,470 --> 00:16:54,028
zoomable jpeg images we actually do

411
00:16:51,929 --> 00:16:56,789
believe yes and that correct I believe

412
00:16:54,028 --> 00:16:59,189
on the website they do have a zoomable

413
00:16:56,789 --> 00:17:00,659
version of this okay good but if you

414
00:16:59,190 --> 00:17:02,790
want to try and download every stall

415
00:17:00,659 --> 00:17:04,289
pixels in one file you need a special

416
00:17:02,789 --> 00:17:06,359
file format because they're just too

417
00:17:04,289 --> 00:17:08,609
many pixels and in terms of the the

418
00:17:06,359 --> 00:17:11,578
addressing internal to the file format

419
00:17:08,609 --> 00:17:15,149
okay alright so let's take a look in

420
00:17:11,578 --> 00:17:16,139
some detail okay so what is the science

421
00:17:15,150 --> 00:17:18,390
we're going to get out of this well the

422
00:17:16,140 --> 00:17:21,240
very first thing about science is that

423
00:17:18,390 --> 00:17:24,630
we're going to look in great detail at

424
00:17:21,240 --> 00:17:27,419
the stellar populations in the various

425
00:17:24,630 --> 00:17:29,520
parts of the galaxy one of the problems

426
00:17:27,419 --> 00:17:32,160
about living in the Milky Way is that

427
00:17:29,519 --> 00:17:35,058
we're inside it and you've got this disk

428

00:17:32,160 --> 00:17:38,580
of material in your way that's a problem

429
00:17:35,058 --> 00:17:40,139
that's a great thing but if you want to

430
00:17:38,579 --> 00:17:42,960
actually look at the center of the

431
00:17:40,140 --> 00:17:43,950
galaxy and then i'll say i get my Sh my

432
00:17:42,960 --> 00:17:45,539
hand if you want to the center of the

433
00:17:43,950 --> 00:17:45,929
galaxy and further out and further and

434
00:17:45,539 --> 00:17:48,178
further

435
00:17:45,929 --> 00:17:50,610
out if you're inside it it's kind of

436
00:17:48,179 --> 00:17:53,340
hard to hard to do so all right you got

437
00:17:50,609 --> 00:17:56,248
a lot of junk in your way Andromeda is

438
00:17:53,339 --> 00:17:57,898
the nearest large galaxy and we can as

439
00:17:56,249 --> 00:18:00,298
I've labeled here look in the central

440
00:17:57,898 --> 00:18:03,719
region I've labeled one getting further

441
00:18:00,298 --> 00:18:05,490
out into the dust lanes to this new

442
00:18:03,720 --> 00:18:07,440

star-forming regions this label 3 and

443

00:18:05,490 --> 00:18:10,288

all the way out to the edge of the disk

444

00:18:07,440 --> 00:18:12,389

in that region I've labeled for okay so

445

00:18:10,288 --> 00:18:15,898

we'll be able to look at the stellar

446

00:18:12,388 --> 00:18:19,079

populations and how they change fraught

447

00:18:15,898 --> 00:18:21,118

with the environment within a galaxy so

448

00:18:19,079 --> 00:18:24,628

let's take a look at that first one one

449

00:18:21,118 --> 00:18:27,928

down at the very core and if you've got

450

00:18:24,628 --> 00:18:30,298

a high-resolution screen you still don't

451

00:18:27,929 --> 00:18:34,230

see the individual stars it is so

452

00:18:30,298 --> 00:18:37,798

crowded here it's just this milky white

453

00:18:34,230 --> 00:18:41,220

glow with the the the shadows of the

454

00:18:37,798 --> 00:18:44,398

dust in front of it what you see that

455

00:18:41,220 --> 00:18:48,058

may look like stars these clumps right

456

00:18:44,398 --> 00:18:49,618

here are actually star clusters all of

457
00:18:48,058 --> 00:18:52,349
those white dots that sort of look like

458
00:18:49,618 --> 00:18:55,019
they could be stars are really star

459
00:18:52,349 --> 00:18:57,449
clusters the stars themselves are so

460
00:18:55,019 --> 00:18:59,730
dense and so packed together they just

461
00:18:57,450 --> 00:19:02,580
form this almost uniform white glow in

462
00:18:59,730 --> 00:19:04,740
the background so very dense a stellar

463
00:19:02,579 --> 00:19:09,079
field stellar field in the center of the

464
00:19:04,740 --> 00:19:12,048
galaxy we move on out toward the US

465
00:19:09,079 --> 00:19:14,668
regions where I called the dust lanes

466
00:19:12,048 --> 00:19:17,548
now you start to see though that the the

467
00:19:14,669 --> 00:19:20,730
populate the number of stars is greatly

468
00:19:17,548 --> 00:19:24,118
reduced and you also can see the clouds

469
00:19:20,730 --> 00:19:26,759
of material so these big dark clouds

470
00:19:24,118 --> 00:19:29,970
material again the big white things that

471
00:19:26,759 --> 00:19:32,788
you see are going to be star clusters in

472
00:19:29,970 --> 00:19:36,240
just the initial analysis of this image

473
00:19:32,788 --> 00:19:40,558
of this billion pixel image they were

474
00:19:36,240 --> 00:19:42,118
able to identify almost 3,000 new star

475
00:19:40,558 --> 00:19:44,428
clusters that they'd never seen before

476
00:19:42,118 --> 00:19:45,959
so how do they do that Frank I mean that

477
00:19:44,429 --> 00:19:47,639
sounds like a lot of work I mean I

478
00:19:45,960 --> 00:19:50,429
there's up people doing this will hire a

479
00:19:47,638 --> 00:19:52,678
lot of graduates to know I started

480
00:19:50,429 --> 00:19:57,149
that's not right don't scare them off

481
00:19:52,679 --> 00:19:59,820
now you of course do it by computers

482
00:19:57,148 --> 00:20:02,639
right but the hard part is telling the

483
00:19:59,819 --> 00:20:08,189
computer what it's looking for you have

484
00:20:02,640 --> 00:20:10,320
to describe in mathematical terms the

485

00:20:08,190 --> 00:20:13,170
brightness profile of what you expect a

486
00:20:10,319 --> 00:20:15,210
star cluster to look like well and and

487
00:20:13,170 --> 00:20:17,880
then once you once the computer says

488
00:20:15,210 --> 00:20:19,860
here I think I found something then you

489
00:20:17,880 --> 00:20:22,560
need a human to come in and look at

490
00:20:19,859 --> 00:20:24,929
every single one of them this is the so

491
00:20:22,559 --> 00:20:26,730
the so the computer would go in and you

492
00:20:24,930 --> 00:20:28,710
would design an algorithm to try and

493
00:20:26,730 --> 00:20:30,420
find these star clusters then the

494
00:20:28,710 --> 00:20:32,190
computer would then pop up on screen

495
00:20:30,420 --> 00:20:34,440
okay here the star clusters I think I

496
00:20:32,190 --> 00:20:35,880
found and you have to go through every

497
00:20:34,440 --> 00:20:38,820
single one of them somebody has to look

498
00:20:35,880 --> 00:20:40,500
at it to check the computer because the

499
00:20:38,819 --> 00:20:42,960

computers only do what you tell them to

500

00:20:40,500 --> 00:20:44,250

do and unfortunately we aren't perfect

501

00:20:42,960 --> 00:20:46,350

people that telling computers to do

502

00:20:44,250 --> 00:20:48,089

exactly what we want to do no but they

503

00:20:46,349 --> 00:20:50,250

do do a pretty good job I mean there's a

504

00:20:48,089 --> 00:20:51,779

I'm they can even even tell the

505

00:20:50,250 --> 00:20:53,549

difference between stars and galaxies a

506

00:20:51,779 --> 00:20:55,440

lot of times or whether sometimes even

507

00:20:53,549 --> 00:20:57,450

if two galaxies are superimposed on each

508

00:20:55,440 --> 00:20:59,100

other one may be way farther away than

509

00:20:57,450 --> 00:21:00,180

the other so they do a pretty good job

510

00:20:59,099 --> 00:21:02,399

but I didn't want to talk about that

511

00:21:00,180 --> 00:21:04,049

briefly because it's it used to be back

512

00:21:02,400 --> 00:21:06,900

in the day like in clyde tombaugh stay

513

00:21:04,049 --> 00:21:09,180

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

514
00:21:06,900 --> 00:21:10,740
all manually write a parrot or and all

515
00:21:09,180 --> 00:21:13,140
that kind of guess I mean when you think

516
00:21:10,740 --> 00:21:17,220
about what clyde tombaugh did to

517
00:21:13,140 --> 00:21:21,050
discover pluto unbelievable i don't the

518
00:21:17,220 --> 00:21:24,240
man had patience is so easy these days

519
00:21:21,049 --> 00:21:27,329
ok so moving on to region 3 which

520
00:21:24,240 --> 00:21:29,460
identified as a cluster of newborn stars

521
00:21:27,329 --> 00:21:30,779
it's not just one cluster of newborn

522
00:21:29,460 --> 00:21:35,100
stars this is a region where you can see

523
00:21:30,779 --> 00:21:36,839
a lot of bright blue stars here now one

524
00:21:35,099 --> 00:21:39,319
problem with this fat image that we

525
00:21:36,839 --> 00:21:41,849
released is we're only using two colors

526
00:21:39,319 --> 00:21:45,450
we're using a blue light and we're using

527
00:21:41,849 --> 00:21:48,929
a near-infrared red light we're not

528
00:21:45,450 --> 00:21:51,000
however using something that would

529
00:21:48,930 --> 00:21:53,009
identify the star-forming regions with

530
00:21:51,000 --> 00:21:55,109
that pink glow that for example you see

531
00:21:53,009 --> 00:21:56,609
in the Whirlpool Galaxy Iraq over my

532
00:21:55,109 --> 00:21:58,559
left shoulder here right there that's

533
00:21:56,609 --> 00:22:01,949
the Whirlpool Galaxy over my left

534
00:21:58,559 --> 00:22:03,869
shoulder and we have a lot of pink star

535
00:22:01,950 --> 00:22:06,240
forming regions that we see in those

536
00:22:03,869 --> 00:22:09,119
galaxies but those are called out

537
00:22:06,240 --> 00:22:11,549
because we use hydrogen alpha filters to

538
00:22:09,119 --> 00:22:13,500
bring out that reddish glow in the star

539
00:22:11,549 --> 00:22:15,119
for images we

540
00:22:13,500 --> 00:22:18,750
don't have the hydrogen alpha filter I

541
00:22:15,119 --> 00:22:21,089
in this observation only two filters

542

00:22:18,750 --> 00:22:22,769
were used here so you can't identify the

543
00:22:21,089 --> 00:22:25,649
star-forming regions by their pink glow

544
00:22:22,769 --> 00:22:28,789
but you can identify the young newborn

545
00:22:25,650 --> 00:22:31,590
stars by their bright blue go glow the

546
00:22:28,789 --> 00:22:34,619
blue stars are the hottest stars and

547
00:22:31,589 --> 00:22:37,589
these hottest stars only live for tens

548
00:22:34,619 --> 00:22:40,559
of millions of years so this you know

549
00:22:37,589 --> 00:22:44,789
that these are regions of new new star

550
00:22:40,559 --> 00:22:46,740
formation yeah all right finally let's

551
00:22:44,789 --> 00:22:49,589
take it on to the outer regions of the

552
00:22:46,740 --> 00:22:51,750
of the galaxy all right and so this

553
00:22:49,589 --> 00:22:55,259
starts to look a little bit like what we

554
00:22:51,750 --> 00:22:57,000
saw in the stellar Deep Field the one

555
00:22:55,259 --> 00:22:59,220
the observation is out in the halo of

556
00:22:57,000 --> 00:23:01,559

Andromeda but if you've got a high res

557

00:22:59,220 --> 00:23:03,750

monitor and it comes up they can really

558

00:23:01,559 --> 00:23:07,440

start to see the individual stars here

559

00:23:03,750 --> 00:23:09,869

that you can understand why the first in

560

00:23:07,440 --> 00:23:12,029

their first deep field that stole the

561

00:23:09,869 --> 00:23:13,619

appeal was done in a halo so that you

562

00:23:12,029 --> 00:23:17,190

could really get a handle on the

563

00:23:13,619 --> 00:23:19,229

individual stars but up in the spot and

564

00:23:17,190 --> 00:23:21,900

the spiral disk of the galaxy you still

565

00:23:19,230 --> 00:23:23,549

have an amazing number of stars well out

566

00:23:21,900 --> 00:23:25,410

from the center all the way out to the

567

00:23:23,549 --> 00:23:28,859

edges of this and you can see the

568

00:23:25,410 --> 00:23:30,240

amazing details you got here okay so

569

00:23:28,859 --> 00:23:32,969

let's take it and do a sort of a

570

00:23:30,240 --> 00:23:34,620

continuum of this we released this image

571
00:23:32,970 --> 00:23:36,650
as part of our press release too short

572
00:23:34,619 --> 00:23:39,779
of show you some of the various things

573
00:23:36,650 --> 00:23:42,390
you can see the Milky Way star just

574
00:23:39,779 --> 00:23:44,369
below into the right of Center you can

575
00:23:42,390 --> 00:23:45,720
see some background galaxies you can see

576
00:23:44,369 --> 00:23:48,149
the stellar clusters that I've pulled

577
00:23:45,720 --> 00:23:50,519
out and they've got a region that they

578
00:23:48,150 --> 00:23:53,220
call the star-forming region all right

579
00:23:50,519 --> 00:23:55,920
and let me just outline that you see

580
00:23:53,220 --> 00:23:58,829
that I do what you are looking at here

581
00:23:55,920 --> 00:24:00,150
is like a tenth of the resolution all

582
00:23:58,829 --> 00:24:02,490
right I'm going to go into that star

583
00:24:00,150 --> 00:24:05,490
forming region area at full resolution

584
00:24:02,490 --> 00:24:06,690
full billion pixel resolution I have to

585
00:24:05,490 --> 00:24:09,059
say those four regions that I went

586
00:24:06,690 --> 00:24:11,220
through that was only quarter resolution

587
00:24:09,059 --> 00:24:13,679
okay so one pixel really should be

588
00:24:11,220 --> 00:24:17,579
replaced by 16 pixels in those here it

589
00:24:13,680 --> 00:24:20,580
is at full resolution okay you get down

590
00:24:17,579 --> 00:24:23,849
and you can I had just the immense

591
00:24:20,579 --> 00:24:25,559
number of stars so that's really where I

592
00:24:23,849 --> 00:24:26,969
want to leave you with is that they

593
00:24:25,559 --> 00:24:30,569
identified over a

594
00:24:26,970 --> 00:24:33,990
hundred and seventy million stars in the

595
00:24:30,569 --> 00:24:36,119
Andromeda galaxy with this survey and it

596
00:24:33,990 --> 00:24:38,759
will be analyzing it and studied how

597
00:24:36,119 --> 00:24:41,189
those stellar types change how the

598
00:24:38,759 --> 00:24:43,259
populations of stars in different

599

00:24:41,190 --> 00:24:45,779
regions change as a function of distance

600
00:24:43,259 --> 00:24:48,529
from the center what is the variation

601
00:24:45,779 --> 00:24:51,389
and really get a great handle on

602
00:24:48,529 --> 00:24:54,779
understanding the star formation history

603
00:24:51,390 --> 00:24:57,360
in galaxies because we see galaxies as

604
00:24:54,779 --> 00:25:00,058
they are today but you know the ages of

605
00:24:57,359 --> 00:25:02,189
the stars can tell you how long ago they

606
00:25:00,058 --> 00:25:04,710
formed which tells you some on gives you

607
00:25:02,190 --> 00:25:06,509
some understanding of when stars formed

608
00:25:04,710 --> 00:25:09,419
at different places within this galaxy

609
00:25:06,509 --> 00:25:11,849
and get a good understanding of how the

610
00:25:09,419 --> 00:25:13,259
galaxy got to be the way it is which is

611
00:25:11,849 --> 00:25:15,658
of course one of the major things we try

612
00:25:13,259 --> 00:25:18,750
to answer in astronomy how things get to

613
00:25:15,659 --> 00:25:21,049

way they are what are the wavelengths

614

00:25:18,750 --> 00:25:25,140

that were used to make this mosaic uh

615

00:25:21,048 --> 00:25:29,129

let's see I believe it's the 814 also

616

00:25:25,140 --> 00:25:32,100

814 nanometers which is just outside the

617

00:25:29,130 --> 00:25:35,010

visible light into the 94 red near-ir um

618

00:25:32,099 --> 00:25:38,279

and then it was a blue filter which is

619

00:25:35,009 --> 00:25:41,009

that what's 450 to 500 nanometers

620

00:25:38,279 --> 00:25:44,759

something in there I don't remember the

621

00:25:41,009 --> 00:25:47,759

exact so between 450 500 I believe okay

622

00:25:44,759 --> 00:25:50,339

mm-hmm they do that two wavelengths in

623

00:25:47,759 --> 00:25:53,730

two wavelengths yes no crime okay they

624

00:25:50,339 --> 00:25:56,668

do of course have more more filters but

625

00:25:53,730 --> 00:25:57,960

only two were put together and creating

626

00:25:56,669 --> 00:26:00,240

this amazing mosaic right this was

627

00:25:57,960 --> 00:26:03,000

already big enough and adding what would

628
00:26:00,240 --> 00:26:05,099
have been really that's a huge project

629
00:26:03,000 --> 00:26:06,690
yeah coming years I actually expect we

630
00:26:05,099 --> 00:26:08,189
will get the other way thanks

631
00:26:06,690 --> 00:26:09,630
incorporated into large mosaics like

632
00:26:08,190 --> 00:26:12,058
yeah I was just thinking about the UV

633
00:26:09,630 --> 00:26:13,559
are wondering what some of this whatever

634
00:26:12,058 --> 00:26:15,149
you'd see in some of that especially

635
00:26:13,558 --> 00:26:16,829
these star forming regions right I mean

636
00:26:15,150 --> 00:26:19,169
then we have more yeah we have just

637
00:26:16,829 --> 00:26:21,029
begun to delve into this Andromeda image

638
00:26:19,169 --> 00:26:22,200
I'm sure we'll be hearing a lot from it

639
00:26:21,029 --> 00:26:25,139
over the year of the next coming years

640
00:26:22,200 --> 00:26:27,000
as the analysis goes on and the day

641
00:26:25,140 --> 00:26:28,440
taking is done now let's go to the

642
00:26:27,000 --> 00:26:33,349
analysis phase is going to take several

643
00:26:28,440 --> 00:26:36,029
years as well alright our second story

644
00:26:33,349 --> 00:26:38,609
moonshadows that sounds like a cat

645
00:26:36,029 --> 00:26:40,980
Steven song or whether it is

646
00:26:38,609 --> 00:26:42,779
name is didn't change the name Joseph

647
00:26:40,980 --> 00:26:48,710
Mohammed or something like that anyway

648
00:26:42,779 --> 00:26:54,480
so no I'm not singing I won't say either

649
00:26:48,710 --> 00:26:56,850
uh in april twenty first of 2014 and we

650
00:26:54,480 --> 00:26:59,970
saw a ganna me shadow on the Great Red

651
00:26:56,849 --> 00:27:03,899
Spot now you may remember we released

652
00:26:59,970 --> 00:27:05,400
this last Halloween right so we released

653
00:27:03,900 --> 00:27:07,650
this last Halloween where Ganymede

654
00:27:05,400 --> 00:27:10,140
shadow passed over the Great Red Spot it

655
00:27:07,650 --> 00:27:13,440
was kind of cute and I think we did this

656

00:27:10,140 --> 00:27:15,270
at a hangout that somebody took this and

657
00:27:13,440 --> 00:27:17,009
a photoshopped it and they doubled the

658
00:27:15,269 --> 00:27:21,929
double the Great Red Spot and they

659
00:27:17,009 --> 00:27:24,859
turned it into that yeah so we've shown

660
00:27:21,929 --> 00:27:29,340
you a shadow on Jupiter with Ganymede

661
00:27:24,859 --> 00:27:32,849
but we just got a chance to a triple

662
00:27:29,339 --> 00:27:36,149
shadow on Jupiter on january twenty

663
00:27:32,849 --> 00:27:39,659
fourth of this year so on january twenty

664
00:27:36,150 --> 00:27:42,570
fourth of 2015 hubble ellos allocated

665
00:27:39,660 --> 00:27:45,450
one orbit which is about 45 minutes of

666
00:27:42,569 --> 00:27:49,019
observing time to look at jupiter and

667
00:27:45,450 --> 00:27:52,950
see the passage of several shadows so

668
00:27:49,019 --> 00:27:55,349
you can see at 628 UT Europa shadow is

669
00:27:52,950 --> 00:27:58,259
lower left Calista shadows above center

670
00:27:55,349 --> 00:28:00,990

and then I of shadow is above and right

671

00:27:58,259 --> 00:28:04,558

of that alright three shadows passing

672

00:28:00,990 --> 00:28:07,109

across it now Hubble has taking pictures

673

00:28:04,558 --> 00:28:08,879

of Jupiter's actually pretty easy it

674

00:28:07,109 --> 00:28:11,969

doesn't require a long exposure time

675

00:28:08,880 --> 00:28:14,669

they could be done in seconds so you

676

00:28:11,970 --> 00:28:17,220

don't need to you know have multiple

677

00:28:14,669 --> 00:28:18,929

orbits so one orbit was allocated so

678

00:28:17,220 --> 00:28:22,500

they got about 40 minutes of good

679

00:28:18,929 --> 00:28:24,720

observing time for looking at Jupiter so

680

00:28:22,500 --> 00:28:30,000

they took a series of two dozen pictures

681

00:28:24,720 --> 00:28:33,210

from 628 UT up until this image here at

682

00:28:30,000 --> 00:28:35,700

seven ten UT and you can see that I Oh

683

00:28:33,210 --> 00:28:37,798

shadow has moved off Callisto shadow is

684

00:28:35,700 --> 00:28:40,470

still there Europa shadow and now

685
00:28:37,798 --> 00:28:42,660
Callisto and Europa are both in the

686
00:28:40,470 --> 00:28:44,880
frame so it was kind of cool we're

687
00:28:42,660 --> 00:28:48,480
looking at this and I put together an

688
00:28:44,880 --> 00:28:50,190
animated gift for this so this is what

689
00:28:48,480 --> 00:28:52,819
we released is just the black and white

690
00:28:50,190 --> 00:28:55,110
of the two dozen images

691
00:28:52,819 --> 00:28:57,389
in between those two images I just

692
00:28:55,109 --> 00:28:59,669
showed you taking a color image of

693
00:28:57,390 --> 00:29:01,500
course requires that you get red green

694
00:28:59,670 --> 00:29:05,910
and blue filters so you have to take

695
00:29:01,500 --> 00:29:08,880
three three exposures whereas to get the

696
00:29:05,910 --> 00:29:12,060
the animation they just took single

697
00:29:08,880 --> 00:29:14,400
filter images at these 24 times during

698
00:29:12,059 --> 00:29:17,730
that orbit so I guess that means there's

699
00:29:14,400 --> 00:29:19,560
about 30 images taken right and so here

700
00:29:17,730 --> 00:29:23,490
you can see the 24 images in the

701
00:29:19,559 --> 00:29:25,319
animated gif with Io Europa I think and

702
00:29:23,490 --> 00:29:27,690
it's kind of nice kind of kind of cool

703
00:29:25,319 --> 00:29:30,869
it's a that's a cute little thing the

704
00:29:27,690 --> 00:29:32,640
public loves planetary stuff so when

705
00:29:30,869 --> 00:29:35,879
every release a planetary press release

706
00:29:32,640 --> 00:29:37,860
they get it they respond really well but

707
00:29:35,880 --> 00:29:39,380
scientifically it's like okay it's a

708
00:29:37,859 --> 00:29:42,119
nice curiosity what's going on here

709
00:29:39,380 --> 00:29:45,120
however since you are talking to me

710
00:29:42,119 --> 00:29:51,089
today you thought of the extra story

711
00:29:45,119 --> 00:29:53,549
okay so in addition to the video that we

712
00:29:51,089 --> 00:29:55,199
showed just showing what Hubble sees we

713

00:29:53,549 --> 00:29:58,319
wanted to give you all the 3d

714
00:29:55,200 --> 00:30:00,120
perspective of it so Greg bacon and I

715
00:29:58,319 --> 00:30:02,480
work together on creating a

716
00:30:00,119 --> 00:30:05,909
visualization to show the 3d perspective

717
00:30:02,480 --> 00:30:10,170
so here is Jupiter isle Europa Ganymede

718
00:30:05,910 --> 00:30:12,630
and Callisto the four Galilean moons as

719
00:30:10,170 --> 00:30:14,130
showing you their orbits you can see the

720
00:30:12,630 --> 00:30:15,930
three of the four of them are almost in

721
00:30:14,130 --> 00:30:17,790
a line to the right exactly we're going

722
00:30:15,930 --> 00:30:20,580
to get there we're going to show you

723
00:30:17,789 --> 00:30:24,149
that in the next frame so what we did

724
00:30:20,579 --> 00:30:26,849
however is because this has a very very

725
00:30:24,150 --> 00:30:29,880
exact alignment we needed to get the

726
00:30:26,849 --> 00:30:31,799
very very exact positions of all of the

727
00:30:29,880 --> 00:30:33,750

actors in this we need to get the the

728

00:30:31,799 --> 00:30:35,849

correct positions for Jupiter IO Europa

729

00:30:33,750 --> 00:30:37,500

close to and Ganymede also the correct

730

00:30:35,849 --> 00:30:39,599

position of Earth and the correct

731

00:30:37,500 --> 00:30:42,119

position of the Sun all relative to

732

00:30:39,599 --> 00:30:44,189

where Jupiter is so one of the cool

733

00:30:42,119 --> 00:30:46,829

things that you can do is you can go to

734

00:30:44,190 --> 00:30:48,570

the Jet Propulsion Laboratory and they

735

00:30:46,829 --> 00:30:51,869

have an ephemeris service they call it

736

00:30:48,569 --> 00:30:54,269

horizons and you can put in what objects

737

00:30:51,869 --> 00:30:58,139

you're looking for what time frame

738

00:30:54,269 --> 00:31:00,690

you're looking for and what and what's

739

00:30:58,140 --> 00:31:02,640

what Center you want to look want to

740

00:31:00,690 --> 00:31:05,490

have for your objects and it will give

741

00:31:02,640 --> 00:31:08,759

you the positions of those objects

742
00:31:05,490 --> 00:31:11,009
for those times so I was able to go to

743
00:31:08,759 --> 00:31:13,349
the JPL ephemeris site and get the exact

744
00:31:11,009 --> 00:31:16,980
positions download them as text files

745
00:31:13,349 --> 00:31:18,689
and import them into our 3d software so

746
00:31:16,980 --> 00:31:21,179
these are this is dumb done in the

747
00:31:18,690 --> 00:31:23,549
software Maya and so these are the

748
00:31:21,179 --> 00:31:25,890
correct positions so we during this

749
00:31:23,549 --> 00:31:29,099
visualization we zoom in now notice

750
00:31:25,890 --> 00:31:30,960
we've got these white dots for the for

751
00:31:29,099 --> 00:31:32,159
representing the moon's and as Tony

752
00:31:30,960 --> 00:31:33,750
pointed out you've got three of the

753
00:31:32,160 --> 00:31:36,240
moon's pretty much on the same line

754
00:31:33,750 --> 00:31:38,759
Ganymede is out of the way but hey we

755
00:31:36,240 --> 00:31:42,900
saw a Ganymede shadow for Halloween oh

756
00:31:38,759 --> 00:31:45,089
you saw that one all right so now as the

757
00:31:42,900 --> 00:31:48,809
camera poles in we fade out those white

758
00:31:45,089 --> 00:31:50,579
dots and can you see the planets you

759
00:31:48,808 --> 00:31:53,339
look really carefully you might be able

760
00:31:50,579 --> 00:31:56,399
to see them right I'll I put some arrows

761
00:31:53,339 --> 00:31:58,379
up oh there we go yes okay so there's

762
00:31:56,400 --> 00:32:01,800
Callisto there's Europa and there's I oh

763
00:31:58,380 --> 00:32:04,260
right and that that's that's where they

764
00:32:01,799 --> 00:32:06,720
are as we're zooming in and then the

765
00:32:04,259 --> 00:32:08,460
camera pulls in to sort of show you what

766
00:32:06,720 --> 00:32:10,319
it looks like and you've got the shadow

767
00:32:08,460 --> 00:32:12,630
of the three shadows moving across and

768
00:32:10,319 --> 00:32:16,169
then we continue to let time pass and

769
00:32:12,630 --> 00:32:18,030
the shadows move across however Tony

770

00:32:16,170 --> 00:32:20,850
here's your challenge for the day

771
00:32:18,029 --> 00:32:24,960
alright oh no I'm being cut where's

772
00:32:20,849 --> 00:32:28,709
Callisto I don't see it's out of the

773
00:32:24,960 --> 00:32:30,480
front of the field of view okay so here

774
00:32:28,710 --> 00:32:33,029
it here here's your challenge for the

775
00:32:30,480 --> 00:32:36,720
today so on the right is the Hubble

776
00:32:33,029 --> 00:32:39,899
observation at 7-10 UT and on the left

777
00:32:36,720 --> 00:32:41,789
is the visualization approximately the

778
00:32:39,900 --> 00:32:44,580
same time and you can see that the

779
00:32:41,789 --> 00:32:48,649
Callisto shadow and Europa shadow line

780
00:32:44,579 --> 00:32:51,689
up yes iowa's in at the same position

781
00:32:48,650 --> 00:32:53,429
Callisto isn't up here and your rope is

782
00:32:51,690 --> 00:32:56,820
still off-screen it hasn't gotten off

783
00:32:53,429 --> 00:32:59,100
screen now I told you that we got the

784
00:32:56,819 --> 00:33:01,379

exact positions from the ephemeris and

785

00:32:59,099 --> 00:33:02,639

matter of fact that positions have to be

786

00:33:01,380 --> 00:33:06,870

right because those shadows are being

787

00:33:02,640 --> 00:33:10,110

cast in the 3d software so what is it

788

00:33:06,869 --> 00:33:14,129

that we couldn't do right and the thing

789

00:33:10,109 --> 00:33:16,918

is we couldn't get a camera to have the

790

00:33:14,130 --> 00:33:19,110

same tiny tiny tiny tiny tiny field of

791

00:33:16,919 --> 00:33:21,690

view as Hubble

792

00:33:19,109 --> 00:33:24,419

ah the visualization software that we

793

00:33:21,690 --> 00:33:25,620

use we try to extend the focal length of

794

00:33:24,420 --> 00:33:27,120

the camera so that the field of view

795

00:33:25,619 --> 00:33:29,819

gets smaller and smaller and smaller and

796

00:33:27,119 --> 00:33:31,829

smaller but it appears it has a limit

797

00:33:29,819 --> 00:33:35,129

and that its smallest field of view is

798

00:33:31,829 --> 00:33:36,599

only a degree across whereas Hubble's

799

00:33:35,130 --> 00:33:39,420
field of view if you remember is about

800

00:33:36,599 --> 00:33:41,669
three arc minutes across and a fact

801

00:33:39,420 --> 00:33:44,370
Jupiter is even smaller than that yeah

802

00:33:41,670 --> 00:33:46,170
so it was kind of funky guy I knew going

803

00:33:44,369 --> 00:33:47,729
into this that all right well it's going

804

00:33:46,170 --> 00:33:49,769
to be difficult to try and exactly

805

00:33:47,730 --> 00:33:52,250
reproduce the Hubble how the Hubble view

806

00:33:49,769 --> 00:33:54,509
is your camera has to be you know almost

807

00:33:52,250 --> 00:33:57,630
orthographic camera almost up a plane

808

00:33:54,509 --> 00:33:59,460
parallel camera but it was funky that we

809

00:33:57,630 --> 00:34:01,590
couldn't that week that this software

810

00:33:59,460 --> 00:34:03,000
only had a limitation yeah well you

811

00:34:01,589 --> 00:34:04,048
could kind of see that in the disk of

812

00:34:03,000 --> 00:34:07,380
Jupiter I mean you can see you've got

813
00:34:04,048 --> 00:34:09,898
all of the disk in the in the frame and

814
00:34:07,380 --> 00:34:13,590
your simulation but the Hubble image has

815
00:34:09,898 --> 00:34:15,628
it cropped out so yeah so the field of

816
00:34:13,590 --> 00:34:17,879
view isn't as big their infield views if

817
00:34:15,628 --> 00:34:19,529
he isn't quite quite big I mean but also

818
00:34:17,878 --> 00:34:23,368
I mean we just couldn't get the camera

819
00:34:19,530 --> 00:34:25,649
the the the the software camera to

820
00:34:23,369 --> 00:34:26,970
reproduce the Hubble camera images and

821
00:34:25,648 --> 00:34:29,219
so what I think I figured out as i was

822
00:34:26,969 --> 00:34:31,199
going to lunch today as I was prepping

823
00:34:29,219 --> 00:34:34,138
this talk I said well you know we could

824
00:34:31,199 --> 00:34:35,638
do we could do a one degree camera but

825
00:34:34,139 --> 00:34:37,800
then put in tons and tons and tons of

826
00:34:35,639 --> 00:34:39,990
pixels in the image and then only do the

827

00:34:37,800 --> 00:34:42,840
very very smallest things but that would

828
00:34:39,989 --> 00:34:45,449
be really uh you didn't do that you gave

829
00:34:42,840 --> 00:34:48,030
you a delete it be lunch is now occult

830
00:34:45,449 --> 00:34:49,799
and be monstrously difficult so Greg

831
00:34:48,030 --> 00:34:51,990
bacon and I actually discussed all right

832
00:34:49,800 --> 00:34:54,359
let's see if we can fake a Hubble camera

833
00:34:51,989 --> 00:34:57,059
I can force the hot software to do what

834
00:34:54,358 --> 00:34:59,460
we think it was so this will be fun to

835
00:34:57,059 --> 00:35:01,049
play with but I just wanted to show you

836
00:34:59,460 --> 00:35:04,710
that some of the things is that because

837
00:35:01,050 --> 00:35:06,269
Hubble has such a tiny feel of you if we

838
00:35:04,710 --> 00:35:07,619
want to try and reproduce these things

839
00:35:06,269 --> 00:35:09,449
we've got to be able to reduce

840
00:35:07,619 --> 00:35:11,760
everything in the visualization software

841
00:35:09,449 --> 00:35:13,589

and sometimes it it's built for

842

00:35:11,760 --> 00:35:15,420

Hollywood make movies and they don't

843

00:35:13,590 --> 00:35:19,460

really have these tiny tiny tiny field

844

00:35:15,420 --> 00:35:21,599

of youth like we do yeah yeah it's uh

845

00:35:19,460 --> 00:35:22,920

that that that's the software they use

846

00:35:21,599 --> 00:35:24,960

for like making special effects and

847

00:35:22,920 --> 00:35:26,460

stuff right and exactly Maya's used on

848

00:35:24,960 --> 00:35:29,400

most every Hollywood film you've ever

849

00:35:26,460 --> 00:35:31,710

seen alright so that was just how the

850

00:35:29,400 --> 00:35:32,220

way of adding a special insight on that

851

00:35:31,710 --> 00:35:35,220

one

852

00:35:32,219 --> 00:35:37,500

cool let me finally get to art Hubble

853

00:35:35,219 --> 00:35:39,959

retrospective because we're doing a lot

854

00:35:37,500 --> 00:35:43,469

of things for 25 years of help where r

855

00:35:39,960 --> 00:35:45,449

Hubble's 25th anniversary and one of the

856
00:35:43,469 --> 00:35:47,608
things that I'm responsible for is sort

857
00:35:45,449 --> 00:35:50,579
of looking over the history of Hubble

858
00:35:47,608 --> 00:35:53,069
and trying to go through what is Hubble

859
00:35:50,579 --> 00:35:56,340
done specifically in certain subject

860
00:35:53,070 --> 00:35:58,619
areas so the first thing I just the

861
00:35:56,340 --> 00:36:01,289
first thing I hit well I pulled together

862
00:35:58,619 --> 00:36:03,900
some slides of what Hubble has observed

863
00:36:01,289 --> 00:36:06,679
in the area of supernovae so supernova

864
00:36:03,900 --> 00:36:11,579
explosions just in case you didn't know

865
00:36:06,679 --> 00:36:14,339
supernova is when a star explodes ok and

866
00:36:11,579 --> 00:36:16,710
there's a couple ways that it can do it

867
00:36:14,340 --> 00:36:20,099
can do so I've one can be a very massive

868
00:36:16,710 --> 00:36:22,260
star reaches the end of its life and it

869
00:36:20,099 --> 00:36:26,760
has a Thurman appear catastrophe on the

870
00:36:22,260 --> 00:36:29,970
inside and explodes another way is that

871
00:36:26,760 --> 00:36:32,340
when a white dwarf star as mass added on

872
00:36:29,969 --> 00:36:34,649
to it it can go over what we call the

873
00:36:32,340 --> 00:36:37,829
Chandrasekhar limit and it could also

874
00:36:34,650 --> 00:36:40,619
then explode all right so this is a

875
00:36:37,829 --> 00:36:43,588
picture of a star that has exploded on

876
00:36:40,619 --> 00:36:46,050
the left is the before image and on the

877
00:36:43,588 --> 00:36:50,190
right is the after image this is

878
00:36:46,050 --> 00:36:56,070
supernova 1987a which was observed in

879
00:36:50,190 --> 00:36:59,220
January of 1987 and this star is a star

880
00:36:56,070 --> 00:37:01,019
in these large magellanic cloud and you

881
00:36:59,219 --> 00:37:03,598
can see that it brightens up by a

882
00:37:01,019 --> 00:37:05,338
concern out well when it does that

883
00:37:03,599 --> 00:37:08,580
explosion and the large reg Atlanta

884

00:37:05,338 --> 00:37:10,769
cloud is a dwarf galaxy that is right

885
00:37:08,579 --> 00:37:12,900
next right next door to us one of our

886
00:37:10,769 --> 00:37:14,460
neighboring galaxies right next door we

887
00:37:12,900 --> 00:37:15,950
talked about in Andromeda galaxy beam

888
00:37:14,460 --> 00:37:19,559
two and a half million light-years away

889
00:37:15,949 --> 00:37:21,539
so the lmc is about a hundred and

890
00:37:19,559 --> 00:37:24,299
seventy-five thousand light-years away

891
00:37:21,539 --> 00:37:25,710
and if you happen to be lucky enough to

892
00:37:24,300 --> 00:37:27,510
live in the southern hemisphere you get

893
00:37:25,710 --> 00:37:29,460
to see it all the time right now all the

894
00:37:27,510 --> 00:37:31,410
time but with this up in the sky

895
00:37:29,460 --> 00:37:32,639
unfortunately I can say I've never never

896
00:37:31,409 --> 00:37:34,679
been down the southern hemisphere and

897
00:37:32,639 --> 00:37:37,529
being able to see the large or small

898
00:37:34,679 --> 00:37:43,440

small Magellanic Clouds I have laa laa

899

00:37:37,530 --> 00:37:45,600

laa laa cera to Lulu I saw it and of

900

00:37:43,440 --> 00:37:49,019

course that means that although

901

00:37:45,599 --> 00:37:52,110

we saw this light in 1987 the star

902

00:37:49,019 --> 00:37:53,969

itself actually exploded about 175,000

903

00:37:52,110 --> 00:37:56,010

years ago and it's the light that has

904

00:37:53,969 --> 00:37:58,889

been traveling 10 75,000 years across

905

00:37:56,010 --> 00:38:02,180

space until we observed it in 1987

906

00:37:58,889 --> 00:38:04,589

there's always that space time

907

00:38:02,179 --> 00:38:06,899

calculation of speed of light land but

908

00:38:04,590 --> 00:38:08,579

at least a couple call an 87 a because

909

00:38:06,900 --> 00:38:11,460

when we observed it is of course the way

910

00:38:08,579 --> 00:38:13,529

we talk about these things ok so when

911

00:38:11,460 --> 00:38:17,789

Hubble this was before Hubble launched

912

00:38:13,530 --> 00:38:19,530

1987 Hubble launched in 1990 Hubble did

913
00:38:17,789 --> 00:38:21,539
look at it while there was the silver

914
00:38:19,530 --> 00:38:23,519
flan amira but i'm going to show the

915
00:38:21,539 --> 00:38:27,570
next one I'm going to jump to is 1994

916
00:38:23,519 --> 00:38:31,380
and this is the image that Hubble got of

917
00:38:27,570 --> 00:38:33,420
supernova 1987a in 1994 after they

918
00:38:31,380 --> 00:38:36,750
repair mission so this is with the fixed

919
00:38:33,420 --> 00:38:37,950
camera and it's important because you

920
00:38:36,750 --> 00:38:41,300
can see that when they've got these

921
00:38:37,949 --> 00:38:43,799
rings here okay these very faint rings

922
00:38:41,300 --> 00:38:45,180
all right let me just talk you through

923
00:38:43,800 --> 00:38:48,000
the image let's start in the very center

924
00:38:45,179 --> 00:38:51,149
that's dot right in there is the

925
00:38:48,000 --> 00:38:52,860
supernova where the star exploded it's

926
00:38:51,150 --> 00:38:56,250
no longer a star there it's now a

927
00:38:52,860 --> 00:38:59,160
supernova remnant a gas cloud and that

928
00:38:56,250 --> 00:39:02,309
gas cloud is expanding at millions of

929
00:38:59,159 --> 00:39:04,460
miles an hour all right then you have

930
00:39:02,309 --> 00:39:07,559
this yellow ring around the center

931
00:39:04,460 --> 00:39:09,539
obviously this yellow ring did not come

932
00:39:07,559 --> 00:39:12,349
from the supernova explosion it was

933
00:39:09,539 --> 00:39:16,139
there in advance this was a blowout

934
00:39:12,349 --> 00:39:18,420
material blown out from the star before

935
00:39:16,139 --> 00:39:20,819
it explodes one of the interesting

936
00:39:18,420 --> 00:39:23,369
things about supernova is to study what

937
00:39:20,820 --> 00:39:25,950
happens in these precursor phases before

938
00:39:23,369 --> 00:39:28,619
the explosion happens we see a lot of

939
00:39:25,949 --> 00:39:30,299
blowouts we see things at the inn in

940
00:39:28,619 --> 00:39:32,159
Ocarina we see things in other places

941

00:39:30,300 --> 00:39:35,010
that there's evidence that there's uh

942
00:39:32,159 --> 00:39:38,279
there's unstable phases before the

943
00:39:35,010 --> 00:39:41,040
actual explosion and so with 87a we see

944
00:39:38,280 --> 00:39:43,410
evidence of definitely a ring that was a

945
00:39:41,039 --> 00:39:45,119
pre-existing that pre-existing before

946
00:39:43,409 --> 00:39:47,069
the supernova must have been blonde in

947
00:39:45,119 --> 00:39:49,769
previous phase now is it true that you

948
00:39:47,070 --> 00:39:52,769
could take the width of that circle or

949
00:39:49,769 --> 00:39:54,509
how far away it is from the star where

950
00:39:52,769 --> 00:39:57,449
it actually exploded and get a sense of

951
00:39:54,510 --> 00:39:58,869
how much earlier it went off prior to

952
00:39:57,449 --> 00:40:01,669
the supernova

953
00:39:58,869 --> 00:40:04,249
only a thon the ring only if you knew

954
00:40:01,670 --> 00:40:07,430
the velocity right which is expanding

955
00:40:04,248 --> 00:40:09,980

okay and so we don't know that I guess

956

00:40:07,429 --> 00:40:13,159

yeah but we will know that in a minute

957

00:40:09,980 --> 00:40:14,480

okay we're gonna know we don't know it

958

00:40:13,159 --> 00:40:16,670

now we're gonna know something's there I

959

00:40:14,480 --> 00:40:17,929

guess I 1984 or we did all right and

960

00:40:16,670 --> 00:40:21,950

then the other cool thing one of these

961

00:40:17,929 --> 00:40:24,108

big red thin rings okay now I notice the

962

00:40:21,949 --> 00:40:25,730

two white dots those are just stars they

963

00:40:24,108 --> 00:40:27,318

happen to be a long line of sight they

964

00:40:25,730 --> 00:40:29,960

have nothing to do with supernova okay

965

00:40:27,318 --> 00:40:34,009

all right but you got these big thin red

966

00:40:29,960 --> 00:40:36,079

rings which are way outside the the

967

00:40:34,009 --> 00:40:38,690

inner yellow ring and the supernova

968

00:40:36,079 --> 00:40:41,269

remnant in the center and these were

969

00:40:38,690 --> 00:40:42,739

kind of puzzling at first because I

970
00:40:41,268 --> 00:40:44,449
don't know I can sort of imagine a TIE

971
00:40:42,739 --> 00:40:48,739
fighter from Star Wars or something here

972
00:40:44,449 --> 00:40:51,018
or look at this gun and so the idea was

973
00:40:48,739 --> 00:40:53,599
that maybe there was a jet from the star

974
00:40:51,018 --> 00:40:55,608
in this pre supernova phase and the jet

975
00:40:53,599 --> 00:40:57,920
goes out in opposite direction and then

976
00:40:55,608 --> 00:41:01,670
rotates around you got a spinning jet

977
00:40:57,920 --> 00:41:06,349
that could illuminate gas and create

978
00:41:01,670 --> 00:41:08,630
these rings way away okay so just really

979
00:41:06,349 --> 00:41:10,130
cool structures that we sort of hadn't

980
00:41:08,630 --> 00:41:11,599
expected to see so I'm you see a

981
00:41:10,130 --> 00:41:13,099
rotating jet are you talking about

982
00:41:11,599 --> 00:41:14,980
something that's kind of doing this kind

983
00:41:13,099 --> 00:41:18,289
of thing where it's making a circle

984
00:41:14,980 --> 00:41:20,838
mm-hmm kind of like that okay yeah I was

985
00:41:18,289 --> 00:41:23,569
doing it on my video as well taking you

986
00:41:20,838 --> 00:41:25,130
know uh you know in a spinning top right

987
00:41:23,568 --> 00:41:27,469
and if it's standing up straight it's is

988
00:41:25,130 --> 00:41:29,838
doing but once it wobbles right in the

989
00:41:27,469 --> 00:41:32,778
spinning top wobbles and that wobbling

990
00:41:29,838 --> 00:41:36,170
motion well certain scribe a circle so

991
00:41:32,778 --> 00:41:40,400
that jet could illuminate material based

992
00:41:36,170 --> 00:41:41,630
upon a five by its waddle okay yeah what

993
00:41:40,400 --> 00:41:44,838
so what wavelengths are we looking at

994
00:41:41,630 --> 00:41:48,349
here oh I don't remember this is 1994

995
00:41:44,838 --> 00:41:49,849
before i came to Apple oh okay no I

996
00:41:48,349 --> 00:41:55,130
didn't look I'm sorry I didn't that's

997
00:41:49,849 --> 00:41:57,710
alright that's cool okay so then we

998

00:41:55,130 --> 00:41:59,720
started looking at that inner ring over

999
00:41:57,710 --> 00:42:02,869
and over and over again and so this is

1000
00:41:59,719 --> 00:42:08,179
an amazing image that shows you the how

1001
00:42:02,869 --> 00:42:11,840
it looks from 1994 through to 2003 now

1002
00:42:08,179 --> 00:42:15,349
as there's a star at about what

1003
00:42:11,840 --> 00:42:16,820
at four o'clock four or five o'clock on

1004
00:42:15,349 --> 00:42:19,969
it that that doesn't have anything to do

1005
00:42:16,820 --> 00:42:21,830
it which is just pre-existing okay okay

1006
00:42:19,969 --> 00:42:24,859
so that's just a bright spot but as you

1007
00:42:21,829 --> 00:42:27,829
go across the top row not much happens

1008
00:42:24,860 --> 00:42:30,559
as you go to the second row you start to

1009
00:42:27,829 --> 00:42:32,299
see another bright spot up here and then

1010
00:42:30,559 --> 00:42:34,549
you know towards the end more bright

1011
00:42:32,300 --> 00:42:36,260
spots appear and then as you come

1012
00:42:34,550 --> 00:42:39,019

through the bottom row you're seeing

1013

00:42:36,260 --> 00:42:43,130

lots and lots of bright spots up here in

1014

00:42:39,019 --> 00:42:45,550

this ring what's happening the shock

1015

00:42:43,130 --> 00:42:50,599

wave from the supernova explosion is

1016

00:42:45,550 --> 00:42:53,080

expanding and reaching that ring you're

1017

00:42:50,599 --> 00:42:56,679

seeing the shock wave from the supernova

1018

00:42:53,079 --> 00:43:01,279

interacting with this projected ring

1019

00:42:56,679 --> 00:43:03,440

really cool that is cool plus you are

1020

00:43:01,280 --> 00:43:07,280

seeing that inner supernova remnant that

1021

00:43:03,440 --> 00:43:09,579

gas cloud also blow out so on this next

1022

00:43:07,280 --> 00:43:12,530

image from 2011 eight years after that

1023

00:43:09,579 --> 00:43:14,960

you can clearly see the ring is lit up

1024

00:43:12,530 --> 00:43:17,300

by the shock wave passing through it as

1025

00:43:14,960 --> 00:43:19,599

well as that supernova explosion

1026

00:43:17,300 --> 00:43:21,950

supernova remnant is blowing out

1027
00:43:19,599 --> 00:43:24,099
although I gotta say when you look at

1028
00:43:21,949 --> 00:43:29,869
that supernova road what do you see ah

1029
00:43:24,099 --> 00:43:32,059
blurry myths I see Homer Simpson oh now

1030
00:43:29,869 --> 00:43:40,130
I do actually see the profile of Homer

1031
00:43:32,059 --> 00:43:42,139
Simpson there's haha I guess so well

1032
00:43:40,130 --> 00:43:45,110
anyways so what's really cool about

1033
00:43:42,139 --> 00:43:46,969
superdome 87a and I'll finish with his

1034
00:43:45,110 --> 00:43:48,829
last image of it with is really small is

1035
00:43:46,969 --> 00:43:51,559
that we've been able to watch the

1036
00:43:48,829 --> 00:43:54,349
development Isis renova on over the

1037
00:43:51,559 --> 00:43:57,079
course of 20 years not many things

1038
00:43:54,349 --> 00:43:58,519
change on human timescales but were able

1039
00:43:57,079 --> 00:44:00,739
to watch the birth of a supernova

1040
00:43:58,519 --> 00:44:05,090
remnant from it's very beginning and

1041
00:44:00,739 --> 00:44:09,309
that's kind of cool now we also looked

1042
00:44:05,090 --> 00:44:12,950
at other supernovae and in john july 4th

1043
00:44:09,309 --> 00:44:15,289
1054 there was a guest star in the night

1044
00:44:12,949 --> 00:44:18,679
sky it was observed by chinese

1045
00:44:15,289 --> 00:44:21,110
astronomers and this here is what they

1046
00:44:18,679 --> 00:44:24,469
call it petrol graph it's in Chaco

1047
00:44:21,110 --> 00:44:25,260
Canyon National Park and they believe it

1048
00:44:24,469 --> 00:44:28,349
may be a ver

1049
00:44:25,260 --> 00:44:31,080
hoarding of that new star appearing in

1050
00:44:28,349 --> 00:44:35,429
the sky you know what we call that star

1051
00:44:31,079 --> 00:44:36,329
today we call it the Crab Nebula okay

1052
00:44:35,429 --> 00:44:40,460
don't know if you want me to give it

1053
00:44:36,329 --> 00:44:44,159
away or not you can give it away please

1054
00:44:40,460 --> 00:44:46,260
the Anasazi may have seen the Crab

1055

00:44:44,159 --> 00:44:49,349
Nebula explosion a thousand years ago

1056
00:44:46,260 --> 00:44:53,520
what Hubble sees today is this image

1057
00:44:49,349 --> 00:44:56,509
this is the Crab Nebula basically the

1058
00:44:53,519 --> 00:44:59,690
guts of a star just blown out into space

1059
00:44:56,510 --> 00:45:03,810
and what we're looking at here are the

1060
00:44:59,690 --> 00:45:05,789
emissions from oxygen and sulfur there's

1061
00:45:03,809 --> 00:45:08,250
neutral neutral oxygen and doubly

1062
00:45:05,789 --> 00:45:10,860
ionized oxygen we're seeing looking at

1063
00:45:08,250 --> 00:45:13,289
the very particular the elements that

1064
00:45:10,860 --> 00:45:15,180
the the very particular wavelengths that

1065
00:45:13,289 --> 00:45:17,880
that emitted by those elements but you

1066
00:45:15,179 --> 00:45:20,129
can see the amazing no detail this is a

1067
00:45:17,880 --> 00:45:22,470
30 million pixel image if you go to

1068
00:45:20,130 --> 00:45:24,510
Hubble site and download you can see the

1069
00:45:22,469 --> 00:45:27,389

structure of the material just throw it

1070

00:45:24,510 --> 00:45:31,380

out this is a thousand years after the

1071

00:45:27,389 --> 00:45:34,049

stars exploded so it's super over 87a we

1072

00:45:31,380 --> 00:45:36,110

get to watch a star that's just in the

1073

00:45:34,050 --> 00:45:39,360

first few decades of its explosion and

1074

00:45:36,110 --> 00:45:41,160

it is here into the Crab Nebula were

1075

00:45:39,360 --> 00:45:43,860

able to see a star that's that exploded

1076

00:45:41,159 --> 00:45:46,619

a thousand years ago we looked at a

1077

00:45:43,860 --> 00:45:50,430

couple other supernova remnants this one

1078

00:45:46,619 --> 00:45:52,409

is Cassiopeia A and I thought this was

1079

00:45:50,429 --> 00:45:54,449

an old supernova remnant in fact I gave

1080

00:45:52,409 --> 00:45:56,039

a talk a couple weeks ago and i said i

1081

00:45:54,449 --> 00:45:58,369

think it's about ten thousand thirty

1082

00:45:56,039 --> 00:46:01,710

thousand years old and i'm totally wrong

1083

00:45:58,369 --> 00:46:04,739

okay why are you wrong I was totally

1084
00:46:01,710 --> 00:46:06,750
wrong do you mark the date yeah this one

1085
00:46:04,739 --> 00:46:09,269
is the youngest supernova remnant we

1086
00:46:06,750 --> 00:46:10,980
know of you can see how broad and

1087
00:46:09,269 --> 00:46:14,309
dispersed it is and I that's what maybe

1088
00:46:10,980 --> 00:46:16,320
think it was really old um it looks like

1089
00:46:14,309 --> 00:46:18,029
it's you know at that they got that

1090
00:46:16,320 --> 00:46:20,220
crowd supernova remnant is a thousand

1091
00:46:18,030 --> 00:46:21,750
years old and then this is diffused away

1092
00:46:20,219 --> 00:46:24,000
and it looks like it's tens of thousands

1093
00:46:21,750 --> 00:46:26,250
of years old I they tell me that this is

1094
00:46:24,000 --> 00:46:28,920
only three hundred and forty years old

1095
00:46:26,250 --> 00:46:31,230
wow it's also very strong in the radio I

1096
00:46:28,920 --> 00:46:32,820
only know that because I was learning

1097
00:46:31,230 --> 00:46:33,929
how to use radio telescope once and that

1098
00:46:32,820 --> 00:46:36,990
was a point source we could easily

1099
00:46:33,929 --> 00:46:38,489
identify so that is why is called

1100
00:46:36,989 --> 00:46:40,469
Cassiopeia A

1101
00:46:38,489 --> 00:46:42,118
because that a means that it's the

1102
00:46:40,469 --> 00:46:45,899
brightest source in the Sun

1103
00:46:42,119 --> 00:46:48,630
constellation Cassiopeia and so this is

1104
00:46:45,900 --> 00:46:50,460
this is the cool image of that and you

1105
00:46:48,630 --> 00:46:53,340
can see it also has that fractured

1106
00:46:50,460 --> 00:46:56,699
appearance that we see in the Crab

1107
00:46:53,340 --> 00:46:59,820
Nebula well we also have looked at this

1108
00:46:56,699 --> 00:47:01,829
image that this supernova remnant this

1109
00:46:59,820 --> 00:47:03,450
is another supernova in the Large

1110
00:47:01,829 --> 00:47:10,829
Magellanic Cloud and it's supernova

1111
00:47:03,449 --> 00:47:14,159
remnant 0509 dash 67.5 oh yeah we call

1112

00:47:10,829 --> 00:47:18,210
0509 for short right it doesn't have a

1113
00:47:14,159 --> 00:47:20,730
fun named funding to it this one is also

1114
00:47:18,210 --> 00:47:23,519
about 400 years old but you can see it's

1115
00:47:20,730 --> 00:47:28,309
roughly circular and the reason for that

1116
00:47:23,519 --> 00:47:31,530
may be that it is a supernova type 1a a

1117
00:47:28,309 --> 00:47:34,590
explosion of a white dwarf whereas the

1118
00:47:31,530 --> 00:47:36,780
crab supernova is a explosion of a

1119
00:47:34,590 --> 00:47:38,789
massive star I told you there are two

1120
00:47:36,780 --> 00:47:41,670
different types of supernovae when a

1121
00:47:38,789 --> 00:47:44,519
massive stars explode versus the white

1122
00:47:41,670 --> 00:47:46,500
dwarfs explode this remarkable symmetry

1123
00:47:44,519 --> 00:47:48,329
that we see here may be due to the fact

1124
00:47:46,500 --> 00:47:51,059
that it's a white dwarf explosion

1125
00:47:48,329 --> 00:47:52,590
instead of massive star explosion all

1126
00:47:51,059 --> 00:47:55,619

right I got one more supernova to go to

1127

00:47:52,590 --> 00:47:57,480

and here is where we see that Hubble

1128

00:47:55,619 --> 00:48:00,390

doesn't always have the prettiest image

1129

00:47:57,480 --> 00:48:04,108

okay so this is what we call Kepler

1130

00:48:00,389 --> 00:48:07,019

supernova supernova of 1604 observed by

1131

00:48:04,108 --> 00:48:10,019

Johannes Kepler and you can see just a

1132

00:48:07,019 --> 00:48:13,500

little bit of stuff in the Hubble image

1133

00:48:10,019 --> 00:48:16,289

on the left the Hubble image just shows

1134

00:48:13,500 --> 00:48:18,030

a little bit of stuff this is again 1604

1135

00:48:16,289 --> 00:48:19,889

so this is another four hundred year old

1136

00:48:18,030 --> 00:48:22,440

I don't know why we have three of these

1137

00:48:19,889 --> 00:48:24,929

that are you know on a year old

1138

00:48:22,440 --> 00:48:26,550

supernova remnants why do we don't have

1139

00:48:24,929 --> 00:48:28,469

that some hundred year old ones five

1140

00:48:26,550 --> 00:48:30,269

minutes it's really frustrating that

1141
00:48:28,469 --> 00:48:32,099
since the invention of the telescope you

1142
00:48:30,269 --> 00:48:35,039
haven't seen a really good supernova in

1143
00:48:32,099 --> 00:48:38,009
our own galaxy and the closest since

1144
00:48:35,039 --> 00:48:39,869
they know telescope all right but you

1145
00:48:38,010 --> 00:48:42,240
can see there's Hubble on the left which

1146
00:48:39,869 --> 00:48:44,369
doesn't see that much Spitzer in the

1147
00:48:42,239 --> 00:48:46,949
center observes an infrared and you can

1148
00:48:44,369 --> 00:48:50,519
seize them the warm gas in the infrared

1149
00:48:46,949 --> 00:48:52,199
but as you said the x-rays are often the

1150
00:48:50,519 --> 00:48:54,239
most exciting for these

1151
00:48:52,199 --> 00:48:56,279
supernova remnants so here on the right

1152
00:48:54,239 --> 00:48:58,889
you see the Chandra x-ray Observatory

1153
00:48:56,280 --> 00:49:01,829
observing an x rays you can see all that

1154
00:48:58,889 --> 00:49:04,739
hot gas hundred thousand million degree

1155
00:49:01,829 --> 00:49:07,140
gasps that's filling that entire bubble

1156
00:49:04,739 --> 00:49:10,379
of the supernova explosion here in

1157
00:49:07,139 --> 00:49:14,009
Kepler's supernova remnant so combining

1158
00:49:10,380 --> 00:49:16,470
Hubble with infrared with x-rays and all

1159
00:49:14,010 --> 00:49:20,040
this history you can see we get to look

1160
00:49:16,469 --> 00:49:22,049
at young supernova some decades old some

1161
00:49:20,039 --> 00:49:24,000
hundreds of years old some thousands of

1162
00:49:22,050 --> 00:49:26,250
years old and there are others that are

1163
00:49:24,000 --> 00:49:27,690
tens of thousands of years old Hubble

1164
00:49:26,250 --> 00:49:30,719
has been able to contribute to our

1165
00:49:27,690 --> 00:49:33,030
knowledge of supernovae both in its own

1166
00:49:30,719 --> 00:49:36,088
observations and in comparison to our

1167
00:49:33,030 --> 00:49:38,010
other great observatories also that you

1168
00:49:36,088 --> 00:49:40,739
bring up an interesting point what is

1169

00:49:38,010 --> 00:49:43,020
the supernova rate do we have an idea

1170
00:49:40,739 --> 00:49:46,769
how often supernova explode in our

1171
00:49:43,019 --> 00:49:48,719
galaxy we do we pretend we do okay what

1172
00:49:46,769 --> 00:49:51,480
do we what do we feel we go and we like

1173
00:49:48,719 --> 00:49:52,409
to think that in a large galaxies like

1174
00:49:51,480 --> 00:49:54,659
the Milky Way there should be

1175
00:49:52,409 --> 00:49:57,719
approximately one supernova every

1176
00:49:54,659 --> 00:50:02,789
hundred years okay okay so we're kind of

1177
00:49:57,719 --> 00:50:05,009
so working on K 1 because of 1987a was

1178
00:50:02,789 --> 00:50:08,159
was in our galaxy in our galaxy it's in

1179
00:50:05,010 --> 00:50:11,369
the lmc oh sorry your kid and we can

1180
00:50:08,159 --> 00:50:13,649
write your hundred years we are 30 and I

1181
00:50:11,369 --> 00:50:18,539
guess we said that the the Cassiopeia A

1182
00:50:13,650 --> 00:50:20,910
wasn't visible and you know why we

1183
00:50:18,539 --> 00:50:23,159

didn't seek a supe 340 years ago I don't

1184

00:50:20,909 --> 00:50:24,420

know but we haven't had a good one in

1185

00:50:23,159 --> 00:50:26,250

the last hundred years when we got these

1186

00:50:24,420 --> 00:50:28,740

really great telescopes to look at it

1187

00:50:26,250 --> 00:50:31,019

although 87a is the best we've got so

1188

00:50:28,739 --> 00:50:32,608

far cool okay well so we are dude that's

1189

00:50:31,019 --> 00:50:33,960

good to know all right let me get to

1190

00:50:32,608 --> 00:50:38,460

some we got some comments and questions

1191

00:50:33,960 --> 00:50:41,068

lined up here I wanna go so Daniel

1192

00:50:38,460 --> 00:50:43,710

Masato is is commenting super Noda

1193

00:50:41,068 --> 00:50:47,219

supernova 1987a does look like a TIE

1194

00:50:43,710 --> 00:50:49,740

fighter or the eye of sauron so I have

1195

00:50:47,219 --> 00:50:52,559

to disagree the eye of sauron is from a

1196

00:50:49,739 --> 00:50:54,799

lot okay os from yeah we do have when

1197

00:50:52,559 --> 00:50:57,420

actually we actually called it um and

1198
00:50:54,800 --> 00:50:59,310
causal Joe is commenting in the Q&A app

1199
00:50:57,420 --> 00:51:01,318
I really enjoyed looking through the

1200
00:50:59,309 --> 00:51:03,239
Andromeda image using the zoom tool I

1201
00:51:01,318 --> 00:51:05,969
can see the star density change with

1202
00:51:03,239 --> 00:51:08,019
distance from the center it's amazing

1203
00:51:05,969 --> 00:51:09,818
that's really what we'd love for you to

1204
00:51:08,019 --> 00:51:12,940
be able to do that self-directed

1205
00:51:09,818 --> 00:51:14,798
expiration using the zoom tool is a way

1206
00:51:12,940 --> 00:51:17,650
you really really learn and really

1207
00:51:14,798 --> 00:51:19,630
understand right and so thank you thank

1208
00:51:17,650 --> 00:51:22,660
you call till Joe that's a great handle

1209
00:51:19,630 --> 00:51:25,630
two so let's go Adam synergy has a

1210
00:51:22,659 --> 00:51:28,029
question has a supermassive black hole

1211
00:51:25,630 --> 00:51:32,349
been identified at the center of

1212
00:51:28,030 --> 00:51:34,059
Andromeda yes it has and one of the

1213
00:51:32,349 --> 00:51:35,260
contributions Hubble made was actually

1214
00:51:34,059 --> 00:51:38,109
identifying where the center of

1215
00:51:35,260 --> 00:51:40,990
Andromeda is and looking in detail at

1216
00:51:38,108 --> 00:51:43,328
the motions of stars around the center

1217
00:51:40,989 --> 00:51:45,399
of Andromeda and measuring the mass of

1218
00:51:43,329 --> 00:51:49,000
the supermassive black hole which I

1219
00:51:45,400 --> 00:51:51,849
believe was on the order of 4 4 to 6

1220
00:51:49,000 --> 00:51:53,440
million solar masses we've got about a 2

1221
00:51:51,849 --> 00:51:56,079
million solar mass black hole center of

1222
00:51:53,440 --> 00:51:57,490
our galaxy the one in Andromeda is like

1223
00:51:56,079 --> 00:51:59,829
4 to 6 million if I remember correctly

1224
00:51:57,489 --> 00:52:01,959
and it's a physically larger galaxy than

1225
00:51:59,829 --> 00:52:04,150
ours too yeah it's about twenty thirty

1226

00:52:01,960 --> 00:52:05,769
percent larger than ours right so good

1227
00:52:04,150 --> 00:52:08,619
question Adam and welcome back it's good

1228
00:52:05,769 --> 00:52:10,838
to have you back Andrew planet I keep

1229
00:52:08,619 --> 00:52:12,430
wanting to eat 10 I know I feel like I

1230
00:52:10,838 --> 00:52:16,210
know you know I want to call you Andy I

1231
00:52:12,429 --> 00:52:18,429
hope you they're mad so he's asking if

1232
00:52:16,210 --> 00:52:20,470
galactic nuclei aren't spherically

1233
00:52:18,429 --> 00:52:22,960
shaped doesn't that mean that the forces

1234
00:52:20,469 --> 00:52:25,558
creating them are indicative of their

1235
00:52:22,960 --> 00:52:28,088
form therefore gravitationally uneven

1236
00:52:25,559 --> 00:52:31,750
has that possibility anything to do with

1237
00:52:28,088 --> 00:52:33,578
dark matter so galactic nuclei aren't

1238
00:52:31,750 --> 00:52:35,260
spherically shaped doesn't that mean

1239
00:52:33,579 --> 00:52:37,599
that the forces creating them are

1240
00:52:35,260 --> 00:52:39,730

indicative of there being some kind of

1241

00:52:37,599 --> 00:52:42,039

inhomogeneities in the gravitational

1242

00:52:39,730 --> 00:52:44,588

field okay so it sort of depends on what

1243

00:52:42,039 --> 00:52:46,779

you mean by eclectic nucleus if you're

1244

00:52:44,588 --> 00:52:49,029

looking at an average galaxy then

1245

00:52:46,780 --> 00:52:52,150

nucleus what you see is really this

1246

00:52:49,030 --> 00:52:54,760

bulge of stars okay so if you're looking

1247

00:52:52,150 --> 00:52:57,190

at that a large scale of a galaxy the

1248

00:52:54,760 --> 00:52:59,200

the central region is as a bulge of

1249

00:52:57,190 --> 00:53:02,409

stars in the plane in it right around

1250

00:52:59,199 --> 00:53:04,739

the center and that shape of that is

1251

00:53:02,409 --> 00:53:08,699

indicative of the orbits of those stars

1252

00:53:04,739 --> 00:53:10,838

those stars aren't always randomized a

1253

00:53:08,699 --> 00:53:13,269

lot of times they are randomizing it's

1254

00:53:10,838 --> 00:53:15,130

roughly spherical but it can also have

1255
00:53:13,269 --> 00:53:16,838
an elongated shape what we call it more

1256
00:53:15,130 --> 00:53:19,150
of a bar shape simply due to

1257
00:53:16,838 --> 00:53:19,779
gravitational resonances that pull those

1258
00:53:19,150 --> 00:53:22,530
stars into

1259
00:53:19,780 --> 00:53:26,290
orbitz that create an elongated shape

1260
00:53:22,530 --> 00:53:28,390
and it can also have oftentimes it also

1261
00:53:26,289 --> 00:53:30,460
has a sort of flattened spheroid an

1262
00:53:28,389 --> 00:53:32,949
oblate spheroid where it's wider it at

1263
00:53:30,460 --> 00:53:36,190
the at the center axis than it is

1264
00:53:32,949 --> 00:53:38,049
straight up and down and that of course

1265
00:53:36,190 --> 00:53:40,389
again would be due to the gravitational

1266
00:53:38,050 --> 00:53:43,120
forces of the disc and other material

1267
00:53:40,389 --> 00:53:44,500
pressing on it so the stars in the

1268
00:53:43,119 --> 00:53:47,559
central region their shapes are

1269
00:53:44,500 --> 00:53:51,880
definitely governed by the gravitational

1270
00:53:47,559 --> 00:53:53,500
forces the galactic nucleus itself is

1271
00:53:51,880 --> 00:53:55,030
generally the supermassive black hole

1272
00:53:53,500 --> 00:53:57,070
and then there's tons of tons of things

1273
00:53:55,030 --> 00:53:59,290
going on there but we don't actually

1274
00:53:57,070 --> 00:54:01,180
have I don't really think I would say I

1275
00:53:59,289 --> 00:54:02,949
know what the shape of a supermassive

1276
00:54:01,179 --> 00:54:04,299
black hole and the stuff around it looks

1277
00:54:02,949 --> 00:54:07,619
like there's no typical shape for that

1278
00:54:04,300 --> 00:54:10,780
right and what dark matter is related to

1279
00:54:07,619 --> 00:54:14,349
galactic axis e rotations though one of

1280
00:54:10,780 --> 00:54:16,420
the one of the ways we think it existed

1281
00:54:14,349 --> 00:54:19,119
one of the strongest indicators that it

1282
00:54:16,420 --> 00:54:21,190
might be there was the rate the way in

1283

00:54:19,119 --> 00:54:24,519
which galaxies rotated didn't match what

1284
00:54:21,190 --> 00:54:26,349
we saw with the visible matter so we

1285
00:54:24,519 --> 00:54:29,099
inferred there must be something else

1286
00:54:26,349 --> 00:54:31,750
out there causing these rotational

1287
00:54:29,099 --> 00:54:33,099
behaviors of galaxies so dark matter of

1288
00:54:31,750 --> 00:54:36,070
course would play a role in that as well

1289
00:54:33,099 --> 00:54:38,889
so good question and finally I have

1290
00:54:36,070 --> 00:54:41,019
something else from causal joe is it

1291
00:54:38,889 --> 00:54:45,250
possible to measure the axis of rotation

1292
00:54:41,019 --> 00:54:46,719
of stars in the Andromeda galaxy are we

1293
00:54:45,250 --> 00:54:50,530
that good at it can we can we measure

1294
00:54:46,719 --> 00:54:52,659
the stars themselves rotating well the

1295
00:54:50,530 --> 00:54:55,900
rotation of a star in an individual star

1296
00:54:52,659 --> 00:54:57,339
no I don't believe so the rotation of

1297
00:54:55,900 --> 00:54:59,800

all the stars around the center of

1298

00:54:57,340 --> 00:55:02,079

Andromeda yes of course we can do that

1299

00:54:59,800 --> 00:55:03,970

but right again it's that's kind of easy

1300

00:55:02,079 --> 00:55:05,230

you've got a disk and if things are

1301

00:55:03,969 --> 00:55:06,819

going to stay in a disk well then

1302

00:55:05,230 --> 00:55:08,769

there's a there's a center to the disk

1303

00:55:06,820 --> 00:55:10,809

and even rotation axis is going to be

1304

00:55:08,769 --> 00:55:12,789

perpendicular to that disk but the

1305

00:55:10,809 --> 00:55:15,250

ending the rotation of an individual

1306

00:55:12,789 --> 00:55:18,279

star is difficult even within our own

1307

00:55:15,250 --> 00:55:19,960

Milky Way galaxy trying to gather in

1308

00:55:18,280 --> 00:55:21,640

fact if we if we didn't we weren't able

1309

00:55:19,960 --> 00:55:22,809

to see features on our own Sun we'd have

1310

00:55:21,639 --> 00:55:25,599

a heck of a time trying to its

1311

00:55:22,809 --> 00:55:27,579

reflective exactly have to figure out is

1312
00:55:25,599 --> 00:55:30,730
there some sort there needs to be some

1313
00:55:27,579 --> 00:55:32,889
sort of in homogeneity okay some bright

1314
00:55:30,730 --> 00:55:33,519
spot emerged from something and so there

1315
00:55:32,889 --> 00:55:35,528
are some still

1316
00:55:33,518 --> 00:55:38,379
ours that have these very large star

1317
00:55:35,528 --> 00:55:40,748
spots correlation us on spots which we

1318
00:55:38,380 --> 00:55:42,608
can actually resolve the spots but we

1319
00:55:40,748 --> 00:55:44,528
can say oh it gets brighter and paint

1320
00:55:42,608 --> 00:55:48,098
and dimmer brighter and dimmer due to

1321
00:55:44,528 --> 00:55:50,648
the rotation and from that we can infer

1322
00:55:48,099 --> 00:55:53,649
the rotation axis in the rotation rate

1323
00:55:50,648 --> 00:55:55,659
of the of those stars awesome okay yep

1324
00:55:53,648 --> 00:55:57,518
Thank You causal Joe good question as it

1325
00:55:55,659 --> 00:55:59,289
has a wonderful question so we only have

1326
00:55:57,518 --> 00:56:00,518
a few minutes left and it looks like

1327
00:55:59,289 --> 00:56:03,069
Frank you want to talk about upcoming

1328
00:56:00,518 --> 00:56:05,528
events I have a couple events i'd like

1329
00:56:03,068 --> 00:56:08,469
to mention we always like to mention our

1330
00:56:05,528 --> 00:56:09,880
next public lecture and this one is

1331
00:56:08,469 --> 00:56:11,969
going to be a special event it's a joint

1332
00:56:09,880 --> 00:56:15,548
lecture with a baltimore museum of art

1333
00:56:11,969 --> 00:56:19,269
da da robledo is a nationally renowned

1334
00:56:15,548 --> 00:56:21,849
artist and he has a exhibited get in the

1335
00:56:19,268 --> 00:56:24,938
gallery in the contemporary wig at the

1336
00:56:21,849 --> 00:56:26,739
VMA he is going to come over and talk

1337
00:56:24,938 --> 00:56:29,408
about his exhibits home which was

1338
00:56:26,739 --> 00:56:31,778
inspired by hubble some of which was

1339
00:56:29,409 --> 00:56:36,759
also inspired by the Golden Record on

1340

00:56:31,778 --> 00:56:38,458
Voyager he has a very insightful way of

1341
00:56:36,759 --> 00:56:40,659
thinking about his art and

1342
00:56:38,458 --> 00:56:43,178
representative and multiple layers

1343
00:56:40,659 --> 00:56:44,949
within his art so I just called his talk

1344
00:56:43,179 --> 00:56:47,648
inside since the interplay of science

1345
00:56:44,949 --> 00:56:49,630
and art but more it's going to be a

1346
00:56:47,648 --> 00:56:53,438
conversation between Dario robledo and

1347
00:56:49,630 --> 00:56:55,689
myself to discuss the way he represents

1348
00:56:53,438 --> 00:56:57,458
Hubble in art and then I will play I

1349
00:56:55,688 --> 00:56:58,868
provide the counterpoint to say well

1350
00:56:57,458 --> 00:57:00,368
here's how we think about those things

1351
00:56:58,869 --> 00:57:02,889
in science and we'll have a great

1352
00:57:00,369 --> 00:57:05,199
conversation with a baltimore museum or

1353
00:57:02,889 --> 00:57:07,358
and that will also be on youtube folks

1354
00:57:05,199 --> 00:57:08,588

and i'll create the G+ event for leading

1355

00:57:07,358 --> 00:57:10,958

up to it so you'll be able to watch it

1356

00:57:08,588 --> 00:57:13,148

that way also as always special thanks

1357

00:57:10,958 --> 00:57:15,818

to Tony for putting those on YouTube

1358

00:57:13,148 --> 00:57:18,788

second thing I want to let anybody who's

1359

00:57:15,818 --> 00:57:21,308

a teacher out there or tell your tell

1360

00:57:18,789 --> 00:57:23,019

your kids teachers are on april twenty

1361

00:57:21,309 --> 00:57:24,880

fourth which is the 25th anniversary of

1362

00:57:23,018 --> 00:57:27,788

Hubble we're going we're doing what we

1363

00:57:24,880 --> 00:57:30,548

call a national teachin so we want to

1364

00:57:27,789 --> 00:57:32,829

present Hubble and it's 25 years and all

1365

00:57:30,548 --> 00:57:35,099

the cool things that it's done directly

1366

00:57:32,829 --> 00:57:38,199

to classrooms through a Hubble hangout

1367

00:57:35,099 --> 00:57:40,119

and so we have this we're planning and

1368

00:57:38,199 --> 00:57:43,179

organizing this Hubble 25 national

1369
00:57:40,119 --> 00:57:46,568
teachin at 1pm Eastern so that's 10 a.m.

1370
00:57:43,179 --> 00:57:47,410
pacific and if you would like email

1371
00:57:46,568 --> 00:57:50,500
information

1372
00:57:47,409 --> 00:57:52,868
email amazing heightened space STScI

1373
00:57:50,500 --> 00:57:56,079
well I guess that should be at sts yet a

1374
00:57:52,869 --> 00:57:57,490
tu isn't that uh there yet because

1375
00:57:56,079 --> 00:57:59,980
that's not an email address that's not

1376
00:57:57,489 --> 00:58:02,548
an email email address I'm sorry about

1377
00:57:59,980 --> 00:58:08,829
that I throw amazing hyphen space at

1378
00:58:02,548 --> 00:58:10,480
stsci edu all right ok cool oh there's a

1379
00:58:08,829 --> 00:58:12,789
really good really good question here I

1380
00:58:10,480 --> 00:58:14,530
went about we're almost out of time but

1381
00:58:12,789 --> 00:58:16,030
I want to hear your answer to this

1382
00:58:14,530 --> 00:58:19,869
question because I've noticed this too

1383
00:58:16,030 --> 00:58:21,760
Marco Pudge from the QA app sorry if I

1384
00:58:19,869 --> 00:58:25,210
messed your name up how many stars are

1385
00:58:21,760 --> 00:58:27,069
in the Milky Way galaxy and sun and some

1386
00:58:25,210 --> 00:58:29,199
documentaries they say hundred billion

1387
00:58:27,068 --> 00:58:31,480
and some two hundred and in some other

1388
00:58:29,199 --> 00:58:34,149
ones 400 billion and I've encountered

1389
00:58:31,480 --> 00:58:36,179
this too so which one which one is it

1390
00:58:34,150 --> 00:58:41,548
Frank how many stars are the Milky Way

1391
00:58:36,179 --> 00:58:47,190
ok um oh look at that slide back oh um

1392
00:58:41,548 --> 00:58:50,019
yeah we don't know for sure ok the

1393
00:58:47,190 --> 00:58:53,048
numbers of stars in mcquay has to be an

1394
00:58:50,019 --> 00:58:55,750
estimate because you are looking at

1395
00:58:53,048 --> 00:58:59,079
representative regions this guy counting

1396
00:58:55,750 --> 00:59:01,809
and then multiplying to see how many as

1397

00:58:59,079 --> 00:59:03,250
you saw with Andromeda if you just count

1398
00:59:01,809 --> 00:59:05,440
the stars in the disk you're going to

1399
00:59:03,250 --> 00:59:07,028
get one answer you count the disk and

1400
00:59:05,440 --> 00:59:09,369
then the stars and the halo you're going

1401
00:59:07,028 --> 00:59:12,159
to get another answer how far out does

1402
00:59:09,369 --> 00:59:14,200
that halo actually extend well you don't

1403
00:59:12,159 --> 00:59:15,940
know you need a good density function

1404
00:59:14,199 --> 00:59:18,909
for that and we can only have such good

1405
00:59:15,940 --> 00:59:20,858
so it's hundreds of billions of stars as

1406
00:59:18,909 --> 00:59:22,929
you point out could it be a hundred

1407
00:59:20,858 --> 00:59:27,969
billion yeah could it be 200 billion

1408
00:59:22,929 --> 00:59:29,798
yeah it could be 400 billion yeah we are

1409
00:59:27,969 --> 00:59:33,278
this is one place where we don't know

1410
00:59:29,798 --> 00:59:35,288
within a factor of two so take the 200

1411
00:59:33,278 --> 00:59:38,019

billion number as as a reasonable

1412

00:59:35,289 --> 00:59:40,359

estimate and if you want to drop it down

1413

00:59:38,019 --> 00:59:41,858

to we could be off by it we would have

1414

00:59:40,358 --> 00:59:44,409

twice as many or we could only have half

1415

00:59:41,858 --> 00:59:46,598

as many it's really not an easy number

1416

00:59:44,409 --> 00:59:49,568

to get exact right when I was taking my

1417

00:59:46,599 --> 00:59:52,150

cosmology course at in the mid-90s my a

1418

00:59:49,568 --> 00:59:53,409

thing my professor said in cosmology if

1419

00:59:52,150 --> 00:59:55,720

we know anything do within twenty

1420

00:59:53,409 --> 00:59:57,219

percent were happy now of course this

1421

00:59:55,719 --> 00:59:58,419

was the 90s and we're a lot better now

1422

00:59:57,219 --> 01:00:01,328

we live in an age where we could do

1423

00:59:58,420 --> 01:00:04,088

precision cosmology but so factors of

1424

01:00:01,329 --> 01:00:07,298

for that's pretty darn good I would say

1425

01:00:04,088 --> 01:00:09,548

so anyway you remember the 1990s when we

1426
01:00:07,298 --> 01:00:11,469
did cosmology we didn't know the Hubble

1427
01:00:09,548 --> 01:00:12,458
constant and what could have been 50

1428
01:00:11,469 --> 01:00:15,219
kilometers per second per megaparsec

1429
01:00:12,458 --> 01:00:17,048
right like a mega parsec that's one of

1430
01:00:15,219 --> 01:00:19,869
the things that you know in when Hubble

1431
01:00:17,048 --> 01:00:23,650
got it down to 70 plus or minus five it

1432
01:00:19,869 --> 01:00:25,660
was a very cool you know so yeah okay

1433
01:00:23,650 --> 01:00:27,338
well thank you for that great ? oh well

1434
01:00:25,659 --> 01:00:29,828
I've wondered the same thing myself and

1435
01:00:27,338 --> 01:00:31,659
Andrew or Andy thank you for the kind

1436
01:00:29,829 --> 01:00:34,630
comments or leaving it I do feel like we

1437
01:00:31,659 --> 01:00:35,949
actually know each other and i look

1438
01:00:34,630 --> 01:00:37,690
forward to thank you for all your

1439
01:00:35,949 --> 01:00:39,189
attending your and attending all of our

1440
01:00:37,690 --> 01:00:41,650
hangouts I really means a lot to me and

1441
01:00:39,190 --> 01:00:42,940
so thank you very much well I guess

1442
01:00:41,650 --> 01:00:45,489
we're going to stop there that's it for

1443
01:00:42,940 --> 01:00:46,809
this that's it for today tomorrow pretty

1444
01:00:45,489 --> 01:00:49,208
I hope you'll join us for our hangout

1445
01:00:46,809 --> 01:00:52,569
where we're going to go over 25 years of

1446
01:00:49,208 --> 01:00:55,419
Hubble images represented in 25

1447
01:00:52,568 --> 01:00:58,088
different images that we've selected to

1448
01:00:55,420 --> 01:00:59,798
sort of celebrate the the anniversary of

1449
01:00:58,088 --> 01:01:02,288
Hubble carol scott and i'll be talking

1450
01:00:59,798 --> 01:01:05,018
about those tomorrow so i hope you'll

1451
01:01:02,289 --> 01:01:08,699
join us there same bat-time same hubble

1452
01:01:05,018 --> 01:01:12,488
time three o'clock eastern standard time

1453
01:01:08,699 --> 01:01:14,409
tomorrow so hope to see you there Frank

1454

01:01:12,489 --> 01:01:15,969
thanks once again another great another

1455
01:01:14,409 --> 01:01:17,739
great episode I appreciate you joining

1456
01:01:15,969 --> 01:01:20,739
us this this month and we'll see you

1457
01:01:17,739 --> 01:01:22,989
back on in early March right definitely

1458
01:01:20,739 --> 01:01:26,559
we can have to do it uh what is it gonna

1459
01:01:22,989 --> 01:01:28,719
be in March 9th again all right ok Mario

1460
01:01:26,559 --> 01:01:31,920
know it mean it would be much 11th March

1461
01:01:28,719 --> 01:01:34,059
11 is 28 days this year so we march 11th

1462
01:01:31,920 --> 01:01:36,130
just before we go up to the South by

1463
01:01:34,059 --> 01:01:37,869
Southwest sounds good look forward to

1464
01:01:36,130 --> 01:01:39,729
talking oh all right thank you guys

1465
01:01:37,869 --> 01:01:43,559
thank you all for watching and as always

1466
01:01:39,728 --> 01:01:43,558
keep looking up