
HUBBLE
hangouts

1
00:00:05,670 --> 00:00:04,550
hello hubble huggers and welcome to

2
00:00:08,710 --> 00:00:05,680
another

3
00:00:11,589 --> 00:00:08,720
hubble hangout to our latest humble

4
00:00:14,950 --> 00:00:11,599
hubble hangout our hearty and happy hub

5
00:00:16,710 --> 00:00:14,960
okay i'll stop by uh

6
00:00:20,230 --> 00:00:16,720
well it's easy with h's it's easy to

7
00:00:22,870 --> 00:00:20,240
alliterate with ages h's so anyway um

8
00:00:23,830 --> 00:00:22,880
so i guess of all the hubble hangouts

9
00:00:25,910 --> 00:00:23,840
i've done

10
00:00:27,670 --> 00:00:25,920
so far i'm particularly excited about

11
00:00:30,230 --> 00:00:27,680
this one because

12
00:00:32,549 --> 00:00:30,240
the topic of this one is about something

13
00:00:35,110 --> 00:00:32,559

very near and dear to my heart it is not

14
00:00:36,630 --> 00:00:35,120
an exaggeration to say that images from

15
00:00:38,869 --> 00:00:36,640
the hubble space telescope have

16
00:00:40,549 --> 00:00:38,879
literally changed my life and i don't

17
00:00:42,069 --> 00:00:40,559
mean that as a figure of speech i could

18
00:00:44,950 --> 00:00:42,079
go on that could be the subject of its

19
00:00:46,150 --> 00:00:44,960
own hangout actually but uh the images

20
00:00:48,150 --> 00:00:46,160
that the hubble space telescope have

21
00:00:51,270 --> 00:00:48,160
taken have profoundly affected me and so

22
00:00:53,590 --> 00:00:51,280
for and and have ultimately uh led me

23
00:00:56,229 --> 00:00:53,600
here uh with this great group of people

24
00:00:57,910 --> 00:00:56,239
that i'm about to introduce to you uh to

25
00:01:00,310 --> 00:00:57,920
talk about the hubble space telescope

26
00:01:03,830 --> 00:01:00,320
and the images from it so let me get

27
00:01:06,950 --> 00:01:03,840
started by introducing my co-hosts or

28
00:01:10,550 --> 00:01:06,960
cohorts or co-habitant no we don't live

29
00:01:12,469 --> 00:01:10,560
together but um our uh with me is uh

30
00:01:13,670 --> 00:01:12,479
mike one of my co-hosts alberto conte

31
00:01:15,910 --> 00:01:13,680
alberto

32
00:01:18,550 --> 00:01:15,920
hi tony how are you welcome yes he is

33
00:01:20,149 --> 00:01:18,560
the jwst innovation scientist and

34
00:01:22,070 --> 00:01:20,159
alberto real quick i know this is about

35
00:01:23,510 --> 00:01:22,080
hubble but i got to ask real quick um

36
00:01:25,270 --> 00:01:23,520
how are things going with jws tube you

37
00:01:26,550 --> 00:01:25,280
still on track everything is still on

38
00:01:29,670 --> 00:01:26,560

track we have a new instrument just

39
00:01:31,749 --> 00:01:29,680
delivered to goddard uh a few days ago

40
00:01:33,749 --> 00:01:31,759
and when one is going into the crowd

41
00:01:35,990 --> 00:01:33,759
chamber for testing so we're really

42
00:01:38,390 --> 00:01:36,000
doing well awesome so we're uh we're

43
00:01:40,069 --> 00:01:38,400
still launching in 2018 then nobody's

44
00:01:42,390 --> 00:01:40,079
dropped a primary or sneezed on the

45
00:01:44,950 --> 00:01:42,400
secondary or anything good not yet no

46
00:01:45,670 --> 00:01:44,960
we won't okay no because they wear masks

47
00:01:49,510 --> 00:01:45,680
right

48
00:01:51,510 --> 00:01:49,520
those sneeze guards anything okay cool

49
00:01:54,069 --> 00:01:51,520
all right also with me is scott lewis

50
00:01:55,990 --> 00:01:54,079
from knowthecosmos.com hi scott hey tony

51
00:01:57,910 --> 00:01:56,000
how's it going hey scotty okay can i

52
00:02:01,429 --> 00:01:57,920
call you that can i call you scotty you

53
00:02:02,870 --> 00:02:01,439
could for like once oh no come on no

54
00:02:04,550 --> 00:02:02,880
i'm going to call you scotty now and

55
00:02:06,069 --> 00:02:04,560
then maybe in tomorrow's hangout we'll

56
00:02:07,990 --> 00:02:06,079
give you a tagline because for me it's

57
00:02:09,910 --> 00:02:08,000
like i stole uh keep looking up from

58
00:02:12,070 --> 00:02:09,920
jack horkheimer and of course alberto's

59
00:02:13,990 --> 00:02:12,080
is get her done so we gotta have

60
00:02:15,589 --> 00:02:14,000
we gotta have one for you too

61
00:02:17,270 --> 00:02:15,599
yeah see yeah now we're gonna have the

62
00:02:19,030 --> 00:02:17,280
youtube comments or start call me scotty

63
00:02:21,430 --> 00:02:19,040

when i do facebook

64
00:02:22,390 --> 00:02:21,440
yes you been

65
00:02:23,830 --> 00:02:22,400
okay

66
00:02:25,190 --> 00:02:23,840
all right well welcome scott it's good

67
00:02:28,470 --> 00:02:25,200
to see you again

68
00:02:30,229 --> 00:02:28,480
um so uh let me talk a little bit about

69
00:02:32,150 --> 00:02:30,239
the before i introduce our other uh

70
00:02:33,910 --> 00:02:32,160
astronomers i would like to get sort of

71
00:02:36,869 --> 00:02:33,920
to the point of what we're doing here

72
00:02:38,630 --> 00:02:36,879
what are we doing and why and we're kind

73
00:02:41,110 --> 00:02:38,640
of doing a social experiment this time

74
00:02:44,150 --> 00:02:41,120
around where at the institute we are

75
00:02:46,869 --> 00:02:44,160
compiling a list of the

76
00:02:49,509 --> 00:02:46,879
greatest images ever taken by the hubble

77
00:02:51,910 --> 00:02:49,519
space telescope and to do that we want

78
00:02:55,190 --> 00:02:51,920
to get you involved and to get you help

79
00:02:57,190 --> 00:02:55,200
or get to get uh your help so to get our

80
00:02:59,910 --> 00:02:57,200
brains kind of kick-started into

81
00:03:01,990 --> 00:02:59,920
thinking about uh what what images there

82
00:03:03,990 --> 00:03:02,000
are and and and what do we mean by the

83
00:03:07,030 --> 00:03:04,000
greatest images let me introduce some of

84
00:03:09,030 --> 00:03:07,040
the people with me now and we we have

85
00:03:10,949 --> 00:03:09,040
these guys to me are all rock stars i

86
00:03:13,110 --> 00:03:10,959
mean i have heard about them long before

87
00:03:15,270 --> 00:03:13,120
i ever met them and and i'm just really

88
00:03:17,030 --> 00:03:15,280

thrilled to have them with me uh on this

89
00:03:18,470 --> 00:03:17,040
hangout today let me start with carol

90
00:03:20,630 --> 00:03:18,480
i'm just going to go from left to right

91
00:03:22,309 --> 00:03:20,640
so with me is dr carol christian hi

92
00:03:25,110 --> 00:03:22,319
carol hello

93
00:03:26,949 --> 00:03:25,120
how are you i'm good thanks and uh now

94
00:03:29,030 --> 00:03:26,959
you were famous long before i met you

95
00:03:31,509 --> 00:03:29,040
because for many years you did the uh

96
00:03:33,670 --> 00:03:31,519
you did the the radio show on mp on npr

97
00:03:34,949 --> 00:03:33,680
uh sky watch and so i knew about you way

98
00:03:37,350 --> 00:03:34,959
before i met you it's a pleasure to

99
00:03:38,390 --> 00:03:37,360
finally be in a hangout with you though

100
00:03:39,750 --> 00:03:38,400
uh so tell us a little bit about

101
00:03:42,630 --> 00:03:39,760
yourself what do you what do you do all

102
00:03:45,030 --> 00:03:42,640
day addition to skywatch um which we're

103
00:03:48,070 --> 00:03:45,040
looking to move to

104
00:03:50,470 --> 00:03:48,080
mobile media and the internet um i'm

105
00:03:52,390 --> 00:03:50,480
actually the hubble space telescope

106
00:03:54,070 --> 00:03:52,400
outreach scientist which

107
00:03:57,030 --> 00:03:54,080
actually to me

108
00:03:58,789 --> 00:03:57,040
is one of the best jobs in astronomy

109
00:04:02,070 --> 00:03:58,799
it means that

110
00:04:04,470 --> 00:04:02,080
they pay me to read all of the research

111
00:04:05,830 --> 00:04:04,480
literature which many astronomers you

112
00:04:07,670 --> 00:04:05,840
know they have to

113
00:04:09,750 --> 00:04:07,680

carve out some time of their day to do

114
00:04:11,910 --> 00:04:09,760
that but i get to do that as part of my

115
00:04:13,750 --> 00:04:11,920
job so i get to see all the different

116
00:04:16,469 --> 00:04:13,760
research that's being done

117
00:04:19,509 --> 00:04:16,479
and then i also support the news and the

118
00:04:21,749 --> 00:04:19,519
education products that are derived from

119
00:04:23,590 --> 00:04:21,759
those discoveries so scientists are

120
00:04:25,670 --> 00:04:23,600
doing using the hubble space telescope

121
00:04:27,830 --> 00:04:25,680
making new discoveries and then we roll

122
00:04:30,070 --> 00:04:27,840
that into news and education and so i

123
00:04:32,950 --> 00:04:30,080
helped do that and that's like a great

124
00:04:35,510 --> 00:04:32,960
job and the thing that's near and dear

125
00:04:38,390 --> 00:04:35,520
to my heart is citizen science so that's

126
00:04:40,390 --> 00:04:38,400
the kind of science where we invite you

127
00:04:43,510 --> 00:04:40,400
to participate in our research by

128
00:04:46,150 --> 00:04:43,520
helping us find new galaxies

129
00:04:48,550 --> 00:04:46,160
identify star clusters

130
00:04:50,469 --> 00:04:48,560
maybe look for star formation bubbles in

131
00:04:52,469 --> 00:04:50,479
the milky way

132
00:04:55,670 --> 00:04:52,479
all of those things are possible for you

133
00:04:57,430 --> 00:04:55,680
to participate in and i'm

134
00:04:59,350 --> 00:04:57,440
pursuing some of those projects with my

135
00:05:01,350 --> 00:04:59,360
colleagues oh yeah i know just how you

136
00:05:02,629 --> 00:05:01,360
feel about you know having the greatest

137
00:05:04,790 --> 00:05:02,639
job in the world it's like sometimes i

138
00:05:06,550 --> 00:05:04,800

can't believe that i get paid to to deal

139
00:05:08,070 --> 00:05:06,560
with you know the hubble space telescope

140
00:05:09,430 --> 00:05:08,080
every single day so i know just what you

141
00:05:10,790 --> 00:05:09,440
mean i think we're going to be doing a

142
00:05:12,150 --> 00:05:10,800
hangout at some point in the future on

143
00:05:13,590 --> 00:05:12,160
some of those citizen science things too

144
00:05:16,150 --> 00:05:13,600
that you talked about

145
00:05:19,749 --> 00:05:16,160
yeah yeah okay so crammed all together

146
00:05:23,350 --> 00:05:19,759
in one room we have three astronomers

147
00:05:26,469 --> 00:05:23,360
who are extremely uh

148
00:05:29,029 --> 00:05:26,479
in my opinion awesome awesome guys so

149
00:05:30,790 --> 00:05:29,039
with his dr frank summers hi frank

150
00:05:32,710 --> 00:05:30,800
hey tony how's it going today really

151
00:05:35,270 --> 00:05:32,720
good so uh you are

152
00:05:36,710 --> 00:05:35,280
i am an outreach astrophysicist outreach

153
00:05:38,390 --> 00:05:36,720
astronomer in the office of public

154
00:05:40,230 --> 00:05:38,400
outreach here at space telescope science

155
00:05:42,870 --> 00:05:40,240
institute so

156
00:05:45,029 --> 00:05:42,880
i also get to talk about the amazing

157
00:05:47,350 --> 00:05:45,039
things that hubble does working on the

158
00:05:50,310 --> 00:05:47,360
press releases working on educational

159
00:05:54,150 --> 00:05:50,320
projects giving teacher training talks

160
00:05:55,909 --> 00:05:54,160
working with planetariums and museums uh

161
00:05:58,310 --> 00:05:55,919
working on the website uh doing all

162
00:06:00,390 --> 00:05:58,320
sorts of cool stuff but you as you know

163
00:06:02,550 --> 00:06:00,400

my favorite thing to do is a scientific

164
00:06:04,870 --> 00:06:02,560
visualization i was the scientific

165
00:06:07,430 --> 00:06:04,880
visualization supervisor on imax hubble

166
00:06:09,510 --> 00:06:07,440
3d and together with zolt levy who

167
00:06:11,990 --> 00:06:09,520
you'll introduce in just a bit we have a

168
00:06:14,870 --> 00:06:12,000
group here the visualization 3d team

169
00:06:15,830 --> 00:06:14,880
that we take hubble images we visualize

170
00:06:17,749 --> 00:06:15,840
we

171
00:06:20,150 --> 00:06:17,759
create three-dimensional models of them

172
00:06:22,309 --> 00:06:20,160
fly cameras through them and are able to

173
00:06:24,150 --> 00:06:22,319
explain the universe uh through 3d

174
00:06:25,430 --> 00:06:24,160
visualizations that's what i like to do

175
00:06:27,189 --> 00:06:25,440
best

176
00:06:30,950 --> 00:06:27,199
awesome and then right next to him is dr

177
00:06:34,230 --> 00:06:30,960
mario livio hi mario hi

178
00:06:37,430 --> 00:06:34,240
go ahead yeah well i'm an astrophysicist

179
00:06:40,070 --> 00:06:37,440
i do i'm a theoretical astrophysicist

180
00:06:42,309 --> 00:06:40,080
which means i hardly know from which

181
00:06:45,510 --> 00:06:42,319
side of the telescope one looks

182
00:06:48,230 --> 00:06:45,520
but i i look at what those astronomers

183
00:06:50,150 --> 00:06:48,240
are coming down with and i'm trying to

184
00:06:51,830 --> 00:06:50,160
explain all of that and explain the

185
00:06:54,309 --> 00:06:51,840
universe

186
00:06:56,230 --> 00:06:54,319
in my spare time i write a blog called

187
00:06:58,550 --> 00:06:56,240
the curious mind

188
00:07:02,150 --> 00:06:58,560

which hopefully everybody reads

189
00:07:05,029 --> 00:07:02,160
and in my non-existent spare time i try

190
00:07:06,870 --> 00:07:05,039
to write popular science books

191
00:07:08,390 --> 00:07:06,880
the latest of which is called brilliant

192
00:07:10,550 --> 00:07:08,400
blunders

193
00:07:13,350 --> 00:07:10,560
where i try to explain all kinds of

194
00:07:15,350 --> 00:07:13,360
complex scientific issues in a lay

195
00:07:17,749 --> 00:07:15,360
person's language

196
00:07:18,950 --> 00:07:17,759
to make science more accessible to a

197
00:07:20,550 --> 00:07:18,960
larger

198
00:07:22,710 --> 00:07:20,560
group of people

199
00:07:24,550 --> 00:07:22,720
i've been with hubble for many many

200
00:07:26,870 --> 00:07:24,560
years

201
00:07:28,390 --> 00:07:26,880
almost since launch

202
00:07:34,950 --> 00:07:28,400
and

203
00:07:37,670 --> 00:07:34,960
hopefully also with

204
00:07:39,189 --> 00:07:37,680
the james webb space telescope all right

205
00:07:41,589 --> 00:07:39,199
awesome thank you thank you mario and i

206
00:07:44,469 --> 00:07:41,599
am also very pleased that dr ken sembach

207
00:07:47,350 --> 00:07:44,479
could be with us today uh ken is like

208
00:07:49,350 --> 00:07:47,360
the hubble guy at the at the institute

209
00:07:50,870 --> 00:07:49,360
can i want to introduce yourself

210
00:07:52,550 --> 00:07:50,880
hi tony i'm the hubble guy at the

211
00:07:54,150 --> 00:07:52,560
institute

212
00:07:55,830 --> 00:07:54,160
well that was simple glad you could make

213
00:07:58,230 --> 00:07:55,840

it

214
00:08:00,390 --> 00:07:58,240
this is a humble hubble guy the humble

215
00:08:03,830 --> 00:08:00,400
hubble guy yeah yeah

216
00:08:05,350 --> 00:08:03,840
so tony mike my day job is to uh

217
00:08:06,629 --> 00:08:05,360
basically watch out over all things

218
00:08:09,189 --> 00:08:06,639
hubble here i'm the head of the hubble

219
00:08:11,589 --> 00:08:09,199
mission office here at space telescope

220
00:08:12,790 --> 00:08:11,599
and i have the privilege of working with

221
00:08:15,110 --> 00:08:12,800
many many

222
00:08:16,550 --> 00:08:15,120
wonderful people here and at the goddard

223
00:08:17,909 --> 00:08:16,560
space flight center every day to keep

224
00:08:19,670 --> 00:08:17,919
hubble operating

225
00:08:21,029 --> 00:08:19,680
efficiently and

226
00:08:23,589 --> 00:08:21,039
producing all that great science it

227
00:08:26,390 --> 00:08:23,599
produces i'm trained as an astronomer so

228
00:08:27,589 --> 00:08:26,400
it's particularly satisfying job

229
00:08:28,790 --> 00:08:27,599
awesome thank you and like i said

230
00:08:30,790 --> 00:08:28,800
welcome i'm really glad you're able to

231
00:08:32,630 --> 00:08:30,800
make it and skipping over scott and me

232
00:08:35,829 --> 00:08:32,640
who we already have introduced ourselves

233
00:08:36,790 --> 00:08:35,839
with me is zolt levay he also is he is

234
00:08:39,589 --> 00:08:36,800
the

235
00:08:41,509 --> 00:08:39,599
hubble heritage team lead and

236
00:08:43,509 --> 00:08:41,519
he's one of the guys that are sort of

237
00:08:45,110 --> 00:08:43,519
responsible for her giving us some of

238
00:08:47,350 --> 00:08:45,120

the most beautiful images hubble has

239
00:08:50,470 --> 00:08:47,360
ever created his old welcome

240
00:08:51,990 --> 00:08:50,480
hi tony hi everybody uh yeah what what

241
00:08:52,870 --> 00:08:52,000
more can i say

242
00:09:12,230 --> 00:08:52,880
i

243
00:09:15,350 --> 00:09:12,240
work and a lot of other people's work

244
00:09:16,870 --> 00:09:15,360
that's right so i work with the team uh

245
00:09:19,190 --> 00:09:16,880
tony talked about the hubble heritage

246
00:09:20,870 --> 00:09:19,200
team uh this is a group

247
00:09:21,670 --> 00:09:20,880
of folks here at the institute who've

248
00:09:23,910 --> 00:09:21,680
been

249
00:09:26,949 --> 00:09:23,920
for a number of years now

250
00:09:27,910 --> 00:09:26,959
have been trying to find and publicize

251
00:09:32,550 --> 00:09:27,920
the

252
00:09:34,870 --> 00:09:32,560
if you will

253
00:09:37,430 --> 00:09:34,880
images from hubble not so much

254
00:09:40,070 --> 00:09:37,440
concentrate on the science aspect of it

255
00:09:41,670 --> 00:09:40,080
but more the visual aspects of it and i

256
00:09:44,470 --> 00:09:41,680
think that all goes into what we're

257
00:09:46,310 --> 00:09:44,480
going to talk about today a little bit

258
00:09:48,550 --> 00:09:46,320
yeah so there you go guys there's the

259
00:09:50,230 --> 00:09:48,560
there's our panel of astronomers and

260
00:09:51,910 --> 00:09:50,240
people working on the hubble space

261
00:09:54,470 --> 00:09:51,920
telescope

262
00:09:55,670 --> 00:09:54,480
i guess so and we decided here at the

263
00:09:57,509 --> 00:09:55,680

institute like i like to mention at the

264
00:09:59,110 --> 00:09:57,519
top of this hangout that we're putting

265
00:10:01,670 --> 00:09:59,120
together a list

266
00:10:03,670 --> 00:10:01,680
a comprehensive list as best can be done

267
00:10:05,590 --> 00:10:03,680
and because we operate the world the

268
00:10:07,829 --> 00:10:05,600
hubble space telescope and we've just

269
00:10:11,829 --> 00:10:07,839
given you our credentials this list will

270
00:10:16,310 --> 00:10:13,750
we are the governing body for the much

271
00:10:19,829 --> 00:10:16,320
too long one

272
00:10:20,870 --> 00:10:19,839
oh yeah and because uh these images will

273
00:10:22,389 --> 00:10:20,880
be the

274
00:10:23,990 --> 00:10:22,399
greatest it will be canonized as the

275
00:10:25,509 --> 00:10:24,000
greatest images but first we have to

276
00:10:27,509 --> 00:10:25,519
kind of talk about what we mean by that

277
00:10:31,030 --> 00:10:27,519
what do we mean by greatest i mean i

278
00:10:33,670 --> 00:10:31,040
know why for example i'm greatest uh at

279
00:10:35,990 --> 00:10:33,680
you know whatever it is i do but i i

280
00:10:37,990 --> 00:10:36,000
don't know what we mean by great hubble

281
00:10:39,910 --> 00:10:38,000
images and i guess you could think of it

282
00:10:42,310 --> 00:10:39,920
in two ways there are the greatest

283
00:10:45,590 --> 00:10:42,320
images that have produced the most

284
00:10:47,670 --> 00:10:45,600
scientifically uh useful uh

285
00:10:50,310 --> 00:10:47,680
data or have made us look at the

286
00:10:51,990 --> 00:10:50,320
universe in a way we may uh have never

287
00:10:53,190 --> 00:10:52,000
done before and then there's just the

288
00:10:55,030 --> 00:10:53,200

pretty pictures there's the most

289
00:10:57,670 --> 00:10:55,040
beautiful hubble images those are also

290
00:10:59,430 --> 00:10:57,680
great and have their own so when we say

291
00:11:03,030 --> 00:10:59,440
greatest we mean all of it to combine

292
00:11:04,870 --> 00:11:03,040
both because what may be scientifically

293
00:11:06,790 --> 00:11:04,880
quite amazing and great doesn't

294
00:11:08,389 --> 00:11:06,800
necessarily mean they're pretty so we

295
00:11:10,630 --> 00:11:08,399
want to kind of talk about all of that

296
00:11:12,710 --> 00:11:10,640
together and we are all as a team going

297
00:11:15,750 --> 00:11:12,720
to sit and discuss which ones mean the

298
00:11:17,269 --> 00:11:15,760
most to us so as um

299
00:11:19,990 --> 00:11:17,279
mario mentioned that the hubble's been

300
00:11:22,470 --> 00:11:20,000
around since 1990 it has been around a

301
00:11:24,389 --> 00:11:22,480
really really long time and i guess the

302
00:11:27,350 --> 00:11:24,399
first thing i'd like to to ask you guys

303
00:11:29,670 --> 00:11:27,360
is um

304
00:11:31,750 --> 00:11:29,680
why why is that why is hubble one of the

305
00:11:33,350 --> 00:11:31,760
ones that of all the space telescopes

306
00:11:36,150 --> 00:11:33,360
it's still around it's still kicking

307
00:11:39,269 --> 00:11:36,160
it's still alive and well and and doing

308
00:11:41,509 --> 00:11:39,279
doing great things who wants to try

309
00:11:43,590 --> 00:11:41,519
well any of us any one of us would try

310
00:11:46,310 --> 00:11:43,600
to answer that

311
00:11:48,630 --> 00:11:46,320
go for it well hubble was built as uh

312
00:11:52,389 --> 00:11:48,640
from the beginning hubble was built as a

313
00:11:53,190 --> 00:11:52,399

serviceable telescope which meant that

314
00:11:56,069 --> 00:11:53,200
uh

315
00:11:58,470 --> 00:11:56,079
shuttle astronauts could get to hubble

316
00:11:59,670 --> 00:11:58,480
hubble is in a low earth orbit

317
00:12:04,630 --> 00:11:59,680
they could

318
00:12:07,030 --> 00:12:04,640
old instruments and put in new ones they

319
00:12:10,230 --> 00:12:07,040
could also repair old instruments and so

320
00:12:13,350 --> 00:12:10,240
on so in some sense you know because

321
00:12:15,670 --> 00:12:13,360
hubble was serviced five times uh it was

322
00:12:17,430 --> 00:12:15,680
actually at every such time that it was

323
00:12:20,150 --> 00:12:17,440
serviced by the shuttle

324
00:12:22,069 --> 00:12:20,160
it was made almost into a new telescope

325
00:12:23,190 --> 00:12:22,079
in the sense that it had new instruments

326
00:12:25,269 --> 00:12:23,200
on board

327
00:12:26,150 --> 00:12:25,279
things that needed re to repairs were

328
00:12:29,430 --> 00:12:26,160
made

329
00:12:32,069 --> 00:12:29,440
and so on so uh this gave it it its

330
00:12:35,829 --> 00:12:32,079
enormous longevity but not only just

331
00:12:38,310 --> 00:12:35,839
longevity but also productivity because

332
00:12:40,550 --> 00:12:38,320
it you know essentially renewed itself

333
00:12:42,470 --> 00:12:40,560
with every servicing mission right and

334
00:12:44,790 --> 00:12:42,480
like spitzer you know had enough cryogen

335
00:12:46,710 --> 00:12:44,800
to last for what five or six years and

336
00:12:48,710 --> 00:12:46,720
then it had to go into its warm mission

337
00:12:50,949 --> 00:12:48,720
right and we were able to go and replace

338
00:12:52,949 --> 00:12:50,959

the batteries and replace gyroscopes and

339
00:12:55,110 --> 00:12:52,959
and you know all of the consumables on

340
00:12:57,110 --> 00:12:55,120
hubble were able to be replaced and that

341
00:12:58,870 --> 00:12:57,120
allowed it to be so long yeah that was

342
00:13:00,790 --> 00:12:58,880
part of the

343
00:13:02,870 --> 00:13:00,800
i mean part of it is the logistics

344
00:13:05,590 --> 00:13:02,880
associated with just making hubble a new

345
00:13:07,990 --> 00:13:05,600
telescope but the telescope has staying

346
00:13:09,590 --> 00:13:08,000
power in that it has public appeal and

347
00:13:10,870 --> 00:13:09,600
it has public appeal right from the

348
00:13:12,150 --> 00:13:10,880
start

349
00:13:13,750 --> 00:13:12,160
and why do you why do you think that is

350
00:13:15,750 --> 00:13:13,760
ken why do you think the the public

351
00:13:18,069 --> 00:13:15,760
appeal is so strong for this telescope

352
00:13:20,230 --> 00:13:18,079
well i think early on when hubble had

353
00:13:21,990 --> 00:13:20,240
some initial problems with the near the

354
00:13:23,590 --> 00:13:22,000
mirror configuration

355
00:13:26,710 --> 00:13:23,600
and the astronauts were able to go up

356
00:13:29,350 --> 00:13:26,720
and repair it there was a great human

357
00:13:31,110 --> 00:13:29,360
interaction with the telescope that

358
00:13:35,030 --> 00:13:31,120
resonates with people

359
00:13:37,110 --> 00:13:35,040
drama there was a real drama exactly and

360
00:13:38,310 --> 00:13:37,120
the fact that when the astronauts

361
00:13:40,069 --> 00:13:38,320
repaired

362
00:13:41,990 --> 00:13:40,079
the vision on hubble

363
00:13:44,470 --> 00:13:42,000

that if the telescope was able to

364
00:13:47,590 --> 00:13:44,480
produce such sensational pictures

365
00:13:49,670 --> 00:13:47,600
it gave the public an immediate visual

366
00:13:51,350 --> 00:13:49,680
representation of what was possible with

367
00:13:52,470 --> 00:13:51,360
this telescope that they hadn't seen

368
00:13:54,629 --> 00:13:52,480
before

369
00:13:56,629 --> 00:13:54,639
and i think that was just the start of

370
00:13:58,870 --> 00:13:56,639
what's been you know 20 plus year

371
00:14:00,710 --> 00:13:58,880
history

372
00:14:02,550 --> 00:14:00,720
yeah in that sense do you think and so

373
00:14:03,750 --> 00:14:02,560
it really did open a new era for

374
00:14:06,870 --> 00:14:03,760
astronomy

375
00:14:09,030 --> 00:14:06,880
oh absolutely in many ways right yeah

376
00:14:12,150 --> 00:14:09,040
yeah and i think what happened with some

377
00:14:14,150 --> 00:14:12,160
of the imagery is that the imagery has

378
00:14:16,310 --> 00:14:14,160
public appeal we make sure that the

379
00:14:18,710 --> 00:14:16,320
imagery gets out there and all of the

380
00:14:21,030 --> 00:14:18,720
data and all the discoveries and in fact

381
00:14:23,430 --> 00:14:21,040
when we started putting these images out

382
00:14:25,750 --> 00:14:23,440
more than 20 years ago all of a sudden

383
00:14:27,430 --> 00:14:25,760
we started seeing other sciences doing

384
00:14:30,150 --> 00:14:27,440
the same thing i mean they were like

385
00:14:33,110 --> 00:14:30,160
trying to find the the coolest images of

386
00:14:35,590 --> 00:14:33,120
biological organisms and medical imaging

387
00:14:38,150 --> 00:14:35,600
and all that and so it's really

388
00:14:41,509 --> 00:14:38,160

sort of changed the way that scientists

389
00:14:44,550 --> 00:14:41,519
present their science and in astronomy

390
00:14:46,470 --> 00:14:44,560
we have the beautiful cosmos to

391
00:14:49,269 --> 00:14:46,480
bring to the public yeah and i know what

392
00:14:51,189 --> 00:14:49,279
you mean about the drama part of the uh

393
00:14:52,710 --> 00:14:51,199
uh the repair part because i remember

394
00:14:54,790 --> 00:14:52,720
back in when i in my former life when i

395
00:14:56,389 --> 00:14:54,800
was in solar physics though the solar

396
00:14:59,509 --> 00:14:56,399
maximum mission was one of the first if

397
00:15:02,150 --> 00:14:59,519
not the first uh telescope to get

398
00:15:04,069 --> 00:15:02,160
repaired by a shuttle and that opened up

399
00:15:05,670 --> 00:15:04,079
a lot of interest in in uh solar

400
00:15:07,350 --> 00:15:05,680
astronomy whereas before there wasn't

401
00:15:09,910 --> 00:15:07,360
before um

402
00:15:13,350 --> 00:15:09,920
so okay so i know for me from personal

403
00:15:15,189 --> 00:15:13,360
experience uh the scientific images that

404
00:15:16,230 --> 00:15:15,199
have come off of hubble have been what

405
00:15:18,470 --> 00:15:16,240
has

406
00:15:19,910 --> 00:15:18,480
affected me the most the pretty the the

407
00:15:22,310 --> 00:15:19,920
beautiful aesthetically pleasing ones

408
00:15:24,230 --> 00:15:22,320
were certainly great but it was the

409
00:15:26,790 --> 00:15:24,240
scientific

410
00:15:28,310 --> 00:15:26,800
once i in fact not just in fact if you

411
00:15:29,910 --> 00:15:28,320
look at the deep field which is the one

412
00:15:31,430 --> 00:15:29,920
i that first caught my attention that's

413
00:15:33,189 --> 00:15:31,440

not a particularly pretty picture it's

414
00:15:35,430 --> 00:15:33,199
just a bunch of fuzzy dots everywhere

415
00:15:37,269 --> 00:15:35,440
but it was how it was taken that really

416
00:15:39,670 --> 00:15:37,279
captured my imagination what do you guys

417
00:15:41,509 --> 00:15:39,680
think is uh er it

418
00:15:42,550 --> 00:15:41,519
well i'm asking a bunch of astronomers

419
00:15:44,870 --> 00:15:42,560
this which one do you think is more

420
00:15:46,470 --> 00:15:44,880
important uh the science or the

421
00:15:47,910 --> 00:15:46,480
aesthetics but uh let's go ahead and do

422
00:15:50,310 --> 00:15:47,920
it which one which one do you think has

423
00:15:52,870 --> 00:15:50,320
a bigger impact on the public

424
00:15:55,350 --> 00:15:52,880
well i think i think the aesthetics has

425
00:15:58,389 --> 00:15:55,360
a bigger impact on the public

426
00:16:00,470 --> 00:15:58,399
but i think that the fact that every now

427
00:16:02,389 --> 00:16:00,480
and then you come up with a really big

428
00:16:05,110 --> 00:16:02,399
discovery and plus

429
00:16:06,790 --> 00:16:05,120
that with hubble as carol described we

430
00:16:09,269 --> 00:16:06,800
have managed actually to take the

431
00:16:11,990 --> 00:16:09,279
excitement of discovery and bring it

432
00:16:13,189 --> 00:16:12,000
into the homes of people all across the

433
00:16:16,310 --> 00:16:13,199
globe

434
00:16:18,470 --> 00:16:16,320
that has made the scientific part also

435
00:16:20,870 --> 00:16:18,480
important for the general public but

436
00:16:23,430 --> 00:16:20,880
there is no question that you know much

437
00:16:26,389 --> 00:16:23,440
of the popularity of hubble derives from

438
00:16:27,509 --> 00:16:26,399

those just astounding images right now i

439
00:16:30,710 --> 00:16:27,519
would take that a little further because

440
00:16:32,710 --> 00:16:30,720
the the beauty allows you to go in and

441
00:16:34,470 --> 00:16:32,720
present the science when i do the

442
00:16:37,110 --> 00:16:34,480
teacher training talks and i talk to

443
00:16:39,670 --> 00:16:37,120
other you can shoot the the images get

444
00:16:42,550 --> 00:16:39,680
the attention and they want to know more

445
00:16:43,910 --> 00:16:42,560
and that is such an easy way to segue

446
00:16:45,670 --> 00:16:43,920
into okay now here's what it really

447
00:16:47,749 --> 00:16:45,680
means here's the science behind it

448
00:16:49,590 --> 00:16:47,759
here's that amazing astronomy that we

449
00:16:51,509 --> 00:16:49,600
discovered using this image and so it's

450
00:16:53,509 --> 00:16:51,519
a combination that are really a lot

451
00:16:54,949 --> 00:16:53,519
gives it you know such such

452
00:16:56,790 --> 00:16:54,959
such the

453
00:16:58,949 --> 00:16:56,800
fact that there's truth behind the

454
00:17:00,949 --> 00:16:58,959
beauty makes it that much more powerful

455
00:17:02,710 --> 00:17:00,959
and tony i'll say that

456
00:17:04,549 --> 00:17:02,720
a little bit in defense of your favorite

457
00:17:06,309 --> 00:17:04,559
image which isn't necessarily my

458
00:17:08,150 --> 00:17:06,319
favorite image but for the hubble deep

459
00:17:11,110 --> 00:17:08,160
field we actually the original publicly

460
00:17:13,110 --> 00:17:11,120
field we made this big big display of it

461
00:17:15,669 --> 00:17:13,120
and we headed out in the public and we

462
00:17:17,189 --> 00:17:15,679
could see people walk up to it you know

463
00:17:19,909 --> 00:17:17,199

a few people together and they would

464
00:17:22,150 --> 00:17:19,919
start classifying the galaxies and then

465
00:17:23,510 --> 00:17:22,160
sometimes you know an astronomer would

466
00:17:25,909 --> 00:17:23,520
go over and say do you know what you're

467
00:17:28,630 --> 00:17:25,919
doing you're doing science

468
00:17:30,950 --> 00:17:28,640
what what i'm doing science oh my god

469
00:17:33,909 --> 00:17:30,960
stop that yeah really it was a very

470
00:17:36,070 --> 00:17:33,919
engaging way as frank says of those

471
00:17:37,750 --> 00:17:36,080
images make people start to ask

472
00:17:39,590 --> 00:17:37,760
questions about what is it why does it

473
00:17:41,669 --> 00:17:39,600
look like this

474
00:17:43,430 --> 00:17:41,679
with the d with the deep field it's

475
00:17:44,390 --> 00:17:43,440
go ahead alberto no no go ahead ken i

476
00:17:45,590 --> 00:17:44,400
think i'm going to say exactly what

477
00:17:47,190 --> 00:17:45,600
you're going to say you can say with the

478
00:17:49,510 --> 00:17:47,200
d with the deep field that's a really

479
00:17:50,310 --> 00:17:49,520
interesting case because as tony was

480
00:17:52,470 --> 00:17:50,320
saying

481
00:17:54,390 --> 00:17:52,480
it may not be the most visually striking

482
00:17:56,310 --> 00:17:54,400
image when you just look at it in sort

483
00:17:57,909 --> 00:17:56,320
of a cursory fashion

484
00:17:59,669 --> 00:17:57,919
but when you show people it and you

485
00:18:01,669 --> 00:17:59,679
start to explain to them what it is that

486
00:18:03,590 --> 00:18:01,679
they're seeing

487
00:18:05,430 --> 00:18:03,600
it you know it starts them thinking

488
00:18:07,590 --> 00:18:05,440

about what it means

489
00:18:09,669 --> 00:18:07,600
exactly and then suddenly the beauty of

490
00:18:11,110 --> 00:18:09,679
that image is apparent that you know

491
00:18:12,950 --> 00:18:11,120
whereas just

492
00:18:14,630 --> 00:18:12,960
from a visual standpoint immediate

493
00:18:16,870 --> 00:18:14,640
visual impact it might not have been

494
00:18:18,549 --> 00:18:16,880
before and i think carol was basically

495
00:18:19,830 --> 00:18:18,559
getting to the same thing yeah when

496
00:18:21,830 --> 00:18:19,840
people start

497
00:18:23,510 --> 00:18:21,840
talking about what's in it and doing

498
00:18:25,029 --> 00:18:23,520
something with the image it becomes a

499
00:18:28,390 --> 00:18:25,039
lot more interesting

500
00:18:30,789 --> 00:18:28,400
when you say that in that image

501
00:18:32,070 --> 00:18:30,799
every point of light essentially that

502
00:18:35,350 --> 00:18:32,080
you see there

503
00:18:37,270 --> 00:18:35,360
is a galaxy with a hundred billion stars

504
00:18:38,470 --> 00:18:37,280
like the sun

505
00:18:41,430 --> 00:18:38,480
you know this

506
00:18:44,310 --> 00:18:41,440
literally staggers people and you know

507
00:18:47,190 --> 00:18:44,320
it also gives them a strong sense of you

508
00:18:48,630 --> 00:18:47,200
know our place in the cosmos

509
00:18:50,310 --> 00:18:48,640
all right i was actually going to say

510
00:18:51,350 --> 00:18:50,320
exactly that because i think it's uh you

511
00:18:52,950 --> 00:18:51,360
know was an

512
00:18:54,710 --> 00:18:52,960
eye-opener in so many ways and then

513
00:18:57,110 --> 00:18:54,720

perhaps i find it extremely beautiful

514
00:18:58,789 --> 00:18:57,120
but i guess i'm biased but uh i suppose

515
00:19:00,470 --> 00:18:58,799
that it's also a

516
00:19:02,070 --> 00:19:00,480
it puts something into perspective as

517
00:19:04,549 --> 00:19:02,080
mario said because when you when you

518
00:19:06,390 --> 00:19:04,559
sort of look at this completely blank

519
00:19:08,230 --> 00:19:06,400
patch of the sky where we pointed our

520
00:19:09,510 --> 00:19:08,240
telescope we see ten thousand galaxies

521
00:19:11,350 --> 00:19:09,520
or three thousand galaxies in the case

522
00:19:12,630 --> 00:19:11,360
of the hubble d field for example and

523
00:19:14,390 --> 00:19:12,640
then you and then as mario said you

524
00:19:16,230 --> 00:19:14,400
point out every little dot there is a

525
00:19:18,310 --> 00:19:16,240
galaxy they say the four main or it's

526
00:19:20,710 --> 00:19:18,320
similar to our own that's quite

527
00:19:23,029 --> 00:19:20,720
mind-boggling and it does you know have

528
00:19:25,110 --> 00:19:23,039
a very very different feel to

529
00:19:26,070 --> 00:19:25,120
um you know for us humans you know he

530
00:19:27,750 --> 00:19:26,080
sort of puts it in a different

531
00:19:29,750 --> 00:19:27,760
perspective and it's actually it's quiet

532
00:19:31,029 --> 00:19:29,760
uh i mean i remember you know when it

533
00:19:33,510 --> 00:19:31,039
came out i was a graduate student it was

534
00:19:35,430 --> 00:19:33,520
quite dramatic and people wanted to know

535
00:19:37,110 --> 00:19:35,440
more and he has told us so much more

536
00:19:39,190 --> 00:19:37,120
about just you know just galaxies in

537
00:19:41,750 --> 00:19:39,200
general and it's it's a fascinating

538
00:19:43,830 --> 00:19:41,760

image oh i know and and i mean i've i've

539
00:19:45,029 --> 00:19:43,840
seen it plenty of times before but it

540
00:19:47,830 --> 00:19:45,039
wasn't until

541
00:19:49,669 --> 00:19:47,840
i learned how it was taken in the

542
00:19:51,430 --> 00:19:49,679
context of that image that i couldn't

543
00:19:53,110 --> 00:19:51,440
stop thinking about it it absolutely

544
00:19:55,350 --> 00:19:53,120
blew me away it was like you know we

545
00:19:56,789 --> 00:19:55,360
stared at this blank spot in the sky for

546
00:19:58,950 --> 00:19:56,799
all this time for hours and hours and

547
00:20:01,110 --> 00:19:58,960
built up this image that was filled with

548
00:20:03,029 --> 00:20:01,120
galaxies in it so let me ask you this

549
00:20:05,909 --> 00:20:03,039
these images i this this image in

550
00:20:07,270 --> 00:20:05,919
particular i think was taken using um

551
00:20:08,789 --> 00:20:07,280
hubble's there's there's this thing

552
00:20:09,909 --> 00:20:08,799
called director's discretionary time or

553
00:20:11,190 --> 00:20:09,919
something like that right that's where

554
00:20:12,870 --> 00:20:11,200
you can just sort of decide how to take

555
00:20:15,190 --> 00:20:12,880
a picture correct

556
00:20:17,110 --> 00:20:15,200
was anybody worried about

557
00:20:20,870 --> 00:20:17,120
how that would turn out you know was

558
00:20:22,549 --> 00:20:20,880
anybody worried was it a risk to uh

559
00:20:25,029 --> 00:20:22,559
to take this image point the telescope a

560
00:20:26,230 --> 00:20:25,039
very valuable piece of um hardware at

561
00:20:27,750 --> 00:20:26,240
nothing

562
00:20:29,830 --> 00:20:27,760
yeah there were there were many

563
00:20:32,830 --> 00:20:29,840

prominent astronomers saying that that

564
00:20:35,909 --> 00:20:32,840
was going to be a waste of time

565
00:20:37,669 --> 00:20:35,919
scientifically and uh

566
00:20:40,470 --> 00:20:37,679
you know but the results speak for

567
00:20:42,230 --> 00:20:40,480
themselves it's one of the most uh

568
00:20:43,909 --> 00:20:42,240
you know productive

569
00:20:45,430 --> 00:20:43,919
projects that hubble's ever undertaken

570
00:20:49,270 --> 00:20:45,440
in terms of the number of scientific

571
00:20:51,190 --> 00:20:49,280
papers and citations and so on

572
00:20:53,510 --> 00:20:51,200
and we repeated it uh several times with

573
00:20:55,029 --> 00:20:53,520
the ultimate field in the 2000 right

574
00:20:57,430 --> 00:20:55,039
right 2010 no it was a very

575
00:20:59,830 --> 00:20:57,440
controversial i i want to remind

576
00:21:02,470 --> 00:20:59,840
everybody also that the area of the sky

577
00:21:04,230 --> 00:21:02,480
you are looking at here is just about

578
00:21:07,110 --> 00:21:04,240
something like what you would see if you

579
00:21:09,190 --> 00:21:07,120
look through a drinking straw so i mean

580
00:21:10,950 --> 00:21:09,200
that gives you another impression of

581
00:21:12,950 --> 00:21:10,960
what it is you're seeing there's very

582
00:21:14,789 --> 00:21:12,960
tiny patch well there's more than 10

583
00:21:17,669 --> 00:21:14,799
million patches on the whole night sky

584
00:21:19,590 --> 00:21:17,679
of this size so the whole night sky

585
00:21:21,750 --> 00:21:19,600
you'd have to tile this over 10 million

586
00:21:24,070 --> 00:21:21,760
times to cover the whole night sky and

587
00:21:26,870 --> 00:21:24,080
if you if and if you do the math you see

588
00:21:29,430 --> 00:21:26,880

that in the in the observable universe

589
00:21:32,149 --> 00:21:29,440
there should be something like 200

590
00:21:34,230 --> 00:21:32,159
billion galaxies do we all feel small

591
00:21:36,310 --> 00:21:34,240
enough now we offer smaller

592
00:21:37,430 --> 00:21:36,320
have a nice day

593
00:21:39,110 --> 00:21:37,440
okay now we're going to come back to

594
00:21:41,830 --> 00:21:39,120
this image in just a bit but i it

595
00:21:43,990 --> 00:21:41,840
occurred to me that i have i have been

596
00:21:45,830 --> 00:21:44,000
neglectful and not telling people how

597
00:21:47,990 --> 00:21:45,840
they can participate so we're building

598
00:21:49,590 --> 00:21:48,000
this list but we want you to help us

599
00:21:51,590 --> 00:21:49,600
build it and the way we want you to help

600
00:21:54,470 --> 00:21:51,600
us build it is to

601
00:21:56,710 --> 00:21:54,480
comment tell us which ones you think are

602
00:21:59,430 --> 00:21:56,720
hubble's greatest images but don't just

603
00:22:01,590 --> 00:21:59,440
post a link on the comment thing of this

604
00:22:03,590 --> 00:22:01,600
event page or anything you know put some

605
00:22:05,590 --> 00:22:03,600
effort in it tell us why

606
00:22:08,070 --> 00:22:05,600
it's it's important why is that image

607
00:22:09,909 --> 00:22:08,080
great and because we're going to all

608
00:22:12,390 --> 00:22:09,919
take a look at this and build build the

609
00:22:14,310 --> 00:22:12,400
list based on your input so

610
00:22:16,070 --> 00:22:14,320
the way you can let us know is you could

611
00:22:17,510 --> 00:22:16,080
you could comment on this event page if

612
00:22:19,909 --> 00:22:17,520
you want to you can go to our facebook

613
00:22:21,990 --> 00:22:19,919

page the uh facebook dot com slash

614
00:22:24,470 --> 00:22:22,000
hubble telescope and and and interact

615
00:22:26,630 --> 00:22:24,480
with us there you can tweet using the

616
00:22:28,870 --> 00:22:26,640
hashtag that you see here on my lower

617
00:22:31,350 --> 00:22:28,880
third called hubbletopshots you can also

618
00:22:32,549 --> 00:22:31,360
use that on uh on the g plus page as

619
00:22:34,070 --> 00:22:32,559
well

620
00:22:36,070 --> 00:22:34,080
also we have

621
00:22:37,990 --> 00:22:36,080
a hubble space telescope community the

622
00:22:39,110 --> 00:22:38,000
link to that community is on the event

623
00:22:41,270 --> 00:22:39,120
page of this

624
00:22:43,430 --> 00:22:41,280
on g plus i would encourage you to join

625
00:22:45,350 --> 00:22:43,440
that community make your post there

626
00:22:47,270 --> 00:22:45,360
discuss other people's pictures plus

627
00:22:49,110 --> 00:22:47,280
want it

628
00:22:51,669 --> 00:22:49,120
tell them why you think it's a good idea

629
00:22:53,350 --> 00:22:51,679
or a bad idea that image be included but

630
00:22:55,510 --> 00:22:53,360
interact with us let us know what you

631
00:22:57,830 --> 00:22:55,520
think because this is it like i said

632
00:22:59,270 --> 00:22:57,840
this is going to be the list and if you

633
00:23:00,470 --> 00:22:59,280
want to be a part of it you're going to

634
00:23:02,070 --> 00:23:00,480
have to

635
00:23:04,070 --> 00:23:02,080
prove it prove it prove it to us that

636
00:23:06,630 --> 00:23:04,080
these are this is in fact a great image

637
00:23:08,149 --> 00:23:06,640
from hubble so there i wanted to so if

638
00:23:09,830 --> 00:23:08,159

you're with us on google plus as well on

639
00:23:12,310 --> 00:23:09,840
the event page if there's something that

640
00:23:14,070 --> 00:23:12,320
you found from the hubble site gallery

641
00:23:15,510 --> 00:23:14,080
take the image itself and put it into

642
00:23:17,750 --> 00:23:15,520
the event page so you're not only

643
00:23:19,669 --> 00:23:17,760
sharing which image the title of it but

644
00:23:21,270 --> 00:23:19,679
you can actually show the world exactly

645
00:23:23,750 --> 00:23:21,280
what you're talking about and why is

646
00:23:25,750 --> 00:23:23,760
that important to you yeah so we want

647
00:23:27,110 --> 00:23:25,760
your input and we want you to tell us

648
00:23:29,430 --> 00:23:27,120
what the greatest images are so let's

649
00:23:30,710 --> 00:23:29,440
get to some specifics uh who wants to

650
00:23:32,149 --> 00:23:30,720
give us their

651
00:23:34,230 --> 00:23:32,159
their favorite image who wants to go

652
00:23:36,390 --> 00:23:34,240
first

653
00:23:38,470 --> 00:23:36,400
oh tony nobody's speaking up i'll do it

654
00:23:42,390 --> 00:23:38,480
okay go ahead ken

655
00:23:43,990 --> 00:23:42,400
i i like abell 370.

656
00:23:44,710 --> 00:23:44,000
and that's a picture and why do you like

657
00:23:46,549 --> 00:23:44,720
that

658
00:23:47,669 --> 00:23:46,559
this this picture i like for several

659
00:23:49,909 --> 00:23:47,679
reasons

660
00:23:52,549 --> 00:23:49,919
um the first reason is that it was one

661
00:23:54,470 --> 00:23:52,559
of the first uh things that we looked at

662
00:23:56,149 --> 00:23:54,480
with the advanced camera for surveys

663
00:23:58,230 --> 00:23:56,159

after it was repaired during servicing

664
00:24:00,149 --> 00:23:58,240
mission four so it has kind of a

665
00:24:02,310 --> 00:24:00,159
personal uh

666
00:24:04,950 --> 00:24:02,320
investment in it that uh a lot of the

667
00:24:07,990 --> 00:24:04,960
people have here that we have a lot of

668
00:24:10,710 --> 00:24:08,000
pride in but scientifically i like it uh

669
00:24:12,870 --> 00:24:10,720
very much because it shows

670
00:24:16,230 --> 00:24:12,880
the effects of gravitational lensing

671
00:24:17,190 --> 00:24:16,240
that is the universe itself acting as a

672
00:24:19,830 --> 00:24:17,200
lens

673
00:24:21,029 --> 00:24:19,840
on the light that's coming from very far

674
00:24:23,430 --> 00:24:21,039
away

675
00:24:25,110 --> 00:24:23,440
and in particular you don't need to be a

676
00:24:26,950 --> 00:24:25,120
scientist to

677
00:24:28,789 --> 00:24:26,960
appreciate what's going on in this image

678
00:24:30,310 --> 00:24:28,799
you can look at it and know just from

679
00:24:33,590 --> 00:24:30,320
looking at it

680
00:24:35,510 --> 00:24:33,600
that in fact matter warps space enough

681
00:24:37,990 --> 00:24:35,520
to distort light

682
00:24:38,950 --> 00:24:38,000
and you can see that in these arcs

683
00:24:40,789 --> 00:24:38,960
um

684
00:24:43,269 --> 00:24:40,799
and and various trails that you see

685
00:24:45,430 --> 00:24:43,279
around this image the light from distant

686
00:24:46,789 --> 00:24:45,440
galaxies gets warped

687
00:24:49,110 --> 00:24:46,799
or

688
00:24:50,950 --> 00:24:49,120

transmitted through this lens this

689
00:24:52,230 --> 00:24:50,960
gravitational lens of this foreground

690
00:24:53,669 --> 00:24:52,240
cluster

691
00:24:56,470 --> 00:24:53,679
and

692
00:24:59,430 --> 00:24:56,480
you end up with these arcs the big arc

693
00:25:01,830 --> 00:24:59,440
on the right is particularly striking

694
00:25:03,669 --> 00:25:01,840
again there you can see that not only is

695
00:25:04,710 --> 00:25:03,679
that cluster in the center of the image

696
00:25:06,549 --> 00:25:04,720
warping

697
00:25:09,430 --> 00:25:06,559
the light and pulling that light of a

698
00:25:11,190 --> 00:25:09,440
distant galaxy into the background

699
00:25:13,669 --> 00:25:11,200
of the background galaxy into that

700
00:25:15,669 --> 00:25:13,679
magnificent arc on the right hand side

701
00:25:16,870 --> 00:25:15,679
if you look along that arc you see that

702
00:25:19,269 --> 00:25:16,880
each time

703
00:25:21,990 --> 00:25:19,279
that arc light passes one of the nearer

704
00:25:23,190 --> 00:25:22,000
galaxies the galaxies themselves warp

705
00:25:25,269 --> 00:25:23,200
that light

706
00:25:27,430 --> 00:25:25,279
so einstein was right you can tell that

707
00:25:29,269 --> 00:25:27,440
just by looking at this picture without

708
00:25:30,870 --> 00:25:29,279
having to know

709
00:25:31,669 --> 00:25:30,880
really any of the physics that's going

710
00:25:33,430 --> 00:25:31,679
on

711
00:25:35,590 --> 00:25:33,440
i think it's just an incredible picture

712
00:25:37,350 --> 00:25:35,600
agreed and so just to clarify this is a

713
00:25:39,430 --> 00:25:37,360

this is a cluster of galaxies and each

714
00:25:41,350 --> 00:25:39,440
one of these dots and smears has a

715
00:25:42,470 --> 00:25:41,360
galaxy in here but every once in a while

716
00:25:44,070 --> 00:25:42,480
what you'll see

717
00:25:46,870 --> 00:25:44,080
are these kind of

718
00:25:49,669 --> 00:25:46,880
long stretched out looking stretchy

719
00:25:51,590 --> 00:25:49,679
things and those are individual galaxies

720
00:25:53,430 --> 00:25:51,600
whose light has been warped by the

721
00:25:55,909 --> 00:25:53,440
gravity of these other galaxies around

722
00:25:58,390 --> 00:25:55,919
it now this this one really dramatic arc

723
00:26:00,470 --> 00:25:58,400
on the right if that one is the one that

724
00:26:02,630 --> 00:26:00,480
is being stretched out by is it by this

725
00:26:05,590 --> 00:26:02,640
elliptical galaxy here or in the right

726
00:26:07,510 --> 00:26:05,600
next to it there or is it some unseen

727
00:26:10,630 --> 00:26:07,520
material somewhere there there are two

728
00:26:13,190 --> 00:26:10,640
concentrations of gas in this of matter

729
00:26:14,870 --> 00:26:13,200
in this image one is right on the center

730
00:26:15,669 --> 00:26:14,880
of the image and that's the main one

731
00:26:19,830 --> 00:26:15,679
that's

732
00:26:22,870 --> 00:26:19,840
arc and you can actually see the galaxy

733
00:26:24,470 --> 00:26:22,880
within that arc repeated multiple times

734
00:26:26,230 --> 00:26:24,480
at both the head and the tail of that

735
00:26:28,149 --> 00:26:26,240
arc for example

736
00:26:31,269 --> 00:26:28,159
and then as i was saying earlier there's

737
00:26:33,269 --> 00:26:31,279
also a shape induced on that arc by the

738
00:26:35,190 --> 00:26:33,279

individual galaxies that are near to

739
00:26:36,630 --> 00:26:35,200
that arc on the sky

740
00:26:39,269 --> 00:26:36,640
and you can see that

741
00:26:41,990 --> 00:26:39,279
the light the the arc kind of bends

742
00:26:44,310 --> 00:26:42,000
around each of those galaxies there uh

743
00:26:47,110 --> 00:26:44,320
let me only clarify tony that that

744
00:26:49,029 --> 00:26:47,120
galaxy that the light of which your c

745
00:26:51,750 --> 00:26:49,039
you're seeing is being stretched like

746
00:26:52,870 --> 00:26:51,760
this that's galaxy is actually much

747
00:26:55,190 --> 00:26:52,880
farther

748
00:26:58,470 --> 00:26:55,200
than the cluster of galaxies that you

749
00:27:02,149 --> 00:26:58,480
see so what happens is that the cluster

750
00:27:04,789 --> 00:27:02,159
of galaxies acts like a lens between us

751
00:27:07,350 --> 00:27:04,799
and the more distant galaxy and by

752
00:27:09,190 --> 00:27:07,360
warping its light it causes all these

753
00:27:11,190 --> 00:27:09,200
shapes that you see in the stretching of

754
00:27:13,269 --> 00:27:11,200
the light i remember the first time i

755
00:27:14,630 --> 00:27:13,279
saw that it was amazing go ahead frank

756
00:27:16,789 --> 00:27:14,640
well i was gonna say i like to call this

757
00:27:18,070 --> 00:27:16,799
visual proof of gender relativity yeah

758
00:27:19,510 --> 00:27:18,080
because i mean when you learn general

759
00:27:21,190 --> 00:27:19,520
relativity in graduate school it's the

760
00:27:22,630 --> 00:27:21,200
christoffel symbols and all these

761
00:27:24,549 --> 00:27:22,640
riemann tensors and everything it's all

762
00:27:25,909 --> 00:27:24,559
this complicated mathematics but you

763
00:27:27,909 --> 00:27:25,919

just have to look at this image from

764
00:27:29,909 --> 00:27:27,919
hubble and you can see the effects of

765
00:27:31,669 --> 00:27:29,919
general relativity in it

766
00:27:33,029 --> 00:27:31,679
is hubble the first telescope to ever

767
00:27:34,870 --> 00:27:33,039
get this i'll get to you just say carol

768
00:27:36,549 --> 00:27:34,880
sorry i is uh

769
00:27:38,630 --> 00:27:36,559
is is the hubble the first one to be

770
00:27:41,590 --> 00:27:38,640
able to take an image of

771
00:27:43,510 --> 00:27:41,600
gravitational lensing like this no no

772
00:27:45,029 --> 00:27:43,520
there but there have been telescopes on

773
00:27:48,230 --> 00:27:45,039
the ground that have certainly done this

774
00:27:50,549 --> 00:27:48,240
but none to the type of resolution or

775
00:27:53,190 --> 00:27:50,559
the depth of field that hubble has been

776
00:27:55,350 --> 00:27:53,200
able to to do got it sorry i interrupted

777
00:27:57,269 --> 00:27:55,360
carol go ahead that's okay we have many

778
00:28:00,230 --> 00:27:57,279
beautiful examples uh

779
00:28:03,269 --> 00:28:00,240
one of my favorites is avail 2218 but i

780
00:28:04,710 --> 00:28:03,279
wanted to bring up a teaser an appetizer

781
00:28:08,389 --> 00:28:04,720
because

782
00:28:10,789 --> 00:28:08,399
an appetizer is that um in in the fall

783
00:28:13,830 --> 00:28:10,799
and over the next uh

784
00:28:17,750 --> 00:28:13,840
several years we have a group that is

785
00:28:20,630 --> 00:28:17,760
working on six lensing clusters

786
00:28:21,830 --> 00:28:20,640
and the project is called frontiers

787
00:28:24,389 --> 00:28:21,840
fields

788
00:28:26,950 --> 00:28:24,399

and the idea is to

789
00:28:30,230 --> 00:28:26,960
look at these six clusters and

790
00:28:32,470 --> 00:28:30,240
then there will be theoretical models to

791
00:28:36,149 --> 00:28:32,480
understand in detail what the mass

792
00:28:38,310 --> 00:28:36,159
distribution of the cluster is and also

793
00:28:40,710 --> 00:28:38,320
information about the more distant

794
00:28:42,870 --> 00:28:40,720
galaxies which are being lensed and so

795
00:28:44,710 --> 00:28:42,880
there'll be six examples and people are

796
00:28:46,950 --> 00:28:44,720
already working

797
00:28:49,110 --> 00:28:46,960
on those even before the hubble

798
00:28:52,070 --> 00:28:49,120
observations are being taken and another

799
00:28:54,789 --> 00:28:52,080
really interesting thing is that

800
00:28:56,789 --> 00:28:54,799
other observatories are already planning

801
00:28:58,549 --> 00:28:56,799
and starting observations of the same

802
00:29:03,110 --> 00:28:58,559
cluster so we're going to have all kinds

803
00:29:05,430 --> 00:29:03,120
of information x-ray infrared hubble

804
00:29:07,190 --> 00:29:05,440
ground-based observations of these six

805
00:29:09,669 --> 00:29:07,200
clusters that will be

806
00:29:11,430 --> 00:29:09,679
coming out over the next couple of years

807
00:29:13,269 --> 00:29:11,440
and so you should stay tuned and you

808
00:29:16,070 --> 00:29:13,279
might be able to participate in trying

809
00:29:18,870 --> 00:29:16,080
to find some of those little lens pieces

810
00:29:20,149 --> 00:29:18,880
um let me get those observations

811
00:29:22,470 --> 00:29:20,159
sorry

812
00:29:24,710 --> 00:29:22,480
someone's calling me about that right

813
00:29:30,630 --> 00:29:24,720

that's right you want to know more

814
00:29:36,310 --> 00:29:33,510
these are observations uh indeed for the

815
00:29:38,870 --> 00:29:36,320
coming future but there already are

816
00:29:43,750 --> 00:29:38,880
observations there is a program called

817
00:29:45,590 --> 00:29:43,760
clash which looked at 25 such clusters

818
00:29:48,549 --> 00:29:45,600
and produced some already some

819
00:29:50,310 --> 00:29:48,559
incredible results including lensing and

820
00:29:52,710 --> 00:29:50,320
many other results

821
00:29:55,909 --> 00:29:52,720
and those results are coming out right

822
00:29:58,230 --> 00:29:55,919
now as we speak okay uh acronym test i

823
00:30:00,310 --> 00:29:58,240
have to run my mavic clash cluster

824
00:30:02,789 --> 00:30:00,320
lensing and

825
00:30:04,070 --> 00:30:02,799
supernova search with hubble supernova

826
00:30:11,110 --> 00:30:04,080
search yeah

827
00:30:16,230 --> 00:30:13,430
another advertise this is another teaser

828
00:30:18,549 --> 00:30:16,240
is that these these uh lensed objects

829
00:30:21,029 --> 00:30:18,559
and this is advertisement for the jwst

830
00:30:23,110 --> 00:30:21,039
scientist here among the group is that

831
00:30:25,830 --> 00:30:23,120
um in some cases some of these little

832
00:30:28,149 --> 00:30:25,840
galaxies that are being lensed we if if

833
00:30:30,870 --> 00:30:28,159
the massive cluster in the front wasn't

834
00:30:33,269 --> 00:30:30,880
there we couldn't actually see it so

835
00:30:35,350 --> 00:30:33,279
this is a clue of what we're going to

836
00:30:37,350 --> 00:30:35,360
see with the james webb telescope in the

837
00:30:38,710 --> 00:30:37,360
future because the james webb telescope

838
00:30:40,950 --> 00:30:38,720

is much bigger

839
00:30:43,990 --> 00:30:40,960
and it will see these galaxies directly

840
00:30:46,310 --> 00:30:44,000
so this is hubble's little lens preview

841
00:30:47,669 --> 00:30:46,320
of what's to come over there yeah i'm

842
00:30:49,029 --> 00:30:47,679
glad you brought that up because that's

843
00:30:50,389 --> 00:30:49,039
an important part of the the frontier

844
00:30:53,990 --> 00:30:50,399
fields thing i think is

845
00:30:55,350 --> 00:30:54,000
using gravity as lens as lenses to make

846
00:30:57,750 --> 00:30:55,360
hubble more powerful than it would

847
00:30:59,269 --> 00:30:57,760
otherwise be and so it can see a little

848
00:31:00,389 --> 00:30:59,279
bit further back and get galaxies you

849
00:31:02,310 --> 00:31:00,399
wouldn't see without the help of

850
00:31:03,510 --> 00:31:02,320
gravitational landing and i think in

851
00:31:04,950 --> 00:31:03,520
fact i'm i've been trying to get

852
00:31:06,710 --> 00:31:04,960
jennifer involved in this too i think

853
00:31:08,149 --> 00:31:06,720
we're going to have a hangout on this

854
00:31:09,909 --> 00:31:08,159
pretty soon alberto we're going to have

855
00:31:11,110 --> 00:31:09,919
to we're going to have to get that going

856
00:31:12,549 --> 00:31:11,120
so because

857
00:31:14,549 --> 00:31:12,559
okay let's talk about some more images

858
00:31:16,950 --> 00:31:14,559
so let me get you in on this you've been

859
00:31:18,630 --> 00:31:16,960
awful quiet i want you to

860
00:31:20,630 --> 00:31:18,640
go in a different direction here yes

861
00:31:22,149 --> 00:31:20,640
please go okay

862
00:31:23,830 --> 00:31:22,159
i'll go maybe i'll go in a more

863
00:31:25,669 --> 00:31:23,840

aesthetic direction

864
00:31:26,549 --> 00:31:25,679
okay yes

865
00:31:33,590 --> 00:31:26,559
let me

866
00:31:36,470 --> 00:31:33,600
let's see here start screen share okay i

867
00:31:39,190 --> 00:31:36,480
have you embiggened so go ahead okay

868
00:31:41,430 --> 00:31:39,200
um there you go so i'm going to talk

869
00:31:43,430 --> 00:31:41,440
about this karina nebula image can you

870
00:31:45,350 --> 00:31:43,440
all see it yes you can

871
00:31:47,190 --> 00:31:45,360
um this is actually is one of my

872
00:31:48,950 --> 00:31:47,200
favorites it's hard to pick a favorite

873
00:31:51,110 --> 00:31:48,960
obviously there's so many

874
00:31:54,149 --> 00:31:51,120
but um this is actually one of the

875
00:31:56,310 --> 00:31:54,159
largest in terms of resolution in terms

876
00:31:57,830 --> 00:31:56,320
of number of pixels

877
00:31:58,710 --> 00:31:57,840
one of the largest images that we've

878
00:32:01,430 --> 00:31:58,720
made

879
00:32:03,590 --> 00:32:01,440
from hubble what is the resolution

880
00:32:08,070 --> 00:32:03,600
uh it's uh

881
00:32:09,110 --> 00:32:08,080
the pixel size is uh 32 000 by 16 000

882
00:32:12,070 --> 00:32:09,120
roughly

883
00:32:14,630 --> 00:32:12,080
so it's about a half a billion pixels

884
00:32:17,350 --> 00:32:14,640
so this is a mosaic then right this is

885
00:32:19,430 --> 00:32:17,360
not this big so this is 16 separate

886
00:32:21,269 --> 00:32:19,440
frames stitched together

887
00:32:22,230 --> 00:32:21,279
there's another odd thing about this

888
00:32:23,830 --> 00:32:22,240

image

889
00:32:25,590 --> 00:32:23,840
well maybe it's not odd but another

890
00:32:28,070 --> 00:32:25,600
unusual thing about this image

891
00:32:29,909 --> 00:32:28,080
is this is a combination of hubble data

892
00:32:33,430 --> 00:32:29,919
and ground-based data

893
00:32:36,710 --> 00:32:33,440
so the hubble uh acs camera took images

894
00:32:39,669 --> 00:32:36,720
in the light of hydrogen so it's h alpha

895
00:32:40,950 --> 00:32:39,679
and but that's all that hubble had for

896
00:32:42,549 --> 00:32:40,960
this

897
00:32:44,789 --> 00:32:42,559
large mosaic

898
00:32:46,070 --> 00:32:44,799
but we were able to take an image from a

899
00:32:47,430 --> 00:32:46,080
ground-based telescope from the

900
00:32:49,269 --> 00:32:47,440
ceratololo

901
00:32:51,110 --> 00:32:49,279
which took an image

902
00:32:52,230 --> 00:32:51,120
of a much actually much wider field

903
00:32:53,110 --> 00:32:52,240
image

904
00:32:54,950 --> 00:32:53,120
and

905
00:32:57,669 --> 00:32:54,960
but that was taken in three different

906
00:32:59,990 --> 00:32:57,679
filters in the light of hydrogen sulfur

907
00:33:02,070 --> 00:33:00,000
and oxygen and from that image we were

908
00:33:03,750 --> 00:33:02,080
able to make a color composite

909
00:33:05,669 --> 00:33:03,760
and so we took the color information

910
00:33:06,789 --> 00:33:05,679
from the ground-based image but we're

911
00:33:08,870 --> 00:33:06,799
able to

912
00:33:10,870 --> 00:33:08,880
combine that with the black and white

913
00:33:13,509 --> 00:33:10,880

image from hubble which has much higher

914
00:33:15,750 --> 00:33:13,519
resolution but we're able to preserve

915
00:33:17,110 --> 00:33:15,760
all the resolution from the hubble data

916
00:33:18,950 --> 00:33:17,120
but but

917
00:33:19,909 --> 00:33:18,960
layer in the color from the ground-based

918
00:33:22,070 --> 00:33:19,919
data

919
00:33:23,990 --> 00:33:22,080
wow so if you zoom into this image i

920
00:33:25,830 --> 00:33:24,000
mean this is showing it much reduced

921
00:33:27,509 --> 00:33:25,840
resolution if you

922
00:33:28,870 --> 00:33:27,519
zoom into this image you just see it's

923
00:33:31,029 --> 00:33:28,880
extraordinary

924
00:33:34,230 --> 00:33:31,039
you see these little tiny knots

925
00:33:36,389 --> 00:33:34,240
where there's uh the gas and dust are

926
00:33:37,350 --> 00:33:36,399
condensing and new stars are being

927
00:33:42,149 --> 00:33:37,360
formed

928
00:33:44,389 --> 00:33:42,159
over this this region of uh the korean

929
00:33:47,269 --> 00:33:44,399
nebula

930
00:33:49,509 --> 00:33:47,279
yep how many sub images did we use as

931
00:33:51,269 --> 00:33:49,519
pictures or individual picture releases

932
00:33:53,509 --> 00:33:51,279
from this image because i can count at

933
00:33:55,750 --> 00:33:53,519
least three or four of them right

934
00:33:57,350 --> 00:33:55,760
uh well we yeah we had several cutouts

935
00:34:00,070 --> 00:33:57,360
that were released at this time and then

936
00:34:02,549 --> 00:34:00,080
the other thing we did was

937
00:34:04,070 --> 00:34:02,559
uh there's a remarkable spot on this

938
00:34:07,190 --> 00:34:04,080

image in this particular place it's kind

939
00:34:08,629 --> 00:34:07,200
of in the upper uh or middle right

940
00:34:10,310 --> 00:34:08,639
portion of the image you see this kind

941
00:34:11,909 --> 00:34:10,320
of funny looking

942
00:34:13,270 --> 00:34:11,919
um thing that looks kind of like a

943
00:34:14,550 --> 00:34:13,280
mountain

944
00:34:17,190 --> 00:34:14,560
on its side

945
00:34:18,069 --> 00:34:17,200
and we were able later to take another

946
00:34:20,869 --> 00:34:18,079
image

947
00:34:22,710 --> 00:34:20,879
with the new camera with with c3

948
00:34:24,710 --> 00:34:22,720
uh and all

949
00:34:27,990 --> 00:34:24,720
do three filters with hubble so we made

950
00:34:29,909 --> 00:34:28,000
a color image from all hubble data

951
00:34:31,829 --> 00:34:29,919
and this is the image that we released

952
00:34:33,510 --> 00:34:31,839
for hubble's 20th anniversary three

953
00:34:36,389 --> 00:34:33,520
years ago

954
00:34:38,550 --> 00:34:36,399
and which we call mystic mountain mystic

955
00:34:39,510 --> 00:34:38,560
mountain yes that's your name right

956
00:34:40,790 --> 00:34:39,520
mario

957
00:34:43,190 --> 00:34:40,800
you gave it that you christened it right

958
00:34:44,629 --> 00:34:43,200
yeah i gave that name

959
00:34:51,419 --> 00:34:44,639
and we thought we were supposed to start

960
00:34:51,429 --> 00:34:55,270
[Laughter]

961
00:34:58,230 --> 00:34:57,349
so in addition to being amazingly

962
00:35:00,829 --> 00:34:58,240
beautiful

963
00:35:03,670 --> 00:35:00,839

can we see that image by the way

964
00:35:05,589 --> 00:35:03,680
yeah yes uh actually this is in uh let

965
00:35:09,109 --> 00:35:05,599
me no that's noted

966
00:35:11,030 --> 00:35:09,119
2010 13 a wait a minute just hang on

967
00:35:13,829 --> 00:35:11,040
here's here it is there's another one

968
00:35:15,190 --> 00:35:13,839
too there yes yes that's it oh there you

969
00:35:16,470 --> 00:35:15,200
go

970
00:35:18,069 --> 00:35:16,480
which one

971
00:35:19,190 --> 00:35:18,079
no i have i have it on my screen you

972
00:35:20,069 --> 00:35:19,200
should be able to see it yeah yeah yeah

973
00:35:22,550 --> 00:35:20,079
yeah

974
00:35:24,870 --> 00:35:22,560
okay i have it i have it in your big i

975
00:35:25,829 --> 00:35:24,880
have the old one either so so this is

976
00:35:28,630 --> 00:35:25,839
the

977
00:35:30,630 --> 00:35:28,640
this is actually a wider view than we

978
00:35:31,829 --> 00:35:30,640
initially released but it really shows

979
00:35:35,349 --> 00:35:31,839
well the

980
00:35:36,550 --> 00:35:35,359
um at the very tip of the the tallest

981
00:35:39,190 --> 00:35:36,560
pillar

982
00:35:40,310 --> 00:35:39,200
uh you see jets coming out on either

983
00:35:42,310 --> 00:35:40,320
side

984
00:35:43,430 --> 00:35:42,320
and that's a telltale signature of a new

985
00:35:45,490 --> 00:35:43,440
star being

986
00:35:47,030 --> 00:35:45,500
formed down in there so um

987
00:35:48,470 --> 00:35:47,040
[Music]

988
00:35:50,230 --> 00:35:48,480

what are those what are those flares

989
00:35:51,670 --> 00:35:50,240
that's not a that's that's an actual

990
00:35:53,589 --> 00:35:51,680
feature that's not that's not an optical

991
00:35:56,069 --> 00:35:53,599
artifact or anything it's a real

992
00:35:59,190 --> 00:35:56,079
that's a real feature yeah

993
00:36:03,190 --> 00:36:00,950
well you know how on these stars you see

994
00:36:05,270 --> 00:36:03,200
these spikes here that's not no no those

995
00:36:06,470 --> 00:36:05,280
are the entire things that smudge

996
00:36:12,069 --> 00:36:06,480
those

997
00:36:15,109 --> 00:36:12,079
when a new star is being born uh there

998
00:36:17,589 --> 00:36:15,119
is like a disc formed around it and from

999
00:36:19,990 --> 00:36:17,599
the center of that disc there are jets

1000
00:36:22,790 --> 00:36:20,000
that emanate to both sides and those are

1001
00:36:24,470 --> 00:36:22,800
the jets that you see

1002
00:36:26,390 --> 00:36:24,480
the birth announcement of his new star

1003
00:36:28,310 --> 00:36:26,400
newborn star yeah

1004
00:36:29,750 --> 00:36:28,320
it's um it's like

1005
00:36:31,990 --> 00:36:29,760
so tell us a little bit about the camera

1006
00:36:35,270 --> 00:36:32,000
that took this um this was this was

1007
00:36:37,589 --> 00:36:35,280
taken with the whiff c3 is that right or

1008
00:36:40,470 --> 00:36:37,599
yeah can maybe wants to talk about that

1009
00:36:42,870 --> 00:36:40,480
yeah so that was the new infrared camera

1010
00:36:44,470 --> 00:36:42,880
that would infrared an optical uv camera

1011
00:36:46,550 --> 00:36:44,480
pan chromatic camera that was installed

1012
00:36:49,190 --> 00:36:46,560
during the servicing mission in uh may

1013
00:36:51,750 --> 00:36:49,200

of 2009 so what's so great about that

1014
00:36:54,630 --> 00:36:51,760
why do we what why do we want uh images

1015
00:36:56,470 --> 00:36:54,640
in the infrared why uh why is that

1016
00:36:59,109 --> 00:36:56,480
important well it allows you to see

1017
00:37:01,030 --> 00:36:59,119
through a lot of the dust that often

1018
00:37:02,630 --> 00:37:01,040
obscures the ultraviolet and the optical

1019
00:37:04,950 --> 00:37:02,640
regions

1020
00:37:07,670 --> 00:37:04,960
in some of these images and so you can

1021
00:37:09,270 --> 00:37:07,680
actually look into star star-forming

1022
00:37:11,670 --> 00:37:09,280
regions like this in some cases you can

1023
00:37:12,710 --> 00:37:11,680
actually look right through them

1024
00:37:14,630 --> 00:37:12,720
and see

1025
00:37:15,829 --> 00:37:14,640
you know see astronomical phenomena that

1026
00:37:17,670 --> 00:37:15,839
you wouldn't have been able to see

1027
00:37:20,150 --> 00:37:17,680
otherwise there are some really good

1028
00:37:23,349 --> 00:37:20,160
examples in the

1029
00:37:25,030 --> 00:37:23,359
the hubble site uh gallery

1030
00:37:26,870 --> 00:37:25,040
where you can blink

1031
00:37:28,470 --> 00:37:26,880
the optical and the infrared images

1032
00:37:30,230 --> 00:37:28,480
together i don't know if we can pull any

1033
00:37:31,829 --> 00:37:30,240
of those up yeah those are i've seen

1034
00:37:34,230 --> 00:37:31,839
those are really great those are they

1035
00:37:36,310 --> 00:37:34,240
kind of fade from the visual to the or

1036
00:37:37,829 --> 00:37:36,320
the optical to the uh near infrared and

1037
00:37:39,829 --> 00:37:37,839
those are well

1038
00:37:41,190 --> 00:37:39,839

i can show one of the infrared images

1039
00:37:44,710 --> 00:37:41,200
the

1040
00:37:46,310 --> 00:37:44,720
show that

1041
00:37:48,550 --> 00:37:46,320
i'm hoping you would do that because the

1042
00:37:50,630 --> 00:37:48,560
horse head is like stunning

1043
00:37:52,630 --> 00:37:50,640
it's one of my favorites now this just

1044
00:37:55,190 --> 00:37:52,640
came out yes

1045
00:37:57,430 --> 00:37:55,200
well this was we did a few months ago

1046
00:37:59,829 --> 00:37:57,440
uh and again an anniversary

1047
00:38:01,270 --> 00:37:59,839
commemoration to commemorate the 23rd

1048
00:38:02,950 --> 00:38:01,280
anniversary

1049
00:38:04,710 --> 00:38:02,960
um so

1050
00:38:07,270 --> 00:38:04,720
the horsehead of course is this this

1051
00:38:10,069 --> 00:38:07,280
object that every astronomer

1052
00:38:11,910 --> 00:38:10,079
uh likes looking at um so we decided to

1053
00:38:13,270 --> 00:38:11,920
do it in the infrared

1054
00:38:15,510 --> 00:38:13,280
and this was a

1055
00:38:17,349 --> 00:38:15,520
i mean uh maybe not as big a gamble as

1056
00:38:19,109 --> 00:38:17,359
the hubble deep field was but it was a

1057
00:38:20,550 --> 00:38:19,119
little bit of a gamble because we didn't

1058
00:38:21,910 --> 00:38:20,560
quite know what we would

1059
00:38:24,790 --> 00:38:21,920
would be getting

1060
00:38:26,870 --> 00:38:24,800
um but we did want to exercise the

1061
00:38:29,430 --> 00:38:26,880
infrared camera a little bit

1062
00:38:31,349 --> 00:38:29,440
and so we took two uh

1063
00:38:33,349 --> 00:38:31,359

filters with the infrared camera and

1064
00:38:34,870 --> 00:38:33,359
this is a color composite of those two

1065
00:38:37,829 --> 00:38:34,880
filters and it's

1066
00:38:39,109 --> 00:38:37,839
to me really remarkable because uh

1067
00:38:39,990 --> 00:38:39,119
we're seeing

1068
00:38:40,870 --> 00:38:40,000
uh

1069
00:38:45,190 --> 00:38:40,880
the

1070
00:38:46,790 --> 00:38:45,200
almost in a negative view from what you

1071
00:38:50,150 --> 00:38:46,800
see in the visible

1072
00:38:51,349 --> 00:38:50,160
so what's bright here largely is dark in

1073
00:38:53,589 --> 00:38:51,359
the visible

1074
00:38:56,390 --> 00:38:53,599
and in addition to that we're seeing

1075
00:38:58,230 --> 00:38:56,400
into the nebula but we're also seeing

1076
00:39:00,470 --> 00:38:58,240
behind the nebula

1077
00:39:02,950 --> 00:39:00,480
whereas in the invisible light at the

1078
00:39:04,550 --> 00:39:02,960
top of the image it's very bright and

1079
00:39:05,430 --> 00:39:04,560
we're not seeing anything behind it but

1080
00:39:06,790 --> 00:39:05,440
here

1081
00:39:08,710 --> 00:39:06,800
that that

1082
00:39:10,069 --> 00:39:08,720
material becomes completely transparent

1083
00:39:12,630 --> 00:39:10,079
and we're able to see

1084
00:39:14,390 --> 00:39:12,640
stars and even very distant galaxies

1085
00:39:16,550 --> 00:39:14,400
much farther away

1086
00:39:19,349 --> 00:39:16,560
right straight through this nebula and

1087
00:39:21,910 --> 00:39:19,359
so it's really remarkable

1088
00:39:24,710 --> 00:39:21,920

salt is telling a very benign story here

1089
00:39:27,589 --> 00:39:24,720
but mario and i can attest that we had

1090
00:39:30,069 --> 00:39:27,599
many discussions about taking this data

1091
00:39:31,510 --> 00:39:30,079
many arguments about exactly what

1092
00:39:33,750 --> 00:39:31,520
filters we were going to use oh we're

1093
00:39:36,950 --> 00:39:33,760
not going to see anything blah blah and

1094
00:39:40,829 --> 00:39:36,960
when the image came out we were all just

1095
00:39:43,910 --> 00:39:40,839
we were blown away oh my goodness

1096
00:39:46,710 --> 00:39:43,920
yeah me just add something tony because

1097
00:39:49,670 --> 00:39:46,720
you asked why do we want an infrared

1098
00:39:51,589 --> 00:39:49,680
camera at all so of course and another

1099
00:39:54,069 --> 00:39:51,599
big reason is that

1100
00:39:55,910 --> 00:39:54,079
because the universe is expanding

1101
00:39:58,550 --> 00:39:55,920
uh light from very good

1102
00:40:01,030 --> 00:39:58,560
i was hoping somebody would say that

1103
00:40:03,349 --> 00:40:01,040
light from very distant galaxies is

1104
00:40:05,670 --> 00:40:03,359
actually red-shifted it is shifted

1105
00:40:08,310 --> 00:40:05,680
towards the red and if you go even

1106
00:40:11,430 --> 00:40:08,320
farther into the infrared so if you want

1107
00:40:13,589 --> 00:40:11,440
to study the very distant universe the

1108
00:40:15,430 --> 00:40:13,599
way to go is the infrared and that's the

1109
00:40:17,510 --> 00:40:15,440
reason why the james webb space

1110
00:40:20,550 --> 00:40:17,520
telescope it will actually look

1111
00:40:21,990 --> 00:40:20,560
exclusively infrared that's right

1112
00:40:25,750 --> 00:40:22,000
i always say the future of astronomy is

1113
00:40:27,829 --> 00:40:25,760

in the infrared yes it is

1114
00:40:29,270 --> 00:40:27,839
yeah i was actually i was actually

1115
00:40:31,190 --> 00:40:29,280
showing some work that frank did

1116
00:40:33,109 --> 00:40:31,200
actually uh from the horse and nebula

1117
00:40:35,030 --> 00:40:33,119
where you can actually since we have a

1118
00:40:36,550 --> 00:40:35,040
little more information than just a

1119
00:40:38,230 --> 00:40:36,560
two-dimensional image we can actually do

1120
00:40:40,870 --> 00:40:38,240
a 3d maybe frankie you want to talk

1121
00:40:42,950 --> 00:40:40,880
about the 3d porcelain nebula tour yeah

1122
00:40:45,349 --> 00:40:42,960
this is a visualization that zolt and i

1123
00:40:47,430 --> 00:40:45,359
and our team and greg and lisa did uh

1124
00:40:49,670 --> 00:40:47,440
just a very simple camera move to show

1125
00:40:51,910 --> 00:40:49,680
you the three-dimensionality of the

1126
00:40:54,710 --> 00:40:51,920
nebula because you know what really

1127
00:40:57,349 --> 00:40:54,720
makes it real cool is that if you uh do

1128
00:40:58,630 --> 00:40:57,359
it a crossfade from the visible to the

1129
00:41:00,550 --> 00:40:58,640
infrared you're playing the isa version

1130
00:41:01,670 --> 00:41:00,560
not the hubble side direction correct

1131
00:41:04,150 --> 00:41:01,680
all right with the hubble side version

1132
00:41:06,390 --> 00:41:04,160
has has the cool crossfade from the

1133
00:41:09,670 --> 00:41:06,400
visible light to the infrared light you

1134
00:41:11,829 --> 00:41:09,680
just see how how much more we see with

1135
00:41:14,150 --> 00:41:11,839
the infrared and it becomes visually

1136
00:41:15,910 --> 00:41:14,160
obvious why we really want to use both

1137
00:41:17,670 --> 00:41:15,920
wavelengths yeah let me see if i can try

1138
00:41:19,510 --> 00:41:17,680

to find that that's amazing work frank i

1139
00:41:22,150 --> 00:41:19,520
love that simulator that

1140
00:41:24,069 --> 00:41:22,160
it's really good tony when that image

1141
00:41:25,910 --> 00:41:24,079
came out one of the engineers here

1142
00:41:27,589 --> 00:41:25,920
changed the way that i look at that

1143
00:41:29,190 --> 00:41:27,599
nebula forever

1144
00:41:30,630 --> 00:41:29,200
and he said

1145
00:41:32,390 --> 00:41:30,640
i asked him

1146
00:41:34,630 --> 00:41:32,400
uh what did he think of the image and he

1147
00:41:37,270 --> 00:41:34,640
said i never realized there were so many

1148
00:41:39,589 --> 00:41:37,280
galaxies behind me

1149
00:41:41,589 --> 00:41:39,599
and actually if you again if you go to

1150
00:41:43,589 --> 00:41:41,599
the hubble site and you look at it up at

1151
00:41:44,950 --> 00:41:43,599
a real nice resolution that you can get

1152
00:41:48,710 --> 00:41:44,960
there

1153
00:41:49,829 --> 00:41:48,720
hundreds of galaxies behind this thing

1154
00:41:51,270 --> 00:41:49,839
it's it's

1155
00:41:52,550 --> 00:41:51,280
amazing that's another point we should

1156
00:41:55,109 --> 00:41:52,560
emphasize that when you go to hubble

1157
00:41:57,190 --> 00:41:55,119
site you get every pixel that we use the

1158
00:41:59,190 --> 00:41:57,200
astronomers see yeah so you want to look

1159
00:42:00,870 --> 00:41:59,200
at that image in all its glory you get

1160
00:42:02,470 --> 00:42:00,880
every single pixel we see so you can see

1161
00:42:04,309 --> 00:42:02,480
all those galaxies that we look at i

1162
00:42:06,069 --> 00:42:04,319
mean this the horse heads 20 degrees off

1163
00:42:07,589 --> 00:42:06,079

the galactic plane so

1164
00:42:09,349 --> 00:42:07,599
it's up out of the dust

1165
00:42:11,030 --> 00:42:09,359
most of the dust of the disk and then

1166
00:42:13,750 --> 00:42:11,040
with the infrared camera you can see

1167
00:42:15,750 --> 00:42:13,760
right through the dust of this region

1168
00:42:17,670 --> 00:42:15,760
to those background galaxies as you as

1169
00:42:18,950 --> 00:42:17,680
you noted before okay before we leave

1170
00:42:20,710 --> 00:42:18,960
this image i just want to point i want

1171
00:42:23,109 --> 00:42:20,720
to ask you guys a question that that i

1172
00:42:25,190 --> 00:42:23,119
was wondering about what is the effect i

1173
00:42:27,349 --> 00:42:25,200
mean it right next to the horse head is

1174
00:42:30,230 --> 00:42:27,359
a really bright star i believe zeta

1175
00:42:32,069 --> 00:42:30,240
orionis is that right uh really what

1176
00:42:33,109 --> 00:42:32,079
what effect do really bright stars have

1177
00:42:34,630 --> 00:42:33,119
on hubble

1178
00:42:36,950 --> 00:42:34,640
do we have talking are you talking about

1179
00:42:39,030 --> 00:42:36,960
sigma orionis the one that's actually uh

1180
00:42:41,030 --> 00:42:39,040
it could be yeah the one that's right

1181
00:42:43,030 --> 00:42:41,040
next to it

1182
00:42:45,670 --> 00:42:43,040
the one there's a really bright star

1183
00:42:48,230 --> 00:42:45,680
that when i was looking

1184
00:42:49,349 --> 00:42:48,240
that is one needs to yeah it's very it's

1185
00:42:51,670 --> 00:42:49,359
within a field of view of a small

1186
00:42:53,670 --> 00:42:51,680
telescope but i i was just i was just

1187
00:42:55,349 --> 00:42:53,680
wondering when you're getting close to

1188
00:42:57,430 --> 00:42:55,359

bright stars or objects that are close

1189
00:42:59,030 --> 00:42:57,440
to very bright stars like that is it a

1190
00:43:00,870 --> 00:42:59,040
danger to hubble i mean do we have to

1191
00:43:03,829 --> 00:43:00,880
take any precautions

1192
00:43:06,550 --> 00:43:03,839
you mean when we point near the

1193
00:43:08,870 --> 00:43:06,560
telescope is not getting near a bright

1194
00:43:11,190 --> 00:43:08,880
star as we're pointing near i'm waiting

1195
00:43:13,030 --> 00:43:11,200
near thank you the telescope stays with

1196
00:43:14,630 --> 00:43:13,040
us yes

1197
00:43:15,910 --> 00:43:14,640
it's not pulling a comet ice in and

1198
00:43:19,750 --> 00:43:15,920
grazing

1199
00:43:23,430 --> 00:43:22,309
tony the answer is pointing near

1200
00:43:25,190 --> 00:43:23,440
yes

1201
00:43:27,109 --> 00:43:25,200
the answer to your question depends on

1202
00:43:28,550 --> 00:43:27,119
what instrument we're using to look at

1203
00:43:31,030 --> 00:43:28,560
the uh

1204
00:43:32,230 --> 00:43:31,040
the nebula or the star that's near the

1205
00:43:34,309 --> 00:43:32,240
nebula

1206
00:43:37,270 --> 00:43:34,319
in some cases it could pose a health and

1207
00:43:40,390 --> 00:43:37,280
safety risk to the instrumentation

1208
00:43:41,829 --> 00:43:40,400
by over lighting the detectors in other

1209
00:43:43,670 --> 00:43:41,839
cases

1210
00:43:46,069 --> 00:43:43,680
it might just end up saturating the

1211
00:43:47,190 --> 00:43:46,079
detector in which case um

1212
00:43:50,069 --> 00:43:47,200
you know the worst thing that might

1213
00:43:52,069 --> 00:43:50,079

happen is that the detector

1214
00:43:54,790 --> 00:43:52,079
kind of blurs out in that particular

1215
00:43:56,710 --> 00:43:54,800
image but then recovers fully from the

1216
00:43:58,790 --> 00:43:56,720
exposure afterwards

1217
00:44:00,790 --> 00:43:58,800
let me point out that there is one star

1218
00:44:03,030 --> 00:44:00,800
that you definitely don't want to point

1219
00:44:05,190 --> 00:44:03,040
the telescope yeah that's the sun oh

1220
00:44:06,710 --> 00:44:05,200
yeah yeah now we take special lots of

1221
00:44:08,550 --> 00:44:06,720
precautions were taken to avoid that

1222
00:44:10,790 --> 00:44:08,560
right ken absolutely

1223
00:44:12,870 --> 00:44:10,800
we have a definite solar avoidance zone

1224
00:44:14,790 --> 00:44:12,880
and there are many safeguards in place

1225
00:44:17,430 --> 00:44:14,800
on hubble to make sure that we don't

1226
00:44:19,349 --> 00:44:17,440
point at the sun even as a last resort

1227
00:44:20,630 --> 00:44:19,359
closing the baffle on the front of the

1228
00:44:22,230 --> 00:44:20,640
telescope

1229
00:44:23,510 --> 00:44:22,240
which you which you never want to do

1230
00:44:25,190 --> 00:44:23,520
because you don't ever know if it's

1231
00:44:26,790 --> 00:44:25,200
going to open

1232
00:44:28,470 --> 00:44:26,800
so why do we put what so is that what

1233
00:44:29,910 --> 00:44:28,480
it's there for just as an ultimate uh

1234
00:44:31,589 --> 00:44:29,920
safeguard against pointing at the sun i

1235
00:44:33,829 --> 00:44:31,599
mean i've always wondered it always it's

1236
00:44:36,150 --> 00:44:33,839
always open isn't it it won't

1237
00:44:37,910 --> 00:44:36,160
close it no we don't ever close it um

1238
00:44:39,750 --> 00:44:37,920

the only time we ever close it is during

1239
00:44:41,430 --> 00:44:39,760
servicing missions right so when the

1240
00:44:44,150 --> 00:44:41,440
telescope's put into the payload bay of

1241
00:44:46,710 --> 00:44:44,160
the shuttle okay um and even then we

1242
00:44:48,710 --> 00:44:46,720
always worry would it open again

1243
00:44:52,309 --> 00:44:48,720
and even then we don't release the

1244
00:44:55,430 --> 00:44:53,190
and

1245
00:44:57,109 --> 00:44:55,440
but you're right tony uh it's kind of

1246
00:44:58,710 --> 00:44:57,119
the ultimate safeguard although if it

1247
00:45:00,390 --> 00:44:58,720
had gotten to the point where sunlight

1248
00:45:02,230 --> 00:45:00,400
was actually

1249
00:45:04,630 --> 00:45:02,240
near enough to be going down the baffle

1250
00:45:06,550 --> 00:45:04,640
that we closed that door

1251
00:45:08,390 --> 00:45:06,560
we'd probably already have had problems

1252
00:45:10,309 --> 00:45:08,400
so in that sense it

1253
00:45:11,430 --> 00:45:10,319
it's not terribly useful

1254
00:45:13,030 --> 00:45:11,440
right yeah the other the other

1255
00:45:14,390 --> 00:45:13,040
safeguards that are in place are far

1256
00:45:17,030 --> 00:45:14,400
more useful

1257
00:45:18,309 --> 00:45:17,040
okay we haven't gotten okay i i we're

1258
00:45:19,750 --> 00:45:18,319
running out of time i see we only have

1259
00:45:21,510 --> 00:45:19,760
about 15 minutes left we haven't talked

1260
00:45:23,270 --> 00:45:21,520
with frank and mario about theirs uh

1261
00:45:25,270 --> 00:45:23,280
frank how you got a you got a favorite

1262
00:45:28,069 --> 00:45:25,280
you'd like to share uh actually uh let

1263
00:45:30,230 --> 00:45:28,079

me share uh go to the third image in

1264
00:45:32,069 --> 00:45:30,240
mine and bring that up uh on screen

1265
00:45:33,190 --> 00:45:32,079
share i'm to do something in praise of

1266
00:45:35,349 --> 00:45:33,200
dots

1267
00:45:37,670 --> 00:45:35,359
okay because we show

1268
00:45:39,990 --> 00:45:37,680
images no no no

1269
00:45:41,990 --> 00:45:40,000
in praise of the dots of uh that hubble

1270
00:45:44,150 --> 00:45:42,000
sees because this shows off hubble's

1271
00:45:45,990 --> 00:45:44,160
resolution okay

1272
00:45:47,589 --> 00:45:46,000
and

1273
00:45:49,589 --> 00:45:47,599
pull that up i think they're pulling it

1274
00:45:50,630 --> 00:45:49,599
up for us yeah all right go to the next

1275
00:45:53,109 --> 00:45:50,640
slide

1276
00:45:55,750 --> 00:45:53,119
and the next one there we go okay

1277
00:45:59,190 --> 00:45:55,760
all right so this is the pluto system

1278
00:46:02,150 --> 00:45:59,200
okay pluto and karen and the four moons

1279
00:46:03,910 --> 00:46:02,160
around them uh nyx hydra and then p4 and

1280
00:46:05,829 --> 00:46:03,920
p5 which have been recently named

1281
00:46:06,710 --> 00:46:05,839
kerberos and sticks

1282
00:46:09,510 --> 00:46:06,720
and

1283
00:46:12,309 --> 00:46:09,520
hubble is the only telescope that can

1284
00:46:15,829 --> 00:46:12,319
really see with such fine resolution to

1285
00:46:18,069 --> 00:46:15,839
see these tiny little dots around pluto

1286
00:46:20,069 --> 00:46:18,079
way out at the edge of our solar system

1287
00:46:23,030 --> 00:46:20,079
and i like this image because it shows

1288
00:46:25,109 --> 00:46:23,040

off the amazing resolution hubble has

1289
00:46:27,349 --> 00:46:25,119
but what it also does

1290
00:46:28,950 --> 00:46:27,359
is it shows that you know we think we

1291
00:46:30,390 --> 00:46:28,960
know our solar system we think now

1292
00:46:33,589 --> 00:46:30,400
there's nothing new in our own

1293
00:46:35,030 --> 00:46:33,599
astronomical backyard but here are you

1294
00:46:37,910 --> 00:46:35,040
know we've known about pluto and karen

1295
00:46:40,630 --> 00:46:37,920
since 1986 but all four of those moons

1296
00:46:43,109 --> 00:46:40,640
were discovered by hubble in the last

1297
00:46:44,870 --> 00:46:43,119
you know what is it since 20 years just

1298
00:46:47,270 --> 00:46:44,880
a few thousand five actually so eight

1299
00:46:48,870 --> 00:46:47,280
years in the last decade yeah within the

1300
00:46:51,510 --> 00:46:48,880
last decade we've discovered these four

1301
00:46:54,630 --> 00:46:51,520
new moons and hubble's resolution allows

1302
00:46:57,589 --> 00:46:54,640
us to do that uh and so our our

1303
00:46:59,670 --> 00:46:57,599
astronomical backyard really uh you know

1304
00:47:01,349 --> 00:46:59,680
we're learning new things with it

1305
00:47:02,630 --> 00:47:01,359
all right and so let's skip that sort of

1306
00:47:04,790 --> 00:47:02,640
a couple more because i want to there

1307
00:47:07,190 --> 00:47:04,800
there's another red dot go keep going

1308
00:47:09,750 --> 00:47:07,200
keep going that was red keep going the

1309
00:47:12,470 --> 00:47:09,760
next one okay and so i want to take that

1310
00:47:14,870 --> 00:47:12,480
one step further um and not planets

1311
00:47:17,430 --> 00:47:14,880
around our own star but i think one of

1312
00:47:19,430 --> 00:47:17,440
the greatest things in our lifetime is

1313
00:47:21,349 --> 00:47:19,440

the discovery of planets around other

1314
00:47:24,150 --> 00:47:21,359
stars i mean this is you know the most

1315
00:47:26,950 --> 00:47:24,160
compelling story we have to offer that

1316
00:47:29,030 --> 00:47:26,960
we are seeing other solar systems and

1317
00:47:31,349 --> 00:47:29,040
this image here i know it looks like the

1318
00:47:34,150 --> 00:47:31,359
eye of sauron from the lord of the rings

1319
00:47:36,309 --> 00:47:34,160
um but what it is is we're blocking out

1320
00:47:37,430 --> 00:47:36,319
the light of this star called fomolot

1321
00:47:39,270 --> 00:47:37,440
okay using that's what's called the

1322
00:47:41,990 --> 00:47:39,280
chronographic mask to block it out and

1323
00:47:43,829 --> 00:47:42,000
you see this dust ring around it and

1324
00:47:45,990 --> 00:47:43,839
because the shape of the dust ring was

1325
00:47:48,230 --> 00:47:46,000
sort of pulled off center we suspected

1326
00:47:49,670 --> 00:47:48,240
there might be a planet and over on the

1327
00:47:51,589 --> 00:47:49,680
right there's that small little box and

1328
00:47:53,990 --> 00:47:51,599
then the pull out that shows you formula

1329
00:47:57,670 --> 00:47:54,000
b and the two images we got of it from

1330
00:47:58,550 --> 00:47:57,680
2004 to 2006 to show it had a nice orbit

1331
00:48:00,230 --> 00:47:58,560
around

1332
00:48:01,270 --> 00:48:00,240
fomalhaut and really we're seeing a

1333
00:48:03,750 --> 00:48:01,280
planet

1334
00:48:06,550 --> 00:48:03,760
well this is the first visible light

1335
00:48:08,230 --> 00:48:06,560
image ever taken of a planet around

1336
00:48:10,230 --> 00:48:08,240
another star

1337
00:48:11,910 --> 00:48:10,240
and so i i brought up these two images

1338
00:48:13,750 --> 00:48:11,920

to show you that you know research

1339
00:48:16,309 --> 00:48:13,760
science is generally done with these

1340
00:48:18,150 --> 00:48:16,319
dots okay you know it's not

1341
00:48:20,309 --> 00:48:18,160
yes we get some fantastic beautiful

1342
00:48:22,230 --> 00:48:20,319
images but you know some of the cutting

1343
00:48:24,870 --> 00:48:22,240
edge you know i always thought i should

1344
00:48:27,190 --> 00:48:24,880
give a talk in praise of red dots

1345
00:48:29,109 --> 00:48:27,200
because you know a lot of uh our cutting

1346
00:48:30,950 --> 00:48:29,119
edge science is done by just looking at

1347
00:48:33,430 --> 00:48:30,960
these dots and the implication of these

1348
00:48:35,430 --> 00:48:33,440
dots are just fantastic

1349
00:48:38,309 --> 00:48:35,440
yeah that is that is an amazing photo

1350
00:48:40,790 --> 00:48:38,319
and or a set of images actually so the

1351
00:48:42,870 --> 00:48:40,800
um uh

1352
00:48:44,069 --> 00:48:42,880
the hubble came and visited it twice oh

1353
00:48:45,829 --> 00:48:44,079
what what do you

1354
00:48:48,630 --> 00:48:45,839
what do you wanna do

1355
00:48:51,270 --> 00:48:48,640
later later go ahead okay so it visited

1356
00:48:53,190 --> 00:48:51,280
it visited the uh the system twice and

1357
00:48:55,430 --> 00:48:53,200
it has a a mask in front of it that it

1358
00:48:57,430 --> 00:48:55,440
uses to block out the the bright star is

1359
00:49:00,150 --> 00:48:57,440
that what you said yeah that's what's

1360
00:49:02,390 --> 00:49:00,160
labeled in the it's a chronographic mask

1361
00:49:03,910 --> 00:49:02,400
um and so it's

1362
00:49:05,349 --> 00:49:03,920
it's it's blocking out the light a foam

1363
00:49:07,190 --> 00:49:05,359

a lot so we can see the faint things

1364
00:49:08,549 --> 00:49:07,200
around just like you would at sunset you

1365
00:49:09,910 --> 00:49:08,559
know you put your hand up to block the

1366
00:49:11,910 --> 00:49:09,920
sun so you can see the road as you're

1367
00:49:13,190 --> 00:49:11,920
driving down well you know we're doing

1368
00:49:14,710 --> 00:49:13,200
that same sort of thing so what's that

1369
00:49:17,829 --> 00:49:14,720
what's that ring there what's uh what's

1370
00:49:21,190 --> 00:49:17,839
it about uh well this is a ring of dust

1371
00:49:22,309 --> 00:49:21,200
and um around the star of home a lot uh

1372
00:49:25,270 --> 00:49:22,319
we have

1373
00:49:27,190 --> 00:49:25,280
dust rings around a lot of stars uh we

1374
00:49:30,950 --> 00:49:27,200
believe that planetary systems all form

1375
00:49:33,190 --> 00:49:30,960
in a nice uh disc and uh we see a ring

1376
00:49:35,270 --> 00:49:33,200
of dust around foam a lot that you know

1377
00:49:36,790 --> 00:49:35,280
in which planets could be forming or

1378
00:49:39,030 --> 00:49:36,800
this could be far enough out that this

1379
00:49:40,549 --> 00:49:39,040
could be a ring that might be similar to

1380
00:49:42,549 --> 00:49:40,559
say the kuiper belt in our own solar

1381
00:49:44,470 --> 00:49:42,559
system

1382
00:49:46,309 --> 00:49:44,480
this is this is an image i believe this

1383
00:49:48,549 --> 00:49:46,319
one was taken with the uh advanced

1384
00:49:50,870 --> 00:49:48,559
camera for surveys high resolution

1385
00:49:52,549 --> 00:49:50,880
yeah this is the hrc we've observed it

1386
00:49:53,829 --> 00:49:52,559
more recently yeah we've seen so

1387
00:49:56,470 --> 00:49:53,839
physically

1388
00:49:59,270 --> 00:49:56,480

and in fact 2011 yeah and in fact it

1389
00:50:01,190 --> 00:49:59,280
continues along this orbit that's

1390
00:50:03,190 --> 00:50:01,200
been predicted here so

1391
00:50:05,829 --> 00:50:03,200
there's a longer baseline available now

1392
00:50:07,589 --> 00:50:05,839
too right we got 2010 and 2012 images

1393
00:50:09,349 --> 00:50:07,599
yeah and the cool thing about those are

1394
00:50:11,750 --> 00:50:09,359
that it's not on this nice

1395
00:50:13,670 --> 00:50:11,760
orbit inside the ring it actually

1396
00:50:15,670 --> 00:50:13,680
extends it's a very elliptical orbit

1397
00:50:17,270 --> 00:50:15,680
right which is even more confusing and

1398
00:50:18,710 --> 00:50:17,280
interesting which is why i went for this

1399
00:50:20,710 --> 00:50:18,720
image because it's easier to understand

1400
00:50:23,430 --> 00:50:20,720
yeah

1401
00:50:26,549 --> 00:50:23,440
okay mario you want to share one with us

1402
00:50:29,109 --> 00:50:26,559
uh sure why not uh maybe let's put the

1403
00:50:31,190 --> 00:50:29,119
bullet cluster which is the third from

1404
00:50:33,589 --> 00:50:31,200
the top here yeah

1405
00:50:35,829 --> 00:50:33,599
yeah that's a good one so uh

1406
00:50:39,270 --> 00:50:35,839
no it's not this one let's attach it

1407
00:50:41,109 --> 00:50:39,280
this one yes so this actually shows uh

1408
00:50:43,910 --> 00:50:41,119
the incredible

1409
00:50:46,230 --> 00:50:43,920
synergy that you can have between two

1410
00:50:48,790 --> 00:50:46,240
great space telescopes

1411
00:50:51,190 --> 00:50:48,800
this is a combination of hubble with the

1412
00:50:53,670 --> 00:50:51,200
chandra x-ray observatory

1413
00:50:55,990 --> 00:50:53,680

what we're seeing here are two clusters

1414
00:50:56,870 --> 00:50:56,000
of galaxies colliding

1415
00:50:59,829 --> 00:50:56,880
and

1416
00:51:03,510 --> 00:50:59,839
clusters of galaxies have in them

1417
00:51:06,069 --> 00:51:03,520
uh gas normal gas lots of hot gas and

1418
00:51:07,109 --> 00:51:06,079
that's what described here by the color

1419
00:51:09,910 --> 00:51:07,119
red

1420
00:51:12,710 --> 00:51:09,920
but they also we think have around them

1421
00:51:15,270 --> 00:51:12,720
dark matter dark matter is matter that

1422
00:51:17,750 --> 00:51:15,280
doesn't shine any light and we know it's

1423
00:51:20,309 --> 00:51:17,760
there only because of its gravity

1424
00:51:23,190 --> 00:51:20,319
in fact 23

1425
00:51:25,589 --> 00:51:23,200
of the density of the universe is in the

1426
00:51:29,430 --> 00:51:25,599
form we think of dark matter

1427
00:51:30,870 --> 00:51:29,440
now this image is pretty amazing because

1428
00:51:34,150 --> 00:51:30,880
dark matter

1429
00:51:37,190 --> 00:51:34,160
interacts very weakly with anything else

1430
00:51:39,510 --> 00:51:37,200
i mean basically dark matter particles

1431
00:51:42,150 --> 00:51:39,520
pass through one another without feeling

1432
00:51:43,430 --> 00:51:42,160
each other and that's what you see here

1433
00:51:46,470 --> 00:51:43,440
in the blue

1434
00:51:48,790 --> 00:51:46,480
while the hot gas the normal gas

1435
00:51:51,589 --> 00:51:48,800
when it collides it really collides and

1436
00:51:54,069 --> 00:51:51,599
it forms a bow shock which you can see

1437
00:51:56,790 --> 00:51:54,079
on the right hand side you see the shock

1438
00:51:59,109 --> 00:51:56,800

that forms you know like just when a

1439
00:52:02,309 --> 00:51:59,119
boat goes through water or when a

1440
00:52:04,710 --> 00:52:02,319
supersonic jet goes through air you see

1441
00:52:07,270 --> 00:52:04,720
that shock front that forms from the

1442
00:52:10,870 --> 00:52:07,280
collision of the gas so you see here a

1443
00:52:13,190 --> 00:52:10,880
separation between the dark matter which

1444
00:52:16,150 --> 00:52:13,200
really passed through without feeling at

1445
00:52:19,030 --> 00:52:16,160
all one the other and the hot

1446
00:52:20,630 --> 00:52:19,040
regular gas that shocked and formed this

1447
00:52:23,349 --> 00:52:20,640
thing so

1448
00:52:24,950 --> 00:52:23,359
this i believe was actually the very

1449
00:52:28,069 --> 00:52:24,960
first image

1450
00:52:30,790 --> 00:52:28,079
that showed this kind of separation

1451
00:52:33,190 --> 00:52:30,800
and really what we expected from dark

1452
00:52:36,150 --> 00:52:33,200
matter as i said you know other than

1453
00:52:39,030 --> 00:52:36,160
dark energy which is something else

1454
00:52:41,349 --> 00:52:39,040
dark matter is the second most abundant

1455
00:52:43,589 --> 00:52:41,359
form of energy in the universe and we

1456
00:52:46,790 --> 00:52:43,599
have seen here uh you know how it is

1457
00:52:49,670 --> 00:52:46,800
different from ordinary matter so mario

1458
00:52:51,670 --> 00:52:49,680
i think it's worth mentioning that um

1459
00:52:52,710 --> 00:52:51,680
the red that you see there is the actual

1460
00:52:54,230 --> 00:52:52,720
chandra

1461
00:52:56,150 --> 00:52:54,240
image image

1462
00:52:58,710 --> 00:52:56,160
of that hot gas in the cluster that's

1463
00:53:00,470 --> 00:52:58,720

right and then the blue is

1464
00:53:02,230 --> 00:53:00,480
a representation

1465
00:53:03,670 --> 00:53:02,240
of the dark matter not the actual

1466
00:53:05,190 --> 00:53:03,680
observation of the dark matter but the

1467
00:53:07,430 --> 00:53:05,200
representation of the dark matter

1468
00:53:09,190 --> 00:53:07,440
derived from gravitational lens from the

1469
00:53:11,190 --> 00:53:09,200
gravitational lensing that's seen within

1470
00:53:14,069 --> 00:53:11,200
the hubble image that's right the the

1471
00:53:15,990 --> 00:53:14,079
dark matter you cannot actually see but

1472
00:53:18,470 --> 00:53:16,000
you see its gravitational effect through

1473
00:53:20,950 --> 00:53:18,480
a gravitational lensing and therefore

1474
00:53:23,670 --> 00:53:20,960
you can map it we can map its location

1475
00:53:25,349 --> 00:53:23,680
and that's what the blue uh region here

1476
00:53:26,790 --> 00:53:25,359
shows yeah that's beautiful yeah thanks

1477
00:53:28,630 --> 00:53:26,800
for the clarification now yeah i wasn't

1478
00:53:30,630 --> 00:53:28,640
wanting to get to that because i i know

1479
00:53:31,990 --> 00:53:30,640
that um you can't actually see the dark

1480
00:53:35,270 --> 00:53:32,000
matter in any way so the way they they

1481
00:53:36,630 --> 00:53:35,280
just look at the individual galaxy uh uh

1482
00:53:38,710 --> 00:53:36,640
the ones that have been lensed by the

1483
00:53:42,069 --> 00:53:38,720
dark matter and mark it as being dark

1484
00:53:43,030 --> 00:53:42,079
due to dark matter um carol

1485
00:53:44,309 --> 00:53:43,040
you have something you want to share

1486
00:53:45,750 --> 00:53:44,319
with us

1487
00:53:48,390 --> 00:53:45,760
so um

1488
00:53:51,190 --> 00:53:48,400

in in the dots theme so i have two

1489
00:53:55,030 --> 00:53:51,200
images to show one is a ground-based

1490
00:53:55,750 --> 00:53:55,040
image of what's called a globular

1491
00:53:59,270 --> 00:53:55,760
okay cluster

1492
00:54:00,630 --> 00:53:59,280
slide number six in my slide so maybe if

1493
00:54:02,630 --> 00:54:00,640
somebody can put that up we're gonna

1494
00:54:04,309 --> 00:54:02,640
just show that briefly

1495
00:54:06,710 --> 00:54:04,319
and then a lot of dots

1496
00:54:08,870 --> 00:54:06,720
so it has lots of dots

1497
00:54:10,950 --> 00:54:08,880
okay so that's a ground-based image of

1498
00:54:13,349 --> 00:54:10,960
something called a globular cluster and

1499
00:54:15,109 --> 00:54:13,359
its particular name is 47 to connie

1500
00:54:16,790 --> 00:54:15,119
because it's in takani

1501
00:54:19,109 --> 00:54:16,800
the constellation

1502
00:54:21,270 --> 00:54:19,119
now the hubble image is the next image

1503
00:54:22,829 --> 00:54:21,280
and what's remarkable about it is it's

1504
00:54:25,990 --> 00:54:22,839
only a tiny

1505
00:54:28,630 --> 00:54:26,000
portion of this cluster

1506
00:54:31,030 --> 00:54:28,640
that's being studied because this the

1507
00:54:34,069 --> 00:54:31,040
cluster is very big and we can only see

1508
00:54:35,349 --> 00:54:34,079
portions of it with the hubble why why

1509
00:54:37,109 --> 00:54:35,359
are these objects

1510
00:54:39,750 --> 00:54:37,119
important well we've been talking about

1511
00:54:42,150 --> 00:54:39,760
galaxies and lenses and galaxies far out

1512
00:54:44,870 --> 00:54:42,160
in the universe but these clusters are

1513
00:54:46,630 --> 00:54:44,880

near us they're in our galaxy and they

1514
00:54:50,069 --> 00:54:46,640
are the remnants

1515
00:54:50,829 --> 00:54:50,079
they are the old old population

1516
00:54:53,750 --> 00:54:50,839
that

1517
00:54:56,390 --> 00:54:53,760
formed at the beginning of the formation

1518
00:54:59,349 --> 00:54:56,400
of our galaxy and so the and the stars

1519
00:55:02,630 --> 00:54:59,359
you're looking at are extremely old

1520
00:55:03,990 --> 00:55:02,640
and so we study these clusters which

1521
00:55:06,309 --> 00:55:04,000
most of my colleagues think they're

1522
00:55:08,390 --> 00:55:06,319
really boring but i like clusters but

1523
00:55:11,349 --> 00:55:08,400
every one of those dots

1524
00:55:13,829 --> 00:55:11,359
is a star and that's only a small

1525
00:55:16,630 --> 00:55:13,839
portion of the whole cluster but we

1526
00:55:17,430 --> 00:55:16,640
study these to understand

1527
00:55:18,950 --> 00:55:17,440
how

1528
00:55:21,510 --> 00:55:18,960
do

1529
00:55:24,150 --> 00:55:21,520
these clusters form and then what

1530
00:55:27,270 --> 00:55:24,160
happens to them over the lifetime of the

1531
00:55:29,349 --> 00:55:27,280
universe what happens to the stone

1532
00:55:38,470 --> 00:55:29,359
and

1533
00:55:42,710 --> 00:55:38,480
an old old old story

1534
00:55:50,230 --> 00:55:45,510
with the james webb telescope which are

1535
00:55:53,430 --> 00:55:50,240
forming when these clusters formed

1536
00:55:56,309 --> 00:55:53,440
that's amazing that is a great image

1537
00:55:59,270 --> 00:55:56,319
okay guys well we are nearing um we are

1538
00:56:00,710 --> 00:55:59,280

nearing our time here uh on what we

1539
00:56:02,870 --> 00:56:00,720
think are some of the

1540
00:56:04,789 --> 00:56:02,880
more amazing images by by hubble that we

1541
00:56:07,190 --> 00:56:04,799
could do this all day they can't you

1542
00:56:09,670 --> 00:56:07,200
wouldn't believe how many images uh we

1543
00:56:11,030 --> 00:56:09,680
have so much more to put up

1544
00:56:13,109 --> 00:56:11,040
totally

1545
00:56:15,190 --> 00:56:13,119
yeah yeah oh sorry ken go ahead we can

1546
00:56:21,910 --> 00:56:15,200
put up all these dots can we put up a

1547
00:56:25,270 --> 00:56:24,150
yes absolutely by all means put it up we

1548
00:56:27,670 --> 00:56:25,280
should we should mention while it's

1549
00:56:29,190 --> 00:56:27,680
being put up though that you know

1550
00:56:32,230 --> 00:56:29,200
there are

1551
00:56:33,750 --> 00:56:32,240
hubble right uh you want to talk about

1552
00:56:35,270 --> 00:56:33,760
that i mean first of all we have how

1553
00:56:37,190 --> 00:56:35,280
many cameras and what other instruments

1554
00:56:39,109 --> 00:56:37,200
are on hubble right now the taking data

1555
00:56:40,549 --> 00:56:39,119
we have the advanced camera for surveys

1556
00:56:42,710 --> 00:56:40,559
and the wide field camera three which

1557
00:56:44,630 --> 00:56:42,720
are the two primary cameras

1558
00:56:45,990 --> 00:56:44,640
then we have the space telescope imaging

1559
00:56:47,829 --> 00:56:46,000
spectrograph

1560
00:56:48,950 --> 00:56:47,839
which can take pictures but also take

1561
00:56:51,990 --> 00:56:48,960
spectra

1562
00:56:54,950 --> 00:56:52,000
and the cosmic origin spectrograph okay

1563
00:56:57,190 --> 00:56:54,960

so and and so when we say we don't want

1564
00:56:59,190 --> 00:56:57,200
to limit you just to uh

1565
00:57:00,710 --> 00:56:59,200
visual images if you uh

1566
00:57:02,069 --> 00:57:00,720
if you think that some of the spectra

1567
00:57:04,789 --> 00:57:02,079
from hubble is also some of the most

1568
00:57:06,870 --> 00:57:04,799
amazing or uh greatest images taken by

1569
00:57:07,990 --> 00:57:06,880
all means you feel free to elect those

1570
00:57:11,190 --> 00:57:08,000
as well

1571
00:57:13,750 --> 00:57:11,200
uh a spectrum is a beautiful thing yeah

1572
00:57:16,150 --> 00:57:13,760
i agree and uh

1573
00:57:17,670 --> 00:57:16,160
this one in particular uh really floats

1574
00:57:20,950 --> 00:57:17,680
my boat because

1575
00:57:24,390 --> 00:57:20,960
it shows the presence of um

1576
00:57:26,230 --> 00:57:24,400
oxygen far far away from galaxies

1577
00:57:27,910 --> 00:57:26,240
uh in the intergalactic medium so what

1578
00:57:30,950 --> 00:57:27,920
you're looking at here

1579
00:57:32,309 --> 00:57:30,960
is light that's been passed through

1580
00:57:34,390 --> 00:57:32,319
um

1581
00:57:36,710 --> 00:57:34,400
a good chunk of the universe on its way

1582
00:57:38,390 --> 00:57:36,720
to hubble and when it enters hubble

1583
00:57:41,030 --> 00:57:38,400
instead of taking a picture of that

1584
00:57:42,950 --> 00:57:41,040
light hubble diverts the light to a

1585
00:57:46,150 --> 00:57:42,960
spectrograph which is an instrument that

1586
00:57:48,710 --> 00:57:46,160
breaks light into its component colors

1587
00:57:50,710 --> 00:57:48,720
so you see the colors here as a function

1588
00:57:51,829 --> 00:57:50,720

of wavelength you see the intensity of

1589
00:57:54,069 --> 00:57:51,839
the light here as a function of

1590
00:57:56,069 --> 00:57:54,079
wavelength in this case it's a very

1591
00:57:58,950 --> 00:57:56,079
ultraviolet light

1592
00:58:01,349 --> 00:57:58,960
and each of those little dips in that

1593
00:58:03,510 --> 00:58:01,359
overall spectrum that you see there

1594
00:58:05,510 --> 00:58:03,520
is the signature of different elements

1595
00:58:06,710 --> 00:58:05,520
in the gas that the light has passed

1596
00:58:08,950 --> 00:58:06,720
through

1597
00:58:11,270 --> 00:58:08,960
the intervening material leaves its

1598
00:58:13,349 --> 00:58:11,280
imprint on the light

1599
00:58:15,510 --> 00:58:13,359
from those distant objects and in this

1600
00:58:18,870 --> 00:58:15,520
particular case

1601
00:58:21,510 --> 00:58:18,880
the imprint is in the form of

1602
00:58:24,470 --> 00:58:21,520
highly ionized oxygen lines

1603
00:58:27,030 --> 00:58:24,480
are

1604
00:58:28,390 --> 00:58:27,040
tracers of the gas that eventually form

1605
00:58:29,990 --> 00:58:28,400
galaxies

1606
00:58:32,150 --> 00:58:30,000
and so that's one of the things that i

1607
00:58:35,190 --> 00:58:32,160
like and if you look out

1608
00:58:36,390 --> 00:58:35,200
at how much of the you can do all kinds

1609
00:58:38,870 --> 00:58:36,400
of things with spectra like this

1610
00:58:40,470 --> 00:58:38,880
including estimating how much

1611
00:58:43,270 --> 00:58:40,480
gas is out there

1612
00:58:45,190 --> 00:58:43,280
and if you estimate um

1613
00:58:47,430 --> 00:58:45,200

the amount of oxygen

1614
00:58:49,910 --> 00:58:47,440
that you see out there

1615
00:58:51,750 --> 00:58:49,920
and you convert that into

1616
00:58:54,710 --> 00:58:51,760
mass you realize that there's as much

1617
00:58:57,109 --> 00:58:54,720
mass just associated with these oxygen

1618
00:58:58,069 --> 00:58:57,119
systems as there is in galaxies as a

1619
00:59:00,470 --> 00:58:58,079
whole

1620
00:59:01,990 --> 00:59:00,480
so there's a lot of material out there

1621
00:59:03,430 --> 00:59:02,000
i don't understand there's a there's as

1622
00:59:05,030 --> 00:59:03,440
much oxygen

1623
00:59:07,430 --> 00:59:05,040
by

1624
00:59:09,190 --> 00:59:07,440
as there is other stuff

1625
00:59:10,470 --> 00:59:09,200
there's as much hydrogen associated with

1626
00:59:11,990 --> 00:59:10,480
that oxygen

1627
00:59:13,910 --> 00:59:12,000
as there is

1628
00:59:16,309 --> 00:59:13,920
mass in galaxies

1629
00:59:18,150 --> 00:59:16,319
right so okay so most of most of most of

1630
00:59:19,349 --> 00:59:18,160
the mass in galaxies is in the form of

1631
00:59:21,030 --> 00:59:19,359
hydrogen

1632
00:59:22,390 --> 00:59:21,040
and you're using the oxygen here as a

1633
00:59:25,349 --> 00:59:22,400
tracer

1634
00:59:27,030 --> 00:59:25,359
a a proxy for that hydrogen

1635
00:59:29,190 --> 00:59:27,040
because you can't you can't observe the

1636
00:59:30,870 --> 00:59:29,200
hydrogen directly associated with that

1637
00:59:32,710 --> 00:59:30,880
very hot gas

1638
00:59:34,549 --> 00:59:32,720

but if you do the conversion

1639
00:59:36,789 --> 00:59:34,559
you find that there's as much hydrogen

1640
00:59:38,630 --> 00:59:36,799
there in all of that gas that's forming

1641
00:59:40,150 --> 00:59:38,640
galaxies as there is in the galaxies

1642
00:59:41,990 --> 00:59:40,160
that you can actually see in hubble

1643
00:59:43,990 --> 00:59:42,000
images for example

1644
00:59:46,390 --> 00:59:44,000
oh that's amazing all right we could do

1645
00:59:48,390 --> 00:59:46,400
a whole hangout on on spectra and i

1646
00:59:50,309 --> 00:59:48,400
would recommend that we do at some point

1647
00:59:52,789 --> 00:59:50,319
i think we should yes we spend an awful

1648
00:59:54,549 --> 00:59:52,799
lot of time uh talking about

1649
00:59:55,829 --> 00:59:54,559
talking about uh the optical or

1650
00:59:57,910 --> 00:59:55,839
two-dimensional pictures but there's a

1651
00:59:59,430 --> 00:59:57,920
lot to be gained from spectra as well so

1652
01:00:01,270 --> 00:59:59,440
i think we should i like that idea i

1653
01:00:03,910 --> 01:00:01,280
mean hubble spends about half of its

1654
01:00:06,549 --> 01:00:03,920
time taking spectra let me add one thing

1655
01:00:08,710 --> 01:00:06,559
you see there is all this gas that is

1656
01:00:10,309 --> 01:00:08,720
between galaxies we call this all this

1657
01:00:12,710 --> 01:00:10,319
cosmic web

1658
01:00:14,789 --> 01:00:12,720
but you cannot really see that because

1659
01:00:16,230 --> 01:00:14,799
that there is no light coming from that

1660
01:00:18,710 --> 01:00:16,240
so what you do

1661
01:00:21,589 --> 01:00:18,720
is you use some very distant source

1662
01:00:24,390 --> 01:00:21,599
point of light and you get that light to

1663
01:00:27,109 --> 01:00:24,400

pass through all this cosmic web and on

1664
01:00:29,510 --> 01:00:27,119
its way it's being absorbed by this gas

1665
01:00:32,150 --> 01:00:29,520
and that's what you see in this spectra

1666
01:00:34,950 --> 01:00:32,160
so these spectra really tell you the

1667
01:00:36,789 --> 01:00:34,960
structure of this cosmic web that fills

1668
01:00:38,309 --> 01:00:36,799
the entire space

1669
01:00:40,309 --> 01:00:38,319
yeah they're one dimensional maps you

1670
01:00:42,470 --> 01:00:40,319
know these probes along this one sight

1671
01:00:45,270 --> 01:00:42,480
line through the universe and through

1672
01:00:46,950 --> 01:00:45,280
lots of various probes and uh through

1673
01:00:49,910 --> 01:00:46,960
other theoretical studies we've built up

1674
01:00:53,589 --> 01:00:49,920
an idea of structure of the universe and

1675
01:00:54,870 --> 01:00:53,599
it's amazing just how much we can learn

1676
01:00:56,549 --> 01:00:54,880
about the three-dimensional structure of

1677
01:00:57,990 --> 01:00:56,559
the universe from these very you know

1678
01:00:59,510 --> 01:00:58,000
one-dimensional light sight lines

1679
01:01:00,870 --> 01:00:59,520
through it

1680
01:01:03,109 --> 01:01:00,880
awesome well there you go guys i want to

1681
01:01:05,349 --> 01:01:03,119
say now i want you guys to start showing

1682
01:01:08,390 --> 01:01:05,359
me some spectra also in your submissions

1683
01:01:11,109 --> 01:01:08,400
so i think there's a lot to begin well i

1684
01:01:13,430 --> 01:01:11,119
think it's important i mean um alberto

1685
01:01:14,710 --> 01:01:13,440
scott this has been really great i mean

1686
01:01:16,950 --> 01:01:14,720
this has been a lot of it's like this

1687
01:01:18,390 --> 01:01:16,960
this is this was one hangout i was very

1688
01:01:20,230 --> 01:01:18,400

much looking forward to and i'm really

1689
01:01:22,390 --> 01:01:20,240
glad we got a chance to do this uh you

1690
01:01:23,910 --> 01:01:22,400
guys have any thoughts

1691
01:01:25,430 --> 01:01:23,920
i'm gonna put up even more of the ones

1692
01:01:27,349 --> 01:01:25,440
that we didn't actually get to share

1693
01:01:29,109 --> 01:01:27,359
there's so many more that we had set

1694
01:01:30,870 --> 01:01:29,119
aside for this hangout that we haven't

1695
01:01:33,190 --> 01:01:30,880
even got to so i'm gonna keep putting

1696
01:01:36,150 --> 01:01:33,200
them up in the event page and

1697
01:01:37,670 --> 01:01:36,160
let in i really i really hope that you

1698
01:01:40,069 --> 01:01:37,680
know the audience out there either on

1699
01:01:42,630 --> 01:01:40,079
youtube facebook twitter google plus

1700
01:01:44,710 --> 01:01:42,640
find your images and let us know what

1701
01:01:47,030 --> 01:01:44,720
you love and why you love it more

1702
01:01:49,670 --> 01:01:47,040
importantly why yes that's right tell us

1703
01:01:51,430 --> 01:01:49,680
what how it's inspired you since 1990

1704
01:01:52,710 --> 01:01:51,440
almost 25 years

1705
01:01:54,789 --> 01:01:52,720
on

1706
01:01:57,270 --> 01:01:54,799
wanting to understand the universe and

1707
01:01:58,950 --> 01:01:57,280
how it i i find looking out through

1708
01:02:01,990 --> 01:01:58,960
hubble and seeing these images really

1709
01:02:03,990 --> 01:02:02,000
helps me find humanity inside those and

1710
01:02:05,270 --> 01:02:04,000
so we can actually see where we've come

1711
01:02:08,390 --> 01:02:05,280
from what we have in common with the

1712
01:02:10,630 --> 01:02:08,400
rest of this expansive universe

1713
01:02:14,150 --> 01:02:10,640

there's nothing i can add to that i know

1714
01:02:15,270 --> 01:02:14,160
follow that alberto there you go

1715
01:02:16,150 --> 01:02:15,280
i can't

1716
01:02:18,309 --> 01:02:16,160
i'm just saying that this should

1717
01:02:19,270 --> 01:02:18,319
probably be part one of 99 because you

1718
01:02:20,630 --> 01:02:19,280
know i was looking at all the images

1719
01:02:22,870 --> 01:02:20,640
that we have i wanted to talk about you

1720
01:02:24,789 --> 01:02:22,880
know hubble is looked at uh planets in

1721
01:02:26,630 --> 01:02:24,799
our solar system we had a close

1722
01:02:28,950 --> 01:02:26,640
encounter with a comet in

1723
01:02:30,870 --> 01:02:28,960
94 i think you know schumacher levy we

1724
01:02:32,309 --> 01:02:30,880
saw his smashing on jupiter so there's

1725
01:02:34,309 --> 01:02:32,319
incredible things that we've done from

1726
01:02:36,470 --> 01:02:34,319
the very very close by you know from our

1727
01:02:38,870 --> 01:02:36,480
solar system all the way to the early

1728
01:02:41,030 --> 01:02:38,880
universe which is uh probably uh the

1729
01:02:42,710 --> 01:02:41,040
most remarkable i guess the hubble will

1730
01:02:44,069 --> 01:02:42,720
uh will leave us

1731
01:02:45,990 --> 01:02:44,079
that's right and i would say i would

1732
01:02:47,990 --> 01:02:46,000
argue that the hubble space telescope is

1733
01:02:50,710 --> 01:02:48,000
probably the most important scientific

1734
01:02:53,430 --> 01:02:50,720
instrument built by humanity and i would

1735
01:02:56,069 --> 01:02:53,440
even i include the lhc in that statement

1736
01:02:57,910 --> 01:02:56,079
i'd love to see uh you know i mean yes

1737
01:02:59,910 --> 01:02:57,920
yes you know cern is doing a lot of

1738
01:03:01,910 --> 01:02:59,920

great work but i still would put hubble

1739
01:03:04,390 --> 01:03:01,920
up against it any day i'd love to see uh

1740
01:03:07,750 --> 01:03:05,190
yeah

1741
01:03:10,630 --> 01:03:07,760
smackdown on that that's right and the

1742
01:03:13,030 --> 01:03:10,640
data is all yours

1743
01:03:15,109 --> 01:03:13,040
that is true

1744
01:03:16,870 --> 01:03:15,119
excellent point carol that's right

1745
01:03:20,630 --> 01:03:16,880
excellent point

1746
01:03:21,589 --> 01:03:20,640
available for you to get all the time in

1747
01:03:23,029 --> 01:03:21,599
fact we're going to talk about that a

1748
01:03:24,789 --> 01:03:23,039
little bit tomorrow in our accommodation

1749
01:03:25,829 --> 01:03:24,799
hangout where you can get hubble data

1750
01:03:28,950 --> 01:03:25,839
yourselves

1751
01:03:31,270 --> 01:03:28,960
so guys thank you for all to all of you

1752
01:03:33,430 --> 01:03:31,280
for participating this was a lot of fun

1753
01:03:35,109 --> 01:03:33,440
i hope hubble huggers you guys get out

1754
01:03:36,549 --> 01:03:35,119
there and oh do you have something you

1755
01:03:42,829 --> 01:03:36,559
want to say carol

1756
01:03:46,470 --> 01:03:44,870
waves yes

1757
01:03:47,080 --> 01:03:46,480
thank you to all the little people out

1758
01:03:52,950 --> 01:03:47,090
there

1759
01:03:54,069 --> 01:03:52,960
[Laughter]

1760
01:03:56,950 --> 01:03:54,079
okay

1761
01:03:59,510 --> 01:03:56,960
ken frank mario

1762
01:04:00,710 --> 01:03:59,520
frank and carol thank you very oh and

1763
01:04:03,109 --> 01:04:00,720

zolt sorry you're on the wrong side of

1764
01:04:05,349 --> 01:04:03,119
my screen there thank you all very much

1765
01:04:06,390 --> 01:04:05,359
for uh for for participating taking time

1766
01:04:07,910 --> 01:04:06,400
out of your day to talk to us about

1767
01:04:12,150 --> 01:04:07,920
humble pictures let's do it again real

1768
01:04:13,910 --> 01:04:12,160
soon yeah i think you and i are

1769
01:04:17,109 --> 01:04:13,920
yeah so we'll see we'll see you tomorrow

1770
01:04:18,710 --> 01:04:17,119
probably um yep uh scott alberto this

1771
01:04:20,870 --> 01:04:18,720
has been great thank you both very much

1772
01:04:22,470 --> 01:04:20,880
thank you let me remind everybody that

1773
01:04:24,069 --> 01:04:22,480
the way to

1774
01:04:26,069 --> 01:04:24,079
interact and let us know what you think

1775
01:04:28,150 --> 01:04:26,079
is to post on this event page use the

1776
01:04:31,190 --> 01:04:28,160
hashtag hubbletopshots to get our

1777
01:04:33,750 --> 01:04:31,200
attention on twitter and facebook uh

1778
01:04:36,630 --> 01:04:33,760
also go to the hubble space telescope uh

1779
01:04:40,789 --> 01:04:36,640
community start posting in there and uh

1780
01:04:42,789 --> 01:04:40,799
just just you know you can even uh

1781
01:04:44,309 --> 01:04:42,799
email us so at well we don't have an

1782
01:04:46,870 --> 01:04:44,319
email address i guess for this so i

1783
01:04:49,589 --> 01:04:46,880
guess never mind but you can enter

1784
01:04:51,109 --> 01:04:49,599
you enter inter tweet us right right um

1785
01:04:52,230 --> 01:04:51,119
so anyway i hope you guys will

1786
01:04:54,549 --> 01:04:52,240
participate we're looking forward to

1787
01:04:55,829 --> 01:04:54,559
compiling this list we will post it i

1788
01:04:58,870 --> 01:04:55,839

think we're going to stop taking

1789
01:05:00,789 --> 01:04:58,880
submissions on the

1790
01:05:03,190 --> 01:05:00,799
it's early next week i should have

1791
01:05:05,510 --> 01:05:03,200
probably had that date

1792
01:05:07,190 --> 01:05:05,520
but i can't remember yeah the 18th that

1793
01:05:08,549 --> 01:05:07,200
sounds about right so

1794
01:05:10,150 --> 01:05:08,559
you have until then to get to give us

1795
01:05:11,990 --> 01:05:10,160
your submissions looking forward to

1796
01:05:14,789 --> 01:05:12,000
seeing what you guys come up with thank

1797
01:05:16,950 --> 01:05:14,799
you guys for watching and as always keep