

PUBLIC LECTURE SERIES

**First Light: Hunting for Galaxies
at the Dawn of Cosmic Time**

**Featuring Guest Speaker:
Guido Roberts-Borsani**

1
00:00:08,470 --> 00:00:05,349
hello and welcome to the space telescope

2
00:00:11,270 --> 00:00:08,480
public lecture series tonight

3
00:00:14,310 --> 00:00:11,280
first light hunting for galaxies at the

4
00:00:17,910 --> 00:00:14,320
dawn of cosmic time by dr guido roberts

5
00:00:19,910 --> 00:00:17,920
borsani of ucla

6
00:00:21,830 --> 00:00:19,920
i'm your host dr frank summers of the

7
00:00:25,349 --> 00:00:21,840
office of public outreach here at the

8
00:00:27,830 --> 00:00:25,359
space telescope science institute and as

9
00:00:30,630 --> 00:00:27,840
always i want to thank our wonderful

10
00:00:31,669 --> 00:00:30,640
tech team thomas marufu and grant

11
00:00:33,590 --> 00:00:31,679
justice

12
00:00:36,549 --> 00:00:33,600
i also need to continue to remind you

13
00:00:40,229 --> 00:00:36,559

that we will be online only until

14

00:00:47,750 --> 00:00:44,470

our upcoming talks on october 4th the

15

00:00:50,790 --> 00:00:47,760

universe of dante alighieri by a

16

00:00:54,229 --> 00:00:50,800

descendant of dante alleghery spirello

17

00:00:56,150 --> 00:00:54,239

de sorego alegre this should be a

18

00:00:59,670 --> 00:00:56,160

massively interesting talk i'm really

19

00:01:02,389 --> 00:00:59,680

looking forward to it on november 1st

20

00:01:04,469 --> 00:01:02,399

black holes how do we see that which

21

00:01:06,550 --> 00:01:04,479

gives off no light

22

00:01:08,789 --> 00:01:06,560

from stephanie lamassa of the space

23

00:01:11,510 --> 00:01:08,799

telescope science institute

24

00:01:13,910 --> 00:01:11,520

and on december 6th

25

00:01:17,830 --> 00:01:13,920

high energy strong astronomy with the

26

00:01:20,469 --> 00:01:17,840

swift observatory by stephen kirby at

27

00:01:22,630 --> 00:01:20,479

penn state university we talk a lot

28

00:01:23,590 --> 00:01:22,640

about a lot of our space telescopes we

29

00:01:26,070 --> 00:01:23,600

have not

30

00:01:28,469 --> 00:01:26,080

yet had a talk from someone about the

31

00:01:29,749 --> 00:01:28,479

swift observatory so this should be a

32

00:01:31,910 --> 00:01:29,759

treat

33

00:01:32,950 --> 00:01:31,920

all this information is available on our

34

00:01:36,950 --> 00:01:32,960

website

35

00:01:41,270 --> 00:01:39,510

public hyphen lectures which will give

36

00:01:42,230 --> 00:01:41,280

you this web page you see here in front

37

00:01:45,270 --> 00:01:42,240

of you

38

00:01:47,990 --> 00:01:45,280

on the left side you can see the uh

39

00:01:49,910 --> 00:01:48,000

our webcasts both our youtube playlists

40

00:01:51,910 --> 00:01:49,920

and our webcast archive at space

41

00:01:55,030 --> 00:01:51,920

telescope science institute

42

00:01:57,270 --> 00:01:55,040

and on the right we have the box where

43

00:02:01,830 --> 00:01:57,280

you can enter your email address and

44

00:02:05,670 --> 00:02:03,910

also on that page are the list of the

45

00:02:07,270 --> 00:02:05,680

upcoming lectures

46

00:02:09,109 --> 00:02:07,280

and if you click on one of those

47

00:02:11,190 --> 00:02:09,119

lectures it will give you all the

48

00:02:14,630 --> 00:02:11,200

information about it including the

49

00:02:18,390 --> 00:02:14,640

description of the talk and after it has

50

00:02:20,470 --> 00:02:18,400

been presented we have the sdsdi webcast

51
00:02:24,790 --> 00:02:20,480
link and down at the bottom you can see

52
00:02:29,910 --> 00:02:28,150
our email is uh basically twice a month

53
00:02:31,830 --> 00:02:29,920
you get a reminder of things you can

54
00:02:32,630 --> 00:02:31,840
sign up on at the website as i showed

55
00:02:42,869 --> 00:02:32,640
you

56
00:02:45,110 --> 00:02:42,879
hubble space telescope all one word

57
00:02:46,869 --> 00:02:45,120
you will get the notices of new videos

58
00:02:50,070 --> 00:02:46,879
that we post on our channel and

59
00:02:51,750 --> 00:02:50,080
reminders of live events such as this

60
00:02:53,830 --> 00:02:51,760
finally if you have comments or

61
00:02:55,910 --> 00:02:53,840
questions you can send them to the email

62
00:03:01,830 --> 00:02:55,920
address public lecture

63
00:03:06,550 --> 00:03:03,670

our social media

64

00:03:08,630 --> 00:03:06,560

for the hubble space telescope the james

65

00:03:11,430 --> 00:03:08,640

webb space telescope and for the space

66

00:03:13,750 --> 00:03:11,440

telescope science institute is available

67

00:03:16,390 --> 00:03:13,760

on facebook twitter

68

00:03:18,949 --> 00:03:16,400

youtube and instagram

69

00:03:21,030 --> 00:03:18,959

i myself do a pathetically tiny

70

00:03:23,830 --> 00:03:21,040

nothing's worth of uh

71

00:03:27,509 --> 00:03:23,840

social media on facebook and twitter as

72

00:03:33,110 --> 00:03:29,589

and now the news from the universe for

73

00:03:34,949 --> 00:03:33,120

september 2022

74

00:03:37,589 --> 00:03:34,959

our first story

75

00:03:39,990 --> 00:03:37,599

betelgeuse blowout and if you are a

76
00:03:43,110 --> 00:03:40,000
regular viewer you remember that betel

77
00:03:45,110 --> 00:03:43,120
juice has been spoken up just a bit over

78
00:03:47,190 --> 00:03:45,120
the last couple years

79
00:03:50,149 --> 00:03:47,200
first of all let me remind you that

80
00:03:54,470 --> 00:03:50,159
betelgeuse is one of the very very very

81
00:03:55,830 --> 00:03:54,480
few stars that can actually be resolved

82
00:03:58,710 --> 00:03:55,840
it is the

83
00:04:00,630 --> 00:03:58,720
left shoulder of orion

84
00:04:02,630 --> 00:04:00,640
in the constellation orion and the left

85
00:04:06,550 --> 00:04:02,640
shoulder is betelgeuse

86
00:04:08,869 --> 00:04:06,560
and hubble uh you know here in 1994

87
00:04:11,750 --> 00:04:08,879
did an observation where it resolved

88
00:04:14,070 --> 00:04:11,760

that star as more than just a point of

89

00:04:17,749 --> 00:04:14,080

light it actually resolved the disk of

90

00:04:19,430 --> 00:04:17,759

belgius betelgeuse is a red supergiant

91

00:04:22,950 --> 00:04:19,440

star

92

00:04:25,909 --> 00:04:22,960

and if it were in place of our sun

93

00:04:29,030 --> 00:04:25,919

its atmosphere would extend out past the

94

00:04:31,590 --> 00:04:29,040

orbit of jupiter okay that's how huge it

95

00:04:33,990 --> 00:04:31,600

is and that's why hubble can actually

96

00:04:35,030 --> 00:04:34,000

resolve the disk of the star

97

00:04:37,270 --> 00:04:35,040

right

98

00:04:41,510 --> 00:04:37,280

but what the recent thing is that in

99

00:04:44,070 --> 00:04:41,520

2019 betelgeuse dimmed unusually right

100

00:04:46,710 --> 00:04:44,080

so this is an uh two observations of

101

00:04:50,150 --> 00:04:46,720

betelgeuse one from 2016 and one from

102

00:04:52,790 --> 00:04:50,160

2019 and you can see how much dimmer it

103

00:04:54,790 --> 00:04:52,800

is in 2019.

104

00:04:56,469 --> 00:04:54,800

uh betelgeuse regularly fluctuates up

105

00:04:59,830 --> 00:04:56,479

and down just a little bit

106

00:05:01,350 --> 00:04:59,840

but now it was at 40 percent of its

107

00:05:05,350 --> 00:05:01,360

regular brightness which is a

108

00:05:07,830 --> 00:05:05,360

significant uh dip in its brightness

109

00:05:10,469 --> 00:05:07,840

however when that happened

110

00:05:13,909 --> 00:05:10,479

betelgeuse did not change its general

111

00:05:15,029 --> 00:05:13,919

characteristics so this is a spectrum of

112

00:05:17,670 --> 00:05:15,039

betelgeuse

113

00:05:21,270 --> 00:05:17,680

the red line is from 2004

114

00:05:23,749 --> 00:05:21,280

and the black line is first from 2020

115

00:05:26,150 --> 00:05:23,759

and you can see that the dips and

116

00:05:28,629 --> 00:05:26,160

wiggles in this spectrum all of the

117

00:05:32,310 --> 00:05:28,639

absorption lines and emission features

118

00:05:35,350 --> 00:05:32,320

are this same it's just that in 2020

119

00:05:37,110 --> 00:05:35,360

they're at a lower level so it's the

120

00:05:39,830 --> 00:05:37,120

light from

121

00:05:42,070 --> 00:05:39,840

betelgeuse that has dimmed it is not the

122

00:05:44,150 --> 00:05:42,080

character essential character of the

123

00:05:46,390 --> 00:05:44,160

light that is actually changing

124

00:05:49,830 --> 00:05:46,400

so that led us to believe

125

00:05:52,790 --> 00:05:49,840

that instead of a major change in the

126
00:05:54,790 --> 00:05:52,800
star betel juice really that there was a

127
00:05:57,510 --> 00:05:54,800
cloud blocking it

128
00:05:58,870 --> 00:05:57,520
so the story we developed based upon the

129
00:06:00,790 --> 00:05:58,880
observations

130
00:06:04,230 --> 00:06:00,800
is that in

131
00:06:06,870 --> 00:06:04,240
2019 there was a blowout from

132
00:06:09,270 --> 00:06:06,880
uh from from betelgeuse probably a

133
00:06:12,790 --> 00:06:09,280
convective cell about a million miles

134
00:06:15,270 --> 00:06:12,800
across erupted through and blew out uh

135
00:06:16,790 --> 00:06:15,280
into space towards in the direction

136
00:06:19,110 --> 00:06:16,800
towards earth

137
00:06:21,430 --> 00:06:19,120
that material then cooled and turned

138
00:06:23,510 --> 00:06:21,440

into a dust cloud

139

00:06:25,110 --> 00:06:23,520

that blocked some of the light so from

140

00:06:27,350 --> 00:06:25,120

our point of view

141

00:06:29,510 --> 00:06:27,360

bail we were seeing view betelgeuse with

142

00:06:32,230 --> 00:06:29,520

this dark dusty cloud in front of it

143

00:06:34,629 --> 00:06:32,240

which blocked a lot of its light and

144

00:06:38,469 --> 00:06:34,639

dimmed the star betelgeuse but the star

145

00:06:39,830 --> 00:06:38,479

itself was not um did not suffer

146

00:06:41,670 --> 00:06:39,840

anything major

147

00:06:43,029 --> 00:06:41,680

all right and then it has since

148

00:06:45,270 --> 00:06:43,039

recovered

149

00:06:47,990 --> 00:06:45,280

and so you have to understand that as i

150

00:06:50,070 --> 00:06:48,000

said betelgeuse is a variable star and

151
00:06:51,830 --> 00:06:50,080
it regularly goes up and down up and

152
00:06:55,749 --> 00:06:51,840
down in its brightness over a small

153
00:06:58,150 --> 00:06:55,759
range over a 400 day period okay so this

154
00:07:00,070 --> 00:06:58,160
sine wave here is to represent the 400

155
00:07:03,110 --> 00:07:00,080
day brightness period

156
00:07:05,430 --> 00:07:03,120
relative to that here in red

157
00:07:07,670 --> 00:07:05,440
are the actual observations

158
00:07:09,749 --> 00:07:07,680
so you can see that in

159
00:07:12,390 --> 00:07:09,759
the left side here it's following its

160
00:07:15,029 --> 00:07:12,400
dip down and rise back up and then the

161
00:07:17,749 --> 00:07:15,039
explosion happens and then it dips way

162
00:07:20,950 --> 00:07:17,759
down okay this is down around forty

163
00:07:23,270 --> 00:07:20,960

percent of its uh its brightness so it's

164

00:07:26,790 --> 00:07:23,280

several magnitudes uh

165

00:07:30,309 --> 00:07:26,800

of to too faint um and then it rises

166

00:07:33,430 --> 00:07:30,319

back up as that cloud dissipates so it's

167

00:07:34,710 --> 00:07:33,440

now back up at its roughly average

168

00:07:37,670 --> 00:07:34,720

brightness

169

00:07:39,909 --> 00:07:37,680

but it hasn't fully recovered from this

170

00:07:42,870 --> 00:07:39,919

eruption because you can see it has not

171

00:07:45,029 --> 00:07:42,880

fully gone back into that standard 400

172

00:07:48,390 --> 00:07:45,039

day brightness period change this

173

00:07:50,070 --> 00:07:48,400

400-day variability and the 400-day

174

00:07:52,869 --> 00:07:50,080

variability is something that has been

175

00:07:54,710 --> 00:07:52,879

observed on betelgeuse for centuries

176

00:07:57,430 --> 00:07:54,720

okay so it's not a short-term effect

177

00:08:01,670 --> 00:07:57,440

this is a long-term thing so it did have

178

00:08:04,469 --> 00:08:01,680

a blowout um in night 2019 2020

179

00:08:07,029 --> 00:08:04,479

but and it is returned back to normal

180

00:08:08,469 --> 00:08:07,039

but not quite fully normal

181

00:08:10,150 --> 00:08:08,479

it doesn't have its long-term

182

00:08:12,629 --> 00:08:10,160

variability period

183

00:08:16,869 --> 00:08:12,639

re-established yet we will continue to

184

00:08:21,510 --> 00:08:18,309

second story

185

00:08:23,350 --> 00:08:21,520

turning cartwheels in the sky

186

00:08:26,550 --> 00:08:23,360

and i'm referring to

187

00:08:28,070 --> 00:08:26,560

the famous cartwheel galaxy

188

00:08:30,309 --> 00:08:28,080

and so this

189

00:08:32,790 --> 00:08:30,319

is resembling now not the cartwheel that

190

00:08:34,310 --> 00:08:32,800

the kids do when they turn over on

191

00:08:37,029 --> 00:08:34,320

in gymnastics

192

00:08:39,909 --> 00:08:37,039

but really a the wheel of a cart where

193

00:08:42,389 --> 00:08:39,919

you have these central hub and then you

194

00:08:43,750 --> 00:08:42,399

have the wheel around it here

195

00:08:46,949 --> 00:08:43,760

in this galaxy

196

00:08:50,630 --> 00:08:46,959

this is what's known as a ring galaxy

197

00:08:52,310 --> 00:08:50,640

and is believed to have been caused by a

198

00:08:54,230 --> 00:08:52,320

smaller galaxy

199

00:08:56,550 --> 00:08:54,240

popping right through the center

200

00:08:58,870 --> 00:08:56,560

creating a ripple uh

201
00:09:00,870 --> 00:08:58,880
effect that spreads across and and

202
00:09:02,870 --> 00:09:00,880
created this ring here

203
00:09:05,509 --> 00:09:02,880
uh you can see it has two companion

204
00:09:06,949 --> 00:09:05,519
galaxies here on the left uh neither one

205
00:09:09,030 --> 00:09:06,959
of them is believed to have been the

206
00:09:11,110 --> 00:09:09,040
small galaxy that popped through there's

207
00:09:12,310 --> 00:09:11,120
a third one that they called g3 that's

208
00:09:13,590 --> 00:09:12,320
off screen

209
00:09:17,829 --> 00:09:13,600
that

210
00:09:20,870 --> 00:09:17,839
the ring structure but it's a very

211
00:09:23,030 --> 00:09:20,880
beautiful structure here

212
00:09:25,590 --> 00:09:23,040
but this image from hubble was taken

213
00:09:29,750 --> 00:09:25,600

back in 1994

214

00:09:31,030 --> 00:09:29,760

with wide field planetary camera 2. um

215

00:09:33,030 --> 00:09:31,040

so well

216

00:09:36,230 --> 00:09:33,040

even by hubble standards it's a kind of

217

00:09:39,190 --> 00:09:36,240

crappy little image okay it's 600 pixels

218

00:09:41,590 --> 00:09:39,200

by 500 pixels um

219

00:09:43,910 --> 00:09:41,600

you can see that uh in the

220

00:09:46,550 --> 00:09:43,920

galaxies they're a little blown out this

221

00:09:48,790 --> 00:09:46,560

galaxy here uh its core is totally blown

222

00:09:51,030 --> 00:09:48,800

out you can't see any details here the

223

00:09:54,150 --> 00:09:51,040

center of the cartwheel's blown out so

224

00:09:56,870 --> 00:09:54,160

uh by today's observational standards

225

00:09:57,750 --> 00:09:56,880

and image processing standards uh this

226
00:09:59,030 --> 00:09:57,760
is not

227
00:10:00,310 --> 00:09:59,040
a great image

228
00:10:02,710 --> 00:10:00,320
however

229
00:10:06,790 --> 00:10:02,720
we have just observed this with the web

230
00:10:08,710 --> 00:10:06,800
space telescope and web gets a much

231
00:10:09,670 --> 00:10:08,720
better image

232
00:10:11,590 --> 00:10:09,680
yeah

233
00:10:14,310 --> 00:10:11,600
much much better okay

234
00:10:16,829 --> 00:10:14,320
uh the web image is four thousand by

235
00:10:20,310 --> 00:10:16,839
four thousand pixels much much higher

236
00:10:22,389 --> 00:10:20,320
resolution and is using a a brand new

237
00:10:23,990 --> 00:10:22,399
detector that is up there so

238
00:10:27,430 --> 00:10:24,000

there's your hubble

239

00:10:31,430 --> 00:10:27,440

uh visible light and there is web in

240

00:10:34,710 --> 00:10:31,440

infrared amazing sorts of details um and

241

00:10:36,230 --> 00:10:34,720

like most of the web images i've seen uh

242

00:10:37,990 --> 00:10:36,240

some of the coolest stuff is not the

243

00:10:39,750 --> 00:10:38,000

foreground say oh yeah the cartwheel

244

00:10:42,230 --> 00:10:39,760

galaxy's cool and these two galaxies are

245

00:10:45,110 --> 00:10:42,240

cool but look at all these background

246

00:10:48,230 --> 00:10:45,120

galaxies all right that's just

247

00:10:51,590 --> 00:10:48,240

fantastic detail in the background most

248

00:10:53,670 --> 00:10:51,600

every uh web image i've seen has this

249

00:10:55,430 --> 00:10:53,680

simply because the

250

00:10:57,110 --> 00:10:55,440

distant galaxies

251
00:11:00,550 --> 00:10:57,120
are redshifted a little bit and they

252
00:11:03,190 --> 00:11:00,560
show up better in infrared light so you

253
00:11:05,509 --> 00:11:03,200
get not only the sensitivity of the web

254
00:11:07,829 --> 00:11:05,519
detectors but you also get the advantage

255
00:11:10,310 --> 00:11:07,839
of looking in infrared and that pulls

256
00:11:12,230 --> 00:11:10,320
out those background galaxies

257
00:11:14,470 --> 00:11:12,240
but there's one thing i'd like to

258
00:11:16,630 --> 00:11:14,480
express to you a little bit more deeply

259
00:11:19,190 --> 00:11:16,640
about this because this is a combination

260
00:11:21,430 --> 00:11:19,200
of near-infrared imagery and

261
00:11:22,790 --> 00:11:21,440
mid-infrared imagery let me explain a

262
00:11:27,509 --> 00:11:22,800
little bit okay

263
00:11:31,030 --> 00:11:27,519

um so here is the um wavelength uh

264

00:11:32,790 --> 00:11:31,040

from 0.1 micron all the way up to a 100

265

00:11:34,069 --> 00:11:32,800

micron and that covers from the

266

00:11:35,509 --> 00:11:34,079

ultraviolet

267

00:11:38,310 --> 00:11:35,519

through the optical

268

00:11:41,030 --> 00:11:38,320

to the near infrared the mid infrared

269

00:11:43,750 --> 00:11:41,040

and all the way to the far infrared you

270

00:11:46,069 --> 00:11:43,760

know while optical covers just a small

271

00:11:48,069 --> 00:11:46,079

range of wavelengths you know about 400

272

00:11:51,750 --> 00:11:48,079

to 700 nanometers or

273

00:11:54,710 --> 00:11:51,760

0.4 to 0.7 microns here

274

00:11:55,590 --> 00:11:54,720

infrared covers a factor of over 100

275

00:11:58,230 --> 00:11:55,600

from

276

00:12:01,350 --> 00:11:58,240

less than one micron on up to a hundred

277

00:12:04,230 --> 00:12:01,360

microns okay so there's a lot larger in

278

00:12:05,509 --> 00:12:04,240

factors of wavelength change uh in the

279

00:12:06,870 --> 00:12:05,519

infrared

280

00:12:09,670 --> 00:12:06,880

such that

281

00:12:11,030 --> 00:12:09,680

we talk about the near infrared the part

282

00:12:13,910 --> 00:12:11,040

of the infrared that's nearest to the

283

00:12:16,710 --> 00:12:13,920

optical and then the mid-infrared and

284

00:12:19,269 --> 00:12:16,720

just as you can see covers both the near

285

00:12:22,069 --> 00:12:19,279

infrared and the mid-infrared and

286

00:12:25,509 --> 00:12:22,079

because these are widely separated in

287

00:12:28,790 --> 00:12:25,519

you know uh you know from one from one

288

00:12:31,030 --> 00:12:28,800

to ten you can get a factor of 10 in

289

00:12:32,629 --> 00:12:31,040

wavelength difference they actually see

290

00:12:34,310 --> 00:12:32,639

different things and i just wanted to

291

00:12:37,030 --> 00:12:34,320

illustrate that with you with the

292

00:12:39,110 --> 00:12:37,040

cartwheel galaxy because we not only

293

00:12:41,509 --> 00:12:39,120

release the cartwheel galaxy with this

294

00:12:42,949 --> 00:12:41,519

combo combination near infrared and

295

00:12:44,949 --> 00:12:42,959

mid-infrared

296

00:12:46,949 --> 00:12:44,959

we also produced

297

00:12:48,629 --> 00:12:46,959

put it on our website in just

298

00:12:49,590 --> 00:12:48,639

the near infrared

299

00:12:51,670 --> 00:12:49,600

okay

300

00:12:53,110 --> 00:12:51,680

so if i go back to the

301
00:12:55,269 --> 00:12:53,120
combo image

302
00:12:58,230 --> 00:12:55,279
and then i go to the near infrared what

303
00:13:00,230 --> 00:12:58,240
do you see all that red the mid infrared

304
00:13:01,910 --> 00:13:00,240
was clear was called red in the previous

305
00:13:04,949 --> 00:13:01,920
images goes away

306
00:13:07,110 --> 00:13:04,959
all right and the gaseous structures

307
00:13:10,069 --> 00:13:07,120
that you see in the main cartwheel

308
00:13:13,190 --> 00:13:10,079
galaxy and one of the small companions

309
00:13:16,710 --> 00:13:13,200
go away and what you're really left with

310
00:13:19,269 --> 00:13:16,720
is stars near infrared is

311
00:13:23,110 --> 00:13:19,279
great for seeing the stellar structures

312
00:13:25,750 --> 00:13:23,120
right so if i go to the mid-infrared

313
00:13:28,870 --> 00:13:25,760

here's the mid-infrared image

314

00:13:30,710 --> 00:13:28,880

and you get that gaseous structure back

315

00:13:33,269 --> 00:13:30,720

but you lose the stars look at this

316

00:13:35,350 --> 00:13:33,279

small galaxy here right if i go back to

317

00:13:37,030 --> 00:13:35,360

the near infrared you see lots and lots

318

00:13:38,790 --> 00:13:37,040

of stars around it

319

00:13:41,910 --> 00:13:38,800

not so in the mid infrared the mid

320

00:13:44,310 --> 00:13:41,920

infrared does not see stars very well

321

00:13:46,710 --> 00:13:44,320

but it does see the gas so if i take for

322

00:13:49,110 --> 00:13:46,720

this and i go to the combo image

323

00:13:51,350 --> 00:13:49,120

you can see that that red that's air all

324

00:13:54,790 --> 00:13:51,360

that gas and dust structure in those two

325

00:13:56,790 --> 00:13:54,800

galaxies is what you see in the mid

326
00:13:57,910 --> 00:13:56,800
infrared

327
00:13:58,949 --> 00:13:57,920
so

328
00:14:00,069 --> 00:13:58,959
what you

329
00:14:01,509 --> 00:14:00,079
really want to do when you're

330
00:14:03,910 --> 00:14:01,519
understanding these images is

331
00:14:06,550 --> 00:14:03,920
recognizing that the near infrared and

332
00:14:09,430 --> 00:14:06,560
the mid infrared can see totally

333
00:14:11,590 --> 00:14:09,440
different structures in them all right

334
00:14:14,389 --> 00:14:11,600
the near infrared

335
00:14:16,470 --> 00:14:14,399
is the instrument it's called near cam

336
00:14:19,670 --> 00:14:16,480
and that's wavelengths from one to five

337
00:14:20,870 --> 00:14:19,680
microns uh and it sees the stars better

338
00:14:22,550 --> 00:14:20,880

than

339

00:14:25,670 --> 00:14:22,560
the other ones and it will be at a

340

00:14:27,269 --> 00:14:25,680
higher resolution okay uh this will be

341

00:14:29,829 --> 00:14:27,279
getting the four thousand by four

342

00:14:32,949 --> 00:14:29,839
thousand per uh image

343

00:14:35,750 --> 00:14:32,959
resolution the mid infrared which is the

344

00:14:37,509 --> 00:14:35,760
miri instrument uh goes generally from 5

345

00:14:40,629 --> 00:14:37,519
to 20 microns

346

00:14:42,870 --> 00:14:40,639
it sees the gas and dust better the gas

347

00:14:45,110 --> 00:14:42,880
and dust emit better in those

348

00:14:47,509 --> 00:14:45,120
wavelengths but it is of lower

349

00:14:49,509 --> 00:14:47,519
resolution uh and that's

350

00:14:52,310 --> 00:14:49,519
not due to the any fault of miri it's

351
00:14:55,030 --> 00:14:52,320
just the the fact that to gain

352
00:14:56,949 --> 00:14:55,040
resolution is determined by the size of

353
00:14:59,350 --> 00:14:56,959
your your

354
00:15:01,430 --> 00:14:59,360
mirror to the size of the wavelength and

355
00:15:03,350 --> 00:15:01,440
so for longer wavelengths the same

356
00:15:07,189 --> 00:15:03,360
mirror will only give you less

357
00:15:08,550 --> 00:15:07,199
resolution so by going up by a factor of

358
00:15:11,110 --> 00:15:08,560
5 or 10

359
00:15:13,189 --> 00:15:11,120
in the wavelengths that you're observing

360
00:15:15,750 --> 00:15:13,199
you're going to get that correspondingly

361
00:15:18,550 --> 00:15:15,760
less resolution so the miri instrument

362
00:15:20,870 --> 00:15:18,560
has less resolution than the near cam

363
00:15:23,110 --> 00:15:20,880

instrument but something to look out for

364

00:15:25,350 --> 00:15:23,120

in the james webb images as they are

365

00:15:27,590 --> 00:15:25,360

released because you get to see two

366

00:15:29,269 --> 00:15:27,600

different sides of the same object as

367

00:15:31,110 --> 00:15:29,279

well as we will generally produce a

368

00:15:34,550 --> 00:15:31,120

combined image that gives you both of

369

00:15:40,870 --> 00:15:36,870

and now back to our

370

00:15:45,430 --> 00:15:40,880

featured presentation uh guido roberts

371

00:15:47,990 --> 00:15:45,440

borsani is out at ucla in los angeles

372

00:15:50,230 --> 00:15:48,000

but he is originally from the uk

373

00:15:52,470 --> 00:15:50,240

uh he did his undergraduate degree at

374

00:15:54,230 --> 00:15:52,480

the university of kent although he did

375

00:15:55,430 --> 00:15:54,240

come to the states there i guess he

376

00:15:57,110 --> 00:15:55,440

maybe love

377

00:15:58,710 --> 00:15:57,120

developed a love for california he might

378

00:16:00,629 --> 00:15:58,720

have spent a year at university of

379

00:16:02,629 --> 00:16:00,639

california san diego

380

00:16:05,829 --> 00:16:02,639

but he was back in london university

381

00:16:09,350 --> 00:16:05,839

called luncheon to do his phd

382

00:16:11,350 --> 00:16:09,360

and then he came to uh ucla where he's

383

00:16:14,710 --> 00:16:11,360

been a postdoc there for the past three

384

00:16:15,829 --> 00:16:14,720

years um his main research well that's

385

00:16:17,910 --> 00:16:15,839

what he's going to talk to you about

386

00:16:21,350 --> 00:16:17,920

looking for galaxies at the dawn of

387

00:16:23,590 --> 00:16:21,360

cosmic time uh but he is also involved

388

00:16:27,110 --> 00:16:23,600

in one of the early release science

389

00:16:29,269 --> 00:16:27,120

observations for the web space telescope

390

00:16:31,430 --> 00:16:29,279

the glass project

391

00:16:34,310 --> 00:16:31,440

and so you'll probably be hearing from

392

00:16:37,030 --> 00:16:34,320

him or his team again in the near future

393

00:16:39,590 --> 00:16:37,040

with their results from that uh in his

394

00:16:42,389 --> 00:16:39,600

spare time he's very athletic he grew up

395

00:16:43,350 --> 00:16:42,399

playing soccer and uh doing all sorts of

396

00:16:46,550 --> 00:16:43,360

sports

397

00:16:48,150 --> 00:16:46,560

uh he's a surfer uh there in california

398

00:16:50,310 --> 00:16:48,160

he loves to go hiking which is another

399

00:16:51,509 --> 00:16:50,320

great thing to do in california so i'm

400

00:16:53,430 --> 00:16:51,519

not sure he's ever really going to want

401
00:16:54,870 --> 00:16:53,440
to leave california

402
00:16:57,910 --> 00:16:54,880
because he's got such great sports

403
00:16:59,990 --> 00:16:57,920
available to him he might have to uh but

404
00:17:01,990 --> 00:17:00,000
until then we're happy to have him here

405
00:17:07,990 --> 00:17:02,000
ladies and gentlemen dr guido robert

406
00:17:15,029 --> 00:17:11,270
well thank you very much uh frank for

407
00:17:16,630 --> 00:17:15,039
that wonderful introduction um it's my

408
00:17:19,029 --> 00:17:16,640
great pleasure to

409
00:17:22,789 --> 00:17:19,039
chat to you today um

410
00:17:24,309 --> 00:17:22,799
let me just share my screen uh over here

411
00:17:25,909 --> 00:17:24,319
there we go so it's it's my great

412
00:17:28,710 --> 00:17:25,919
pleasure to chat to you today i'd like

413
00:17:31,270 --> 00:17:28,720

to thank uh the organizers uh for giving

414

00:17:33,669 --> 00:17:31,280

me the opportunity uh to talk a little

415

00:17:36,390 --> 00:17:33,679

bit about the research that i'm doing

416

00:17:39,350 --> 00:17:36,400

over here at ucla it's a particularly

417

00:17:42,230 --> 00:17:39,360

exciting time uh with the arrival of uh

418

00:17:44,310 --> 00:17:42,240

the james webb space telescope and uh in

419

00:17:47,190 --> 00:17:44,320

particular what i'd like to do is take

420

00:17:48,870 --> 00:17:47,200

you right to uh the very edge of the

421

00:17:51,350 --> 00:17:48,880

observable universe and together we're

422

00:17:53,909 --> 00:17:51,360

going to go through a journey through

423

00:17:55,430 --> 00:17:53,919

about 96

424

00:17:57,909 --> 00:17:55,440

of cosmic time right to the very

425

00:17:59,990 --> 00:17:57,919

beginning of when the first stars in the

426
00:18:01,750 --> 00:18:00,000
first galaxies formed

427
00:18:03,430 --> 00:18:01,760
and what i'm going to talk to you about

428
00:18:05,830 --> 00:18:03,440
today is hopefully give you a little bit

429
00:18:08,150 --> 00:18:05,840
of a description of how we search for

430
00:18:10,390 --> 00:18:08,160
these galaxies why they're important and

431
00:18:12,710 --> 00:18:10,400
also how we've been using

432
00:18:14,630 --> 00:18:12,720
our foremost telescopes to really push

433
00:18:16,870 --> 00:18:14,640
the boundaries uh in terms of

434
00:18:19,110 --> 00:18:16,880
characterizing their properties and

435
00:18:21,830 --> 00:18:19,120
finally i'll try and end with a little

436
00:18:24,310 --> 00:18:21,840
bit of uh showcasing let's say the very

437
00:18:26,789 --> 00:18:24,320
first data that we've obtained with the

438
00:18:29,830 --> 00:18:26,799

james webb space telescope and how that

439

00:18:33,029 --> 00:18:29,840

telescope is um well revolutionizing

440

00:18:35,110 --> 00:18:33,039

early galaxy evolution already

441

00:18:38,150 --> 00:18:35,120

uh so to start off with as astronomers

442

00:18:40,710 --> 00:18:38,160

our aim really is to try and paint a

443

00:18:43,350 --> 00:18:40,720

coherent picture of the build-up of

444

00:18:45,430 --> 00:18:43,360

matter in the universe and

445

00:18:47,830 --> 00:18:45,440

through the eyes of our foremost

446

00:18:50,630 --> 00:18:47,840

telescopes we essentially can directly

447

00:18:52,950 --> 00:18:50,640

witness uh the past and what i mean by

448

00:18:55,270 --> 00:18:52,960

this is if you look on the left side of

449

00:18:57,750 --> 00:18:55,280

this screen for instance you can see

450

00:19:00,310 --> 00:18:57,760

two very large galaxies one at the top

451
00:19:01,750 --> 00:19:00,320
which is a spiral galaxy uh one at the

452
00:19:04,150 --> 00:19:01,760
bottom which is what we call an

453
00:19:07,270 --> 00:19:04,160
elliptical galaxy essentially just a

454
00:19:09,110 --> 00:19:07,280
sphere of a few stars it's not really

455
00:19:11,430 --> 00:19:09,120
forming many stars anymore it doesn't

456
00:19:14,070 --> 00:19:11,440
seem to have this beautiful ring-like

457
00:19:16,470 --> 00:19:14,080
structure that this milky way like

458
00:19:18,630 --> 00:19:16,480
star-forming galaxy at the top does and

459
00:19:22,070 --> 00:19:18,640
these two galaxies exist

460
00:19:24,950 --> 00:19:22,080
at the present day so uh 13.8 billion

461
00:19:26,870 --> 00:19:24,960
years after the big bang

462
00:19:30,070 --> 00:19:26,880
but if you just go a little bit further

463
00:19:31,990 --> 00:19:30,080

back to about six billion years

464

00:19:34,230 --> 00:19:32,000

after the big bang you can see that

465

00:19:36,310 --> 00:19:34,240

these galaxies look very very different

466

00:19:37,590 --> 00:19:36,320

so we've crossed a large fraction of

467

00:19:40,150 --> 00:19:37,600

cosmic time

468

00:19:42,390 --> 00:19:40,160

and you can see the galaxy at the top uh

469

00:19:43,590 --> 00:19:42,400

looks rather different to what we see on

470

00:19:45,669 --> 00:19:43,600

the left

471

00:19:48,070 --> 00:19:45,679

but it might be a precursor to this

472

00:19:50,310 --> 00:19:48,080

spiral galaxy whilst the galaxy is at

473

00:19:51,990 --> 00:19:50,320

the bottom might be precursors to the

474

00:19:53,350 --> 00:19:52,000

elliptical galaxies so i'm sure you'll

475

00:19:54,950 --> 00:19:53,360

agree they already

476
00:19:56,710 --> 00:19:54,960
look quite different but there seems to

477
00:19:58,470 --> 00:19:56,720
be a little bit of resemblance in terms

478
00:20:00,950 --> 00:19:58,480
of the structures

479
00:20:02,630 --> 00:20:00,960
uh on the right however if we look even

480
00:20:03,990 --> 00:20:02,640
further back in time so now we're

481
00:20:05,350 --> 00:20:04,000
crossing about

482
00:20:07,669 --> 00:20:05,360
96

483
00:20:10,230 --> 00:20:07,679
of cosmic time or so about 1 billion

484
00:20:12,390 --> 00:20:10,240
years after the big bang you can see

485
00:20:14,789 --> 00:20:12,400
that these galaxies now lose

486
00:20:16,549 --> 00:20:14,799
all resemblance really to the galaxies

487
00:20:18,789 --> 00:20:16,559
that we see in the present day you don't

488
00:20:21,190 --> 00:20:18,799

see any more lovely spiral arms you

489

00:20:23,029 --> 00:20:21,200

don't see any more real structure uh

490

00:20:24,310 --> 00:20:23,039

they're pretty much just these small

491

00:20:26,149 --> 00:20:24,320

blobs

492

00:20:28,390 --> 00:20:26,159

and this red that you see from the

493

00:20:30,149 --> 00:20:28,400

galaxies is not how they actually are if

494

00:20:31,430 --> 00:20:30,159

we were to travel to them uh they

495

00:20:35,430 --> 00:20:31,440

wouldn't be read this is just an

496

00:20:38,870 --> 00:20:35,440

artifact of um how we image them

497

00:20:41,909 --> 00:20:38,880

so why are why is it important for us to

498

00:20:44,789 --> 00:20:41,919

uh paint this uh a picture of cosmic

499

00:20:47,270 --> 00:20:44,799

history um it's good i think to put this

500

00:20:51,110 --> 00:20:47,280

into context a little bit so over here

501
00:20:53,750 --> 00:20:51,120
you can see uh the um history of the

502
00:20:55,750 --> 00:20:53,760
universe in graphic form uh with the age

503
00:20:57,750 --> 00:20:55,760
of the universe there at the bottom so

504
00:20:59,350 --> 00:20:57,760
on the left you have the

505
00:21:01,590 --> 00:20:59,360
big bang which we're all familiar with

506
00:21:03,990 --> 00:21:01,600
about 13.8

507
00:21:06,310 --> 00:21:04,000
billion years ago at time

508
00:21:08,310 --> 00:21:06,320
universal time equals zero straight

509
00:21:10,470 --> 00:21:08,320
after that you have this beautiful

510
00:21:11,750 --> 00:21:10,480
imprint called the cosmic microwave

511
00:21:14,470 --> 00:21:11,760
background

512
00:21:16,630 --> 00:21:14,480
uh which we imaged with wmap and also

513
00:21:18,310 --> 00:21:16,640

the planck satellites and this imprint

514

00:21:21,270 --> 00:21:18,320

is the imprint of the big bang this is

515

00:21:23,270 --> 00:21:21,280

what we see um and is characteristic of

516

00:21:25,270 --> 00:21:23,280

the large scale structure that we saw

517

00:21:27,750 --> 00:21:25,280

that we see today it's the seeds for

518

00:21:30,230 --> 00:21:27,760

that straight after that we enter a

519

00:21:31,669 --> 00:21:30,240

period called the cosmic dark ages over

520

00:21:33,350 --> 00:21:31,679

there this sort of

521

00:21:36,549 --> 00:21:33,360

dark stripe right in the middle over

522

00:21:38,310 --> 00:21:36,559

here there is a complete absence of uv

523

00:21:40,310 --> 00:21:38,320

sources there are no stars there are no

524

00:21:43,270 --> 00:21:40,320

galaxies all that exists

525

00:21:44,549 --> 00:21:43,280

for the time being are clouds of atomic

526
00:21:47,190 --> 00:21:44,559
hydrogen

527
00:21:48,789 --> 00:21:47,200
so let's let's call it a fog essentially

528
00:21:51,029 --> 00:21:48,799
of cosmic hydrogen

529
00:21:52,710 --> 00:21:51,039
but then approximately one billion years

530
00:21:54,310 --> 00:21:52,720
after the big bang the very first

531
00:21:57,669 --> 00:21:54,320
sources start to have formed the very

532
00:21:59,909 --> 00:21:57,679
first uv stars these stars then

533
00:22:01,669 --> 00:21:59,919
merge into globular clusters and these

534
00:22:02,630 --> 00:22:01,679
clusters then start forming the very

535
00:22:04,310 --> 00:22:02,640
small

536
00:22:06,230 --> 00:22:04,320
first galaxies that you saw in the

537
00:22:08,470 --> 00:22:06,240
previous image and crucially these

538
00:22:10,070 --> 00:22:08,480

galaxies start emitting a lot of uv

539

00:22:12,390 --> 00:22:10,080

light and this is important because this

540

00:22:14,710 --> 00:22:12,400

uv light ends up stripping

541

00:22:17,750 --> 00:22:14,720

the electron from the proton by the

542

00:22:19,750 --> 00:22:17,760

hydrogen atom and ionizes the universe

543

00:22:21,669 --> 00:22:19,760

uh into what we see today so you can see

544

00:22:24,310 --> 00:22:21,679

the very first sources start to form

545

00:22:25,669 --> 00:22:24,320

over here then through gravity uh they

546

00:22:27,909 --> 00:22:25,679

combine into bigger and bigger

547

00:22:29,909 --> 00:22:27,919

structures they put these ionized

548

00:22:32,230 --> 00:22:29,919

bubbles which you can see around them

549

00:22:34,470 --> 00:22:32,240

start to percolate to create bigger and

550

00:22:37,190 --> 00:22:34,480

bigger bubbles uh and then eventually

551

00:22:39,830 --> 00:22:37,200

all of this neutral hydrogen fog

552

00:22:42,310 --> 00:22:39,840

is um is ionized and you see the

553

00:22:43,909 --> 00:22:42,320

beautiful structure uh both in terms of

554

00:22:46,789 --> 00:22:43,919

the universe and also within the

555

00:22:49,669 --> 00:22:46,799

galaxies themselves that we see today

556

00:22:51,909 --> 00:22:49,679

so clearly the emergence of the first

557

00:22:55,270 --> 00:22:51,919

galaxies and the first stars is

558

00:22:56,070 --> 00:22:55,280

extremely important for how it impacted

559

00:22:59,190 --> 00:22:56,080

the

560

00:23:01,270 --> 00:22:59,200

universe into what we see today and uh

561

00:23:03,350 --> 00:23:01,280

this epoch is called the epoch of

562

00:23:06,470 --> 00:23:03,360

realization and this is going to form

563

00:23:08,710 --> 00:23:06,480

the basis uh for my talk today and if

564

00:23:10,310 --> 00:23:08,720

we're to take a slice of the universe at

565

00:23:12,230 --> 00:23:10,320

this particular time it might look

566

00:23:14,310 --> 00:23:12,240

something like this this is a small

567

00:23:16,470 --> 00:23:14,320

little video where you see essentially a

568

00:23:19,190 --> 00:23:16,480

sort of block of cheese let's say

569

00:23:21,590 --> 00:23:19,200

uh in terms of the universe and the dark

570

00:23:25,510 --> 00:23:21,600

clouds are this neutral hydrogen fog so

571

00:23:26,710 --> 00:23:25,520

this hydrogen is blocking the uv light

572

00:23:28,630 --> 00:23:26,720

of

573

00:23:31,750 --> 00:23:28,640

the galaxies it's absorbing it and it's

574

00:23:33,350 --> 00:23:31,760

essentially getting burnt let's say

575

00:23:34,870 --> 00:23:33,360

you can see those sources in the middle

576
00:23:36,310 --> 00:23:34,880
over there these yellow dots and you can

577
00:23:39,110 --> 00:23:36,320
see these bubbles getting bigger and

578
00:23:40,950 --> 00:23:39,120
bigger as time goes on until eventually

579
00:23:45,909 --> 00:23:40,960
all of that hydrogen is burnt away and

580
00:23:49,269 --> 00:23:47,669
so we want to characterize then these

581
00:23:51,590 --> 00:23:49,279
distant galaxies because clearly they

582
00:23:53,590 --> 00:23:51,600
had a profound effect on the universe as

583
00:23:55,110 --> 00:23:53,600
we see it today but what does that mean

584
00:23:57,029 --> 00:23:55,120
exactly when we say characterize a

585
00:23:58,950 --> 00:23:57,039
galaxy what does that mean well i think

586
00:24:01,029 --> 00:23:58,960
it's useful to try and understand a

587
00:24:03,350 --> 00:24:01,039
galaxy's composition what does a galaxy

588
00:24:05,750 --> 00:24:03,360

actually look like so this is an example

589

00:24:07,909 --> 00:24:05,760

galaxy in the local universe and you can

590

00:24:10,870 --> 00:24:07,919

see that it has quite a few components

591

00:24:14,630 --> 00:24:10,880

to it has some stars both young and old

592

00:24:17,669 --> 00:24:14,640

it has dust over here it's also got gas

593

00:24:18,950 --> 00:24:17,679

hydrogen gas for instance or gas from

594

00:24:20,950 --> 00:24:18,960

metals

595

00:24:22,230 --> 00:24:20,960

it also has a supermassive black hole

596

00:24:24,789 --> 00:24:22,240

right at the center which is this

597

00:24:27,269 --> 00:24:24,799

particularly luminous point and all of

598

00:24:29,430 --> 00:24:27,279

these things combine uh to give a

599

00:24:31,110 --> 00:24:29,440

particular light profile to the galaxy

600

00:24:33,830 --> 00:24:31,120

so that's what you're seeing over here

601
00:24:36,070 --> 00:24:33,840
this black curve essentially is the

602
00:24:38,070 --> 00:24:36,080
total light profile of a galaxy as a

603
00:24:40,310 --> 00:24:38,080
function of wavelength or frequency

604
00:24:41,430 --> 00:24:40,320
shall we say and on the y-axis you can

605
00:24:43,269 --> 00:24:41,440
see

606
00:24:44,630 --> 00:24:43,279
the brightness of that profile so you

607
00:24:46,630 --> 00:24:44,640
see the brightness at different

608
00:24:49,590 --> 00:24:46,640
wavelengths really changes and that's

609
00:24:52,070 --> 00:24:49,600
due to uh the composition of the galaxy

610
00:24:54,070 --> 00:24:52,080
you can see the individual contributions

611
00:24:56,149 --> 00:24:54,080
from young stars in blue over here in

612
00:24:58,870 --> 00:24:56,159
the ultraviolet when you start getting

613
00:25:01,029 --> 00:24:58,880

to the rest frame optical portion of the

614

00:25:03,590 --> 00:25:01,039

spectrum you can see old star

615

00:25:05,110 --> 00:25:03,600

contributions in red uh whilst

616

00:25:07,350 --> 00:25:05,120

underneath that you can also get the

617

00:25:09,350 --> 00:25:07,360

contributions from the gas that's in the

618

00:25:11,750 --> 00:25:09,360

galaxy let's say for instance hydrogen

619

00:25:13,669 --> 00:25:11,760

or carbon or oxygen and these create

620

00:25:15,269 --> 00:25:13,679

these peaks over here these emission

621

00:25:17,669 --> 00:25:15,279

lines

622

00:25:20,149 --> 00:25:17,679

and so overall that then creates this

623

00:25:22,710 --> 00:25:20,159

black profile that you see here

624

00:25:25,110 --> 00:25:22,720

but if we were to point out telescopes

625

00:25:28,390 --> 00:25:25,120

uh at a particular wavelength you know

626

00:25:30,789 --> 00:25:28,400

sort of blindly let's say trying to um

627

00:25:33,430 --> 00:25:30,799

trying to look at this portion of the

628

00:25:35,269 --> 00:25:33,440

galaxy spectrum we might be disappointed

629

00:25:37,830 --> 00:25:35,279

the reason for that is uh the effect

630

00:25:39,830 --> 00:25:37,840

that we call redshift the stretching of

631

00:25:42,070 --> 00:25:39,840

the universe so

632

00:25:44,070 --> 00:25:42,080

this is an example you have the earth

633

00:25:46,950 --> 00:25:44,080

over here you have the galaxy here in

634

00:25:49,350 --> 00:25:46,960

the middle uh which reside in space and

635

00:25:52,390 --> 00:25:49,360

as the universe expands from the big

636

00:25:54,789 --> 00:25:52,400

bang up until now uh you can see that it

637

00:25:56,630 --> 00:25:54,799

ends up stretching the space between the

638

00:25:58,710 --> 00:25:56,640

earth and the galaxy what this does is

639

00:26:00,470 --> 00:25:58,720

it stretches the

640

00:26:02,710 --> 00:26:00,480

spectrum to redder and redder

641

00:26:04,470 --> 00:26:02,720

wavelengths that is why the galaxy

642

00:26:06,310 --> 00:26:04,480

appears redder and redder the further

643

00:26:07,830 --> 00:26:06,320

away it is from earth

644

00:26:10,390 --> 00:26:07,840

and this is particularly important

645

00:26:12,390 --> 00:26:10,400

because it means if we are to look at

646

00:26:15,110 --> 00:26:12,400

the galaxy let's play that one more time

647

00:26:17,190 --> 00:26:15,120

in the ultraviolet for instance uh we

648

00:26:19,190 --> 00:26:17,200

would see it if it's close by but we

649

00:26:21,669 --> 00:26:19,200

might miss it when it's further away

650

00:26:23,590 --> 00:26:21,679

because the galaxy is no longer emitting

651
00:26:25,909 --> 00:26:23,600
light in the ultraviolet it's emitting

652
00:26:27,909 --> 00:26:25,919
it in the infrared and that's nicely

653
00:26:30,390 --> 00:26:27,919
highlighted in this schematic below

654
00:26:32,710 --> 00:26:30,400
where you can see that as redshift

655
00:26:34,710 --> 00:26:32,720
increases so the distance between the

656
00:26:36,710 --> 00:26:34,720
earth and the object the

657
00:26:39,430 --> 00:26:36,720
number that characterizes the stretching

658
00:26:41,269 --> 00:26:39,440
of the universe the light of the galaxy

659
00:26:44,230 --> 00:26:41,279
then shifts from the visible or the

660
00:26:46,789 --> 00:26:44,240
ultraviolet into the infrared

661
00:26:48,950 --> 00:26:46,799
but this is actually uh sort of useful

662
00:26:50,870 --> 00:26:48,960
because it's allowed us to develop quite

663
00:26:53,269 --> 00:26:50,880

a useful technique to try and confirm

664

00:26:55,190 --> 00:26:53,279

the distances to these very distant

665

00:26:57,750 --> 00:26:55,200

galaxies or the redshift redshift and

666

00:26:59,590 --> 00:26:57,760

distance essentially uh equals sort of

667

00:27:01,830 --> 00:26:59,600

more or less the same thing

668

00:27:03,510 --> 00:27:01,840

their proxy for for the two so this is

669

00:27:05,430 --> 00:27:03,520

called the lyman break

670

00:27:09,510 --> 00:27:05,440

technique this was pioneered by chuck

671

00:27:11,590 --> 00:27:09,520

steidel at caltech in the in the 90s

672

00:27:13,990 --> 00:27:11,600

and uh here at the top you can see again

673

00:27:15,990 --> 00:27:14,000

the light profile of a galaxy

674

00:27:18,389 --> 00:27:16,000

you can see on the right it's emitting

675

00:27:20,630 --> 00:27:18,399

light from stars but then all of a

676

00:27:21,909 --> 00:27:20,640

sudden you see this drop in the

677

00:27:23,909 --> 00:27:21,919

brightness

678

00:27:27,029 --> 00:27:23,919

characteristic of a distant galaxy and

679

00:27:29,669 --> 00:27:27,039

the reason for this is that um

680

00:27:32,710 --> 00:27:29,679

the uv light of galaxies gets blocked

681

00:27:35,190 --> 00:27:32,720

out by clouds of hydrogen

682

00:27:37,110 --> 00:27:35,200

that uh intervene between the galaxy

683

00:27:38,870 --> 00:27:37,120

itself and the line of sight so we

684

00:27:41,669 --> 00:27:38,880

talked about the epoch of reionization

685

00:27:44,389 --> 00:27:41,679

where uh the universe is bathed in this

686

00:27:46,470 --> 00:27:44,399

hydrogen fog that hydrogen fog blocks

687

00:27:49,510 --> 00:27:46,480

the uv light from that galaxy and

688

00:27:51,269 --> 00:27:49,520

because we know exactly where that drop

689

00:27:54,710 --> 00:27:51,279

is supposed to occur it's supposed to

690

00:27:56,389 --> 00:27:54,720

occur at 912 angstroms any light that

691

00:27:59,190 --> 00:27:56,399

comes from the galaxy that is more

692

00:28:01,669 --> 00:27:59,200

energetic so more in the uv than that

693

00:28:03,909 --> 00:28:01,679

particular wavelength will get absorbed

694

00:28:05,669 --> 00:28:03,919

so as the universe stretches this

695

00:28:07,750 --> 00:28:05,679

characteristic drop

696

00:28:09,430 --> 00:28:07,760

uh will shift more and more to the right

697

00:28:13,269 --> 00:28:09,440

and if you measure that this that

698

00:28:15,190 --> 00:28:13,279

difference between the 912 angstroms or

699

00:28:16,710 --> 00:28:15,200

it's about 0.09

700

00:28:18,710 --> 00:28:16,720

microns you can see there's a big

701
00:28:21,110 --> 00:28:18,720
difference between 0.09 microns here on

702
00:28:22,549 --> 00:28:21,120
the graph and about 1 microns over here

703
00:28:25,350 --> 00:28:22,559
where this drop actually is and that

704
00:28:26,789 --> 00:28:25,360
difference gives you the redshift now to

705
00:28:28,630 --> 00:28:26,799
highlight this a little bit better you

706
00:28:30,870 --> 00:28:28,640
can see the images that we would take

707
00:28:33,029 --> 00:28:30,880
with our telescopes

708
00:28:34,710 --> 00:28:33,039
over these three portions of the

709
00:28:37,190 --> 00:28:34,720
spectrum and this is called the drop out

710
00:28:39,669 --> 00:28:37,200
technique and you can see that

711
00:28:41,830 --> 00:28:39,679
if we look at the orange filter so this

712
00:28:43,990 --> 00:28:41,840
would be an image taken with

713
00:28:46,070 --> 00:28:44,000

the james webb space telescope we would

714

00:28:48,070 --> 00:28:46,080

see the galaxy perfectly in the postage

715

00:28:50,149 --> 00:28:48,080

stamp on the bottom right because it's

716

00:28:52,389 --> 00:28:50,159

emitting light over there that is not

717

00:28:54,230 --> 00:28:52,399

getting absorbed the same thing for the

718

00:28:55,669 --> 00:28:54,240

blue filter over here you see the light

719

00:28:57,269 --> 00:28:55,679

being emitted and we see the galaxy

720

00:28:59,269 --> 00:28:57,279

clearly in the middle of the image but

721

00:29:01,190 --> 00:28:59,279

then if you move to the pink filter over

722

00:29:04,310 --> 00:29:01,200

here where it's not measuring any flux

723

00:29:07,750 --> 00:29:04,320

or any any emit any um brightness from

724

00:29:09,990 --> 00:29:07,760

the galaxy the galaxy drops out so to

725

00:29:12,549 --> 00:29:10,000

speak of this filter and that's

726

00:29:14,470 --> 00:29:12,559

important because the location of this

727

00:29:16,870 --> 00:29:14,480

so-called drop tells you where this

728

00:29:18,789 --> 00:29:16,880

break is this lineman break which gives

729

00:29:19,830 --> 00:29:18,799

you the redshift or the distance of the

730

00:29:21,669 --> 00:29:19,840

galaxy

731

00:29:23,750 --> 00:29:21,679

so just to reiterate if you look on the

732

00:29:25,830 --> 00:29:23,760

right this is a nice sort of schematic

733

00:29:28,389 --> 00:29:25,840

let's say you have the galaxy at the top

734

00:29:30,470 --> 00:29:28,399

if it's emitting blue uv light that

735

00:29:33,269 --> 00:29:30,480

light then gets absorbed by the hydrogen

736

00:29:34,950 --> 00:29:33,279

cloud between the galaxy and ourselves

737

00:29:37,350 --> 00:29:34,960

but if the galaxy is emitting redder

738

00:29:40,230 --> 00:29:37,360

light at infrared infrared wavelengths

739

00:29:42,149 --> 00:29:40,240

that goes through and we then capture

740

00:29:44,470 --> 00:29:42,159

that image

741

00:29:47,110 --> 00:29:44,480

so it's quite important then to choose

742

00:29:49,190 --> 00:29:47,120

carefully which telescope you want to

743

00:29:51,430 --> 00:29:49,200

use to try and characterize your galaxy

744

00:29:53,750 --> 00:29:51,440

or determine uh the distance to it the

745

00:29:55,350 --> 00:29:53,760

reason for that being is you have to

746

00:29:56,950 --> 00:29:55,360

carefully understand which physical

747

00:29:58,710 --> 00:29:56,960

process

748

00:30:01,110 --> 00:29:58,720

you are looking at from the galaxy

749

00:30:03,269 --> 00:30:01,120

electromagnetic spectrum but equally you

750

00:30:05,510 --> 00:30:03,279

need to make sure that you are pointing

751
00:30:07,350 --> 00:30:05,520
in the correct um at the correct

752
00:30:09,830 --> 00:30:07,360
wavelength where those physical

753
00:30:11,830 --> 00:30:09,840
processes are going to

754
00:30:14,070 --> 00:30:11,840
emit

755
00:30:15,590 --> 00:30:14,080
so if we take the hubble space telescope

756
00:30:18,149 --> 00:30:15,600
for instance to try and confirm the

757
00:30:20,549 --> 00:30:18,159
distances to these galaxies the distance

758
00:30:23,510 --> 00:30:20,559
of a galaxy is a fundamental component

759
00:30:25,350 --> 00:30:23,520
to trying to characterize it we might

760
00:30:27,830 --> 00:30:25,360
take uh hubble so

761
00:30:30,710 --> 00:30:27,840
if you remember the example just before

762
00:30:33,510 --> 00:30:30,720
we had three different images we now can

763
00:30:35,510 --> 00:30:33,520

use the full assortment of um

764

00:30:38,070 --> 00:30:35,520

of optical and infrared filters from the

765

00:30:42,070 --> 00:30:38,080

hubble space telescope so here you see

766

00:30:44,070 --> 00:30:42,080

an example spectrum of a distant galaxy

767

00:30:47,430 --> 00:30:44,080

right here um where the mouse is

768

00:30:50,630 --> 00:30:47,440

pointing this is that 912 angstrom break

769

00:30:52,710 --> 00:30:50,640

which you will see so as the galaxy

770

00:30:54,149 --> 00:30:52,720

then gets redshifted further and further

771

00:30:55,909 --> 00:30:54,159

away from us

772

00:30:58,230 --> 00:30:55,919

you can see that the hydrogen is

773

00:31:00,710 --> 00:30:58,240

absorbing this light from the galaxy and

774

00:31:02,710 --> 00:31:00,720

it's creating this break and as it moves

775

00:31:04,789 --> 00:31:02,720

through these hubble filters these

776

00:31:06,389 --> 00:31:04,799

filters are what we use to take the

777

00:31:09,430 --> 00:31:06,399

images you can see that in the

778

00:31:12,149 --> 00:31:09,440

corresponding images below the galaxy

779

00:31:15,029 --> 00:31:12,159

drops out and that again is important

780

00:31:17,750 --> 00:31:15,039

because the location of this dropout

781

00:31:19,590 --> 00:31:17,760

tells you an approximate redshift or

782

00:31:22,389 --> 00:31:19,600

distance let's see

783

00:31:24,389 --> 00:31:22,399

so now that we know how to search for

784

00:31:25,990 --> 00:31:24,399

distant galaxies uh what sort of

785

00:31:28,549 --> 00:31:26,000

galaxies have we found which are the

786

00:31:30,549 --> 00:31:28,559

most distant galaxies that we

787

00:31:32,950 --> 00:31:30,559

know of

788

00:31:34,630 --> 00:31:32,960

i like this picture uh quite a lot i

789

00:31:37,269 --> 00:31:34,640

think this serves as a lot of

790

00:31:40,149 --> 00:31:37,279

inspiration for many astronomers this is

791

00:31:42,470 --> 00:31:40,159

the hubble ultra deep field so the

792

00:31:44,870 --> 00:31:42,480

hubble space telescope is or was our

793

00:31:47,269 --> 00:31:44,880

premier flagship telescope was launched

794

00:31:48,870 --> 00:31:47,279

in 1990s and it's been taking these

795

00:31:51,669 --> 00:31:48,880

stunning images

796

00:31:54,870 --> 00:31:51,679

of the universe ever since for us

797

00:31:57,590 --> 00:31:54,880

so in 2002 they installed the advanced

798

00:31:59,029 --> 00:31:57,600

camera for surveys acs instrument which

799

00:32:01,909 --> 00:31:59,039

is uh

800

00:32:05,269 --> 00:32:01,919

visible optical instrument let's say uh

801
00:32:07,830 --> 00:32:05,279
and in 2004 they pointed at the sky uh

802
00:32:10,389 --> 00:32:07,840
took um took an image

803
00:32:12,630 --> 00:32:10,399
for about a hundred different hours

804
00:32:16,630 --> 00:32:12,640
approximately this was supposed to be a

805
00:32:18,230 --> 00:32:16,640
blank area of the sky no larger than um

806
00:32:19,909 --> 00:32:18,240
if you take a a

807
00:32:21,750 --> 00:32:19,919
a pound coin

808
00:32:22,630 --> 00:32:21,760
and stretch it

809
00:32:25,269 --> 00:32:22,640
about

810
00:32:27,669 --> 00:32:25,279
an arm's length and look at the eye of

811
00:32:29,830 --> 00:32:27,679
the queen on on that pound coin uh it

812
00:32:31,110 --> 00:32:29,840
would be roughly that size area it's a

813
00:32:33,190 --> 00:32:31,120

tiny area

814

00:32:34,950 --> 00:32:33,200

and instead of revealing a blank sky

815

00:32:37,669 --> 00:32:34,960

with nothing in it what it revealed

816

00:32:39,350 --> 00:32:37,679

actually was thousands and thousands of

817

00:32:40,870 --> 00:32:39,360

galaxies and that's exactly what you're

818

00:32:43,350 --> 00:32:40,880

seeing here over here there are

819

00:32:45,750 --> 00:32:43,360

virtually no stars whatsoever what

820

00:32:48,230 --> 00:32:45,760

you're seeing are all galaxies

821

00:32:49,269 --> 00:32:48,240

approximately ten thousand uh in this

822

00:32:51,430 --> 00:32:49,279

image

823

00:32:53,269 --> 00:32:51,440

and if you use this so-called dropout

824

00:32:55,669 --> 00:32:53,279

technique then looking at the different

825

00:32:57,430 --> 00:32:55,679

images uh taken with the with the hubble

826

00:33:00,630 --> 00:32:57,440

space telescope over this area of the

827

00:33:03,430 --> 00:33:00,640

sky uh team uh revealed lots of

828

00:33:05,350 --> 00:33:03,440

different uh young galaxy candidates

829

00:33:07,830 --> 00:33:05,360

which were extremely far away

830

00:33:10,230 --> 00:33:07,840

approximately a few hundred million

831

00:33:12,870 --> 00:33:10,240

years after the big bang and you can see

832

00:33:15,909 --> 00:33:12,880

that they only resemble these sort of

833

00:33:17,509 --> 00:33:15,919

glob-like uh objects

834

00:33:20,070 --> 00:33:17,519

they don't appear to have very much

835

00:33:22,070 --> 00:33:20,080

structure again the red

836

00:33:24,870 --> 00:33:22,080

is not what they look like intrinsically

837

00:33:28,070 --> 00:33:24,880

this is just an artifact of of what what

838

00:33:28,440 --> 00:33:28,080

they of how we image them

839

00:33:30,630 --> 00:33:28,450

um

840

00:33:32,310 --> 00:33:30,640

[Music]

841

00:33:34,310 --> 00:33:32,320

and you can see that there are quite a

842

00:33:36,389 --> 00:33:34,320

few of them a lot more than one

843

00:33:40,549 --> 00:33:36,399

initially anticipated

844

00:33:43,110 --> 00:33:40,559

uh however again this is these redshifts

845

00:33:45,590 --> 00:33:43,120

are only approximate uh values they are

846

00:33:49,430 --> 00:33:45,600

approximate distances what really we

847

00:33:52,789 --> 00:33:49,440

need is spectroscopy so spectroscopy is

848

00:33:55,029 --> 00:33:52,799

the act of splitting up the lights over

849

00:33:57,350 --> 00:33:55,039

a finer wavelength grid so that we can

850

00:33:59,669 --> 00:33:57,360

really identify signatures within a

851

00:34:02,149 --> 00:33:59,679

spectrum rather than over a coarse

852

00:34:04,070 --> 00:34:02,159

wavelength grid that is given by

853

00:34:06,950 --> 00:34:04,080

imaging capabilities and what i mean by

854

00:34:11,909 --> 00:34:06,960

that is an example over here so the top

855

00:34:13,669 --> 00:34:11,919

you have um a galaxy spectrum not at

856

00:34:16,230 --> 00:34:13,679

the redshifts we're talking about of

857

00:34:18,869 --> 00:34:16,240

redshift 7 then above or so

858

00:34:20,550 --> 00:34:18,879

this is roughly redshifts of 2 which is

859

00:34:21,990 --> 00:34:20,560

still about half of the age of the

860

00:34:24,069 --> 00:34:22,000

universe or so

861

00:34:25,030 --> 00:34:24,079

at the top you can see

862

00:34:27,270 --> 00:34:25,040

these

863

00:34:29,109 --> 00:34:27,280

2d spectra taken with the keck

864

00:34:31,190 --> 00:34:29,119

telescopes on top of warner care in

865

00:34:34,629 --> 00:34:31,200

hawaii and these bright points

866

00:34:38,710 --> 00:34:34,639

correspond to emission lines so

867

00:34:41,510 --> 00:34:38,720

we are no longer looking at uh this uh

868

00:34:43,750 --> 00:34:41,520

this lyman break which covers a very

869

00:34:45,990 --> 00:34:43,760

coarse grid and this approximate

870

00:34:48,550 --> 00:34:46,000

distance but now we are pinpointing the

871

00:34:51,430 --> 00:34:48,560

distances with these very characteristic

872

00:34:54,310 --> 00:34:51,440

features uh from gas within the galaxies

873

00:34:56,629 --> 00:34:54,320

such as oxygen over here or hydrogen or

874

00:34:58,390 --> 00:34:56,639

nitrogen or sulfur for instance so it's

875

00:35:00,390 --> 00:34:58,400

a much more precise

876

00:35:03,190 --> 00:35:00,400

technique to try and pinpoint the

877

00:35:05,030 --> 00:35:03,200

distance of the galaxy however as we

878

00:35:06,710 --> 00:35:05,040

mentioned these galaxies are redshifted

879

00:35:09,270 --> 00:35:06,720

so a lot of these features when they're

880

00:35:12,950 --> 00:35:09,280

very very distant uh end up being

881

00:35:16,710 --> 00:35:12,960

outside of our telescope capabilities

882

00:35:19,190 --> 00:35:16,720

one emission line which still is visible

883

00:35:21,109 --> 00:35:19,200

from our telescopes on the ground is

884

00:35:23,109 --> 00:35:21,119

called the lyman alpha line and that's

885

00:35:25,750 --> 00:35:23,119

what you see at the bottom here this is

886

00:35:28,150 --> 00:35:25,760

a distant galaxy at a redshift of six

887

00:35:29,510 --> 00:35:28,160

approximately um so these distant

888

00:35:31,510 --> 00:35:29,520

galaxies that we're trying to look for

889

00:35:35,270 --> 00:35:31,520

at redshift 7 and above generally

890

00:35:37,670 --> 00:35:35,280

speaking and you can see this much finer

891

00:35:39,349 --> 00:35:37,680

grid of wavelengths if you want the

892

00:35:41,829 --> 00:35:39,359

y-axis shows the brightness of the

893

00:35:42,950 --> 00:35:41,839

galaxy the x-axis shows the wavelength

894

00:35:45,190 --> 00:35:42,960

and again you can see this

895

00:35:46,950 --> 00:35:45,200

characteristic drop that we were talking

896

00:35:49,990 --> 00:35:46,960

about which we look at with

897

00:35:52,950 --> 00:35:50,000

imaging but you can also see this larger

898

00:35:55,270 --> 00:35:52,960

peak over here and this peak is

899

00:35:57,510 --> 00:35:55,280

emission that comes from

900

00:36:00,550 --> 00:35:57,520

hydrogen this emission generally

901
00:36:02,150 --> 00:36:00,560
speaking however is uh occulted by the

902
00:36:04,790 --> 00:36:02,160
hydrogen along the line of site it's

903
00:36:07,430 --> 00:36:04,800
absorbed so the galaxies that reside

904
00:36:10,310 --> 00:36:07,440
within this hydrogen fog we typically

905
00:36:12,230 --> 00:36:10,320
don't expect to see this line however it

906
00:36:13,670 --> 00:36:12,240
is one of the only lines that we can

907
00:36:15,990 --> 00:36:13,680
look for for these ultra distant

908
00:36:18,310 --> 00:36:16,000
galaxies because they are at such high

909
00:36:21,349 --> 00:36:18,320
redshifts uh and we have to consider the

910
00:36:23,109 --> 00:36:21,359
capabilities of our telescopes

911
00:36:23,910 --> 00:36:23,119
so it's a little bit like trying to look

912
00:36:26,790 --> 00:36:23,920
for

913
00:36:29,589 --> 00:36:26,800

uh you know car headlights uh in a fog

914

00:36:32,310 --> 00:36:29,599

from uh you know the us and europe it's

915

00:36:34,710 --> 00:36:32,320

not exactly easy but this is what we try

916

00:36:39,670 --> 00:36:37,109

so we set out to try and confirm the

917

00:36:40,950 --> 00:36:39,680

distances in this way with the keck

918

00:36:43,030 --> 00:36:40,960

telescope

919

00:36:45,109 --> 00:36:43,040

about five-ish years ago

920

00:36:48,790 --> 00:36:45,119

we looked for the most distant galaxies

921

00:36:51,190 --> 00:36:48,800

we could possibly find at the time over

922

00:36:53,190 --> 00:36:51,200

what we call the candles fields the

923

00:36:55,349 --> 00:36:53,200

candles fields are

924

00:36:57,349 --> 00:36:55,359

different portions of the sky taken with

925

00:36:59,430 --> 00:36:57,359

deep hubble imaging you can see them

926
00:37:01,990 --> 00:36:59,440
here at the bottom right this schematic

927
00:37:03,589 --> 00:37:02,000
over here shows you the patches of um of

928
00:37:05,349 --> 00:37:03,599
the sky image with

929
00:37:07,190 --> 00:37:05,359
with the hubble space telescope and

930
00:37:09,190 --> 00:37:07,200
their size is relative to the moon so

931
00:37:11,349 --> 00:37:09,200
you can see it's a very small area of

932
00:37:13,589 --> 00:37:11,359
the sky but they are especially deep

933
00:37:15,829 --> 00:37:13,599
images so they're taken with very long

934
00:37:17,910 --> 00:37:15,839
exposures to try and find

935
00:37:20,630 --> 00:37:17,920
not just bright galaxies but also very

936
00:37:22,150 --> 00:37:20,640
fainter galaxies

937
00:37:23,430 --> 00:37:22,160
and so we used these fields that we

938
00:37:25,670 --> 00:37:23,440

tried to look for the most distant

939

00:37:28,550 --> 00:37:25,680

galaxies we could and lo and behold we

940

00:37:31,270 --> 00:37:28,560

found four galaxies using this so-called

941

00:37:32,790 --> 00:37:31,280

dropout technique um

942

00:37:34,630 --> 00:37:32,800

which suggested they would be at

943

00:37:36,550 --> 00:37:34,640

redshifts greater than seven greater

944

00:37:39,510 --> 00:37:36,560

than seven corresponds to just a few

945

00:37:41,829 --> 00:37:39,520

hundred million years after the big bang

946

00:37:43,910 --> 00:37:41,839

however these only remain candidates as

947

00:37:46,069 --> 00:37:43,920

long as they haven't been confirmed with

948

00:37:48,390 --> 00:37:46,079

spectroscopy with a spectrum looking for

949

00:37:50,630 --> 00:37:48,400

that signature lyman alpha line that

950

00:37:53,510 --> 00:37:50,640

comes from these star-forming

951
00:37:55,589 --> 00:37:53,520
galaxies and lo and behold we went out

952
00:37:58,310 --> 00:37:55,599
and we managed to find

953
00:38:00,390 --> 00:37:58,320
lyman alpha this small peak as you can

954
00:38:03,430 --> 00:38:00,400
see here in each of these four galaxies

955
00:38:05,030 --> 00:38:03,440
these spectra over here correspond to

956
00:38:05,910 --> 00:38:05,040
each of these four galaxies and at the

957
00:38:08,150 --> 00:38:05,920
time

958
00:38:09,670 --> 00:38:08,160
two of these broke the distance records

959
00:38:13,510 --> 00:38:09,680
for galaxies

960
00:38:15,829 --> 00:38:13,520
at redshifts of uh 7.7 and 8.6 so these

961
00:38:18,870 --> 00:38:15,839
were the most distant galaxies that we

962
00:38:21,750 --> 00:38:18,880
knew of at the time so four in total

963
00:38:23,990 --> 00:38:21,760

about five hours or more of spectroscopy

964

00:38:26,550 --> 00:38:24,000

with keck and four out of four of these

965

00:38:29,510 --> 00:38:26,560

show uh this lyman alpha line which

966

00:38:32,630 --> 00:38:29,520

suggests that there's no more hydrogen

967

00:38:34,390 --> 00:38:32,640

around these galaxies blocking that uv

968

00:38:36,950 --> 00:38:34,400

light

969

00:38:39,829 --> 00:38:36,960

we ended up taking this uh a little bit

970

00:38:42,230 --> 00:38:39,839

further however there was another galaxy

971

00:38:43,510 --> 00:38:42,240

called jd1 unfortunately we're not that

972

00:38:46,630 --> 00:38:43,520

inventive with

973

00:38:50,069 --> 00:38:46,640

names in astronomy jd1 is a galaxy that

974

00:38:51,750 --> 00:38:50,079

we thought was a redshift of nine or so

975

00:38:54,470 --> 00:38:51,760

you can you can see over here the

976

00:38:56,390 --> 00:38:54,480

postage stamps uh taken with the hubble

977

00:38:58,550 --> 00:38:56,400

space telescope again this drop out

978

00:39:00,950 --> 00:38:58,560

technique if you look at the red circle

979

00:39:03,430 --> 00:39:00,960

you can see that at infrared wavelengths

980

00:39:06,630 --> 00:39:03,440

the galaxy is very clear but then at

981

00:39:09,109 --> 00:39:06,640

optical wavelengths the galaxy drops out

982

00:39:10,030 --> 00:39:09,119

and it's because it drops out between

983

00:39:13,829 --> 00:39:10,040

this

984

00:39:18,069 --> 00:39:13,839

f105w and f125w which corresponds to

985

00:39:20,470 --> 00:39:18,079

about 1.05 and 1.25 microns that tells

986

00:39:23,270 --> 00:39:20,480

us that this characteristic break should

987

00:39:25,510 --> 00:39:23,280

be somewhere around here but because the

988

00:39:27,270 --> 00:39:25,520

imaging filters are very broad we don't

989

00:39:30,710 --> 00:39:27,280

know exactly where

990

00:39:33,109 --> 00:39:30,720

so we then set out on arduous journey to

991

00:39:36,230 --> 00:39:33,119

try and confirm uh the distance to this

992

00:39:39,109 --> 00:39:36,240

galaxy via spectroscopy

993

00:39:41,030 --> 00:39:39,119

myself and my two collaborators uh

994

00:39:43,030 --> 00:39:41,040

richard ellis and nicola lapocz at the

995

00:39:44,870 --> 00:39:43,040

time at university college london we

996

00:39:47,750 --> 00:39:44,880

went to the very large telescope in

997

00:39:50,069 --> 00:39:47,760

chile and we looked at this galaxy with

998

00:39:52,069 --> 00:39:50,079

more than eight hours uh with some of

999

00:39:55,750 --> 00:39:52,079

the world's foremost telescopes trying

1000

00:39:57,990 --> 00:39:55,760

to look for this lyman alpha line and lo

1001
00:39:59,990 --> 00:39:58,000
and behold we found this line as you can

1002
00:40:04,309 --> 00:40:00,000
see on the left this fairly clear line

1003
00:40:05,430 --> 00:40:04,319
which indicated a redshift of 9.1 or so

1004
00:40:08,470 --> 00:40:05,440
um

1005
00:40:10,630 --> 00:40:08,480
thereby confirming this galaxy as an

1006
00:40:12,390 --> 00:40:10,640
ultra distant galaxy

1007
00:40:14,550 --> 00:40:12,400
at the same time

1008
00:40:17,270 --> 00:40:14,560
our collaborators in japan had used the

1009
00:40:19,510 --> 00:40:17,280
alma telescope to look for a prominent

1010
00:40:21,430 --> 00:40:19,520
oxygen line which they found then on the

1011
00:40:24,550 --> 00:40:21,440
right suggesting that

1012
00:40:26,710 --> 00:40:24,560
this galaxy was actually quite young and

1013
00:40:29,109 --> 00:40:26,720

not only that but confirming the

1014

00:40:32,630 --> 00:40:29,119

redshifts fairly precisely so the oxygen

1015

00:40:36,069 --> 00:40:32,640

suggests that some young stars are

1016

00:40:37,670 --> 00:40:36,079

ionizing the oxygen around it

1017

00:40:40,630 --> 00:40:37,680

so at the time then this was the most

1018

00:40:43,349 --> 00:40:40,640

distant galaxy that we knew of which we

1019

00:40:46,309 --> 00:40:43,359

published this paper in 2018.

1020

00:40:48,230 --> 00:40:46,319

however that was not the end of uh this

1021

00:40:49,750 --> 00:40:48,240

story in terms of confirming the most

1022

00:40:53,910 --> 00:40:49,760

distant galaxies

1023

00:40:56,069 --> 00:40:53,920

um later on in about 2009 the hubble

1024

00:40:57,109 --> 00:40:56,079

ultra deep field infrared was combined

1025

00:40:59,670 --> 00:40:57,119

with the

1026
00:41:01,829 --> 00:40:59,680
optical data from the hubble ultra deep

1027
00:41:04,069 --> 00:41:01,839
field so now we're combining

1028
00:41:06,470 --> 00:41:04,079
infrared data from

1029
00:41:08,630 --> 00:41:06,480
hubble's flagship instrument the wide

1030
00:41:09,910 --> 00:41:08,640
field camera 3 which is an infrared

1031
00:41:11,030 --> 00:41:09,920
instrument

1032
00:41:13,829 --> 00:41:11,040
with the

1033
00:41:16,790 --> 00:41:13,839
bluer wavelengths of the optical filters

1034
00:41:19,109 --> 00:41:16,800
and hubble then

1035
00:41:21,910 --> 00:41:19,119
the team of observers combined all of

1036
00:41:24,309 --> 00:41:21,920
this data to create this beautiful image

1037
00:41:26,150 --> 00:41:24,319
over here called the extreme deep field

1038
00:41:27,190 --> 00:41:26,160

now just like the hubble ultra deep

1039

00:41:29,270 --> 00:41:27,200

field

1040

00:41:30,150 --> 00:41:29,280

there are virtually no stars in this

1041

00:41:33,589 --> 00:41:30,160

image

1042

00:41:36,950 --> 00:41:33,599

there are about 5 000 galaxies or so a

1043

00:41:39,589 --> 00:41:36,960

lot of them very very distant and uh

1044

00:41:41,589 --> 00:41:39,599

ultimately uh this covers about 30

1045

00:41:44,950 --> 00:41:41,599

millionth of the whole sky so it's a

1046

00:41:47,030 --> 00:41:44,960

tiny tiny portion of the entire sky

1047

00:41:48,950 --> 00:41:47,040

and this uh this team then set out to

1048

00:41:51,270 --> 00:41:48,960

look for these ultra distant galaxies

1049

00:41:54,710 --> 00:41:51,280

once again via this lyman break

1050

00:41:59,349 --> 00:41:57,349

and ended up finding four of these

1051
00:42:00,950 --> 00:41:59,359
galaxies you can see them over here

1052
00:42:02,870 --> 00:42:00,960
again

1053
00:42:05,510 --> 00:42:02,880
like we saw before they're these sort of

1054
00:42:08,309 --> 00:42:05,520
little blobs don't seem particularly

1055
00:42:11,190 --> 00:42:08,319
interesting uh but when you follow these

1056
00:42:13,990 --> 00:42:11,200
up with spectroscopy uh they are quite

1057
00:42:16,710 --> 00:42:14,000
interesting and this team did follow up

1058
00:42:19,190 --> 00:42:16,720
the galaxy this c component galaxy over

1059
00:42:22,390 --> 00:42:19,200
here which they thought was the best

1060
00:42:23,349 --> 00:42:22,400
candidate for a ultra distant galaxy and

1061
00:42:24,950 --> 00:42:23,359
uh

1062
00:42:27,230 --> 00:42:24,960
you can see a zoom in over here it does

1063
00:42:30,790 --> 00:42:27,240

not have a particularly imaginative name

1064

00:42:33,829 --> 00:42:30,800

gnz11 suggests that this galaxy might be

1065

00:42:35,829 --> 00:42:33,839

at a redshift of 10 or so and the team

1066

00:42:37,910 --> 00:42:35,839

went out then with the hubble space

1067

00:42:39,829 --> 00:42:37,920

telescope to get a spectrum not just

1068

00:42:42,069 --> 00:42:39,839

images but a spectrum

1069

00:42:43,190 --> 00:42:42,079

and this is what they found and you can

1070

00:42:44,870 --> 00:42:43,200

see that it's

1071

00:42:46,230 --> 00:42:44,880

first thing you might you might take

1072

00:42:48,550 --> 00:42:46,240

away from this image is that it's

1073

00:42:50,630 --> 00:42:48,560

actually very very challenging to get a

1074

00:42:53,829 --> 00:42:50,640

spectrum of these sort of galaxies and

1075

00:42:56,150 --> 00:42:53,839

to confirm their distances however this

1076

00:42:57,750 --> 00:42:56,160

also might remind you of

1077

00:43:00,630 --> 00:42:57,760

the spectrum that you saw before where

1078

00:43:02,630 --> 00:43:00,640

you see this characteristic break again

1079

00:43:05,670 --> 00:43:02,640

and this break over here tells you that

1080

00:43:09,270 --> 00:43:05,680

this galaxy actually is at a redshift of

1081

00:43:12,069 --> 00:43:09,280

11. so this corresponds roughly of about

1082

00:43:15,349 --> 00:43:12,079

400 million years after the big bang we

1083

00:43:19,270 --> 00:43:15,359

are now probing about 96

1084

00:43:24,309 --> 00:43:21,910

so can we perhaps age date these

1085

00:43:26,390 --> 00:43:24,319

galaxies now that we've confirmed uh

1086

00:43:28,230 --> 00:43:26,400

that they are ultra distant galaxies can

1087

00:43:30,230 --> 00:43:28,240

we perhaps say something about them

1088

00:43:32,550 --> 00:43:30,240

about their properties for instance how

1089

00:43:36,150 --> 00:43:32,560

old are their stars

1090

00:43:38,790 --> 00:43:36,160

uh the answer is in parts uh so if you

1091

00:43:41,270 --> 00:43:38,800

look at the light distribution of a

1092

00:43:44,069 --> 00:43:41,280

galaxy here in blue you can see that

1093

00:43:46,870 --> 00:43:44,079

this is matched by the brightness that's

1094

00:43:49,109 --> 00:43:46,880

measured in the hubble filters and again

1095

00:43:50,790 --> 00:43:49,119

you can see this characteristic break

1096

00:43:53,190 --> 00:43:50,800

now we know that

1097

00:43:55,270 --> 00:43:53,200

this imaging is influenced by the

1098

00:43:58,390 --> 00:43:55,280

intrinsic properties of the galaxies as

1099

00:44:00,550 --> 00:43:58,400

well as the gas that resides around the

1100

00:44:02,470 --> 00:44:00,560

galaxy itself so the gas that resides

1101

00:44:05,349 --> 00:44:02,480

around the galaxy itself gives rise to

1102

00:44:08,710 --> 00:44:05,359

this characteristic drop but at the same

1103

00:44:10,390 --> 00:44:08,720

time you might see that this um

1104

00:44:12,550 --> 00:44:10,400

that this point over here on the far

1105

00:44:14,710 --> 00:44:12,560

right seems boosted relative to the

1106

00:44:18,309 --> 00:44:14,720

others that means that the galaxy is far

1107

00:44:20,069 --> 00:44:18,319

brighter in this particular filter uh

1108

00:44:21,670 --> 00:44:20,079

than it is in any of the others these

1109

00:44:23,589 --> 00:44:21,680

last two filters by the way come from

1110

00:44:26,309 --> 00:44:23,599

the spitzer space telescope so here

1111

00:44:28,390 --> 00:44:26,319

we're combining hubble with spitzer

1112

00:44:30,390 --> 00:44:28,400

so this tells us something about the

1113

00:44:32,710 --> 00:44:30,400

underlying properties of the galaxies

1114

00:44:35,109 --> 00:44:32,720

and actually what this is telling us is

1115

00:44:37,349 --> 00:44:35,119

that this galaxy has very intense

1116

00:44:39,430 --> 00:44:37,359

nebular emission lines from oxygen so

1117

00:44:41,589 --> 00:44:39,440

it's saying that there are young stars

1118

00:44:44,390 --> 00:44:41,599

there prominent young stars that are

1119

00:44:47,430 --> 00:44:44,400

ionizing the oxygen around us in a crazy

1120

00:44:50,550 --> 00:44:47,440

fashion and uh this is giving rise to

1121

00:44:52,710 --> 00:44:50,560

this boosting of galaxy light in this

1122

00:44:54,710 --> 00:44:52,720

particular filter so we can try and

1123

00:44:57,190 --> 00:44:54,720

estimate them the ages of these young

1124

00:44:59,829 --> 00:44:57,200

stars via these lines

1125

00:45:02,069 --> 00:44:59,839

however this is not the only source for

1126

00:45:03,829 --> 00:45:02,079

this apparent boosting of

1127

00:45:06,470 --> 00:45:03,839

the light in this filter compared to the

1128

00:45:09,030 --> 00:45:06,480

others another one is what we call the

1129

00:45:11,990 --> 00:45:09,040

bomber break so the bomber break is

1130

00:45:13,829 --> 00:45:12,000

another one of these drops in brightness

1131

00:45:16,069 --> 00:45:13,839

that you can see over here these are

1132

00:45:18,390 --> 00:45:16,079

this is the spectrum of a galaxy at

1133

00:45:21,589 --> 00:45:18,400

different ages 20 million years followed

1134

00:45:24,230 --> 00:45:21,599

by 50 million years 100 and 500 million

1135

00:45:26,550 --> 00:45:24,240

years and you can see that clearly as a

1136

00:45:28,550 --> 00:45:26,560

function of age this drop becomes much

1137

00:45:30,630 --> 00:45:28,560

more prominent so what's happening over

1138

00:45:32,790 --> 00:45:30,640

here is that as a star gets older the

1139

00:45:35,829 --> 00:45:32,800

atmospheres of these stars are absorbing

1140

00:45:39,030 --> 00:45:35,839

the metals that are here and so that

1141

00:45:41,670 --> 00:45:39,040

absorption of the lights causes uh this

1142

00:45:44,230 --> 00:45:41,680

um this dipping of the flux over here

1143

00:45:46,309 --> 00:45:44,240

and if we're to over plot let's say all

1144

00:45:47,910 --> 00:45:46,319

the points that you see on the left over

1145

00:45:50,150 --> 00:45:47,920

here

1146

00:45:51,670 --> 00:45:50,160

you see that it gives actually uh more

1147

00:45:54,630 --> 00:45:51,680

or less the same

1148

00:45:57,829 --> 00:45:54,640

profile the same shape so one can ask

1149

00:45:59,349 --> 00:45:57,839

then if we take this this

1150

00:46:01,670 --> 00:45:59,359

distribution of light from the hubble

1151
00:46:03,910 --> 00:46:01,680
and spitzer space telescopes can we age

1152
00:46:06,550 --> 00:46:03,920
date the galaxies can we age date the

1153
00:46:09,910 --> 00:46:06,560
stars that are within these galaxies

1154
00:46:12,069 --> 00:46:09,920
so coming back to jd1 this galaxy that

1155
00:46:14,790 --> 00:46:12,079
we had looked at with

1156
00:46:17,670 --> 00:46:14,800
the vlt and with alma now that we have a

1157
00:46:20,630 --> 00:46:17,680
secure redshift we can actually map out

1158
00:46:23,030 --> 00:46:20,640
the underlying properties of

1159
00:46:25,349 --> 00:46:23,040
that galaxy and over here you can see

1160
00:46:27,270 --> 00:46:25,359
the total light profile in red

1161
00:46:30,069 --> 00:46:27,280
you can see this particular jump over

1162
00:46:32,630 --> 00:46:30,079
here and this jump can only be explained

1163
00:46:34,950 --> 00:46:32,640

if you uh if you have this young

1164

00:46:37,190 --> 00:46:34,960

component over here in blue as well as

1165

00:46:39,910 --> 00:46:37,200

this older component from more mature

1166

00:46:42,150 --> 00:46:39,920

stars that are not just a few tens of

1167

00:46:43,589 --> 00:46:42,160

millions of years old but a few hundred

1168

00:46:46,470 --> 00:46:43,599

million years old

1169

00:46:48,470 --> 00:46:46,480

and uh so we conducted a search for more

1170

00:46:51,030 --> 00:46:48,480

galaxies like this we found three of

1171

00:46:52,790 --> 00:46:51,040

them you can see similar uh sort of

1172

00:46:55,430 --> 00:46:52,800

technique similar analysis and you can

1173

00:46:57,270 --> 00:46:55,440

see that in each of these cases you are

1174

00:46:58,950 --> 00:46:57,280

seeing this jump between the last two

1175

00:47:02,069 --> 00:46:58,960

points and that jump can only be

1176

00:47:03,030 --> 00:47:02,079

explained by the presence of more mature

1177

00:47:05,109 --> 00:47:03,040

stars

1178

00:47:07,589 --> 00:47:05,119

but galaxies in general are expected to

1179

00:47:09,510 --> 00:47:07,599

be quite young they haven't had a

1180

00:47:12,230 --> 00:47:09,520

ton of time to evolve in the early

1181

00:47:13,750 --> 00:47:12,240

universe so do we expect these more

1182

00:47:15,589 --> 00:47:13,760

mature stars

1183

00:47:17,750 --> 00:47:15,599

or are these sort of flukes are they

1184

00:47:18,870 --> 00:47:17,760

representative of the

1185

00:47:21,510 --> 00:47:18,880

normal

1186

00:47:23,750 --> 00:47:21,520

star-forming population or not that

1187

00:47:25,109 --> 00:47:23,760

remains to be seen

1188

00:47:27,190 --> 00:47:25,119

we can then ask ourselves do the

1189

00:47:29,190 --> 00:47:27,200

earliest galaxies already have black

1190

00:47:32,630 --> 00:47:29,200

supermassive black holes in the local

1191

00:47:35,190 --> 00:47:32,640

universe we know uh we know that um most

1192

00:47:37,190 --> 00:47:35,200

galaxies host a supermassive black hole

1193

00:47:39,829 --> 00:47:37,200

uh and that this supermassive black hole

1194

00:47:42,950 --> 00:47:39,839

evolves as a galaxy evolves as well but

1195

00:47:44,470 --> 00:47:42,960

it's unclear when they started to form

1196

00:47:46,790 --> 00:47:44,480

so the way that we can look for this

1197

00:47:49,589 --> 00:47:46,800

again is with spectroscopy where we try

1198

00:47:52,549 --> 00:47:49,599

and find emission lines that

1199

00:47:54,230 --> 00:47:52,559

cannot be ionized by from the radiation

1200

00:47:56,710 --> 00:47:54,240

of regular stars they need something

1201

00:47:58,870 --> 00:47:56,720

more potent more powerful like a

1202

00:48:01,349 --> 00:47:58,880

supermassive black hole and some of

1203

00:48:03,910 --> 00:48:01,359

these lines include helium-2 for

1204

00:48:06,390 --> 00:48:03,920

instance so these are two examples uh

1205

00:48:08,470 --> 00:48:06,400

over here where you can see at the

1206

00:48:11,270 --> 00:48:08,480

bottom you see the yellow line this is

1207

00:48:14,710 --> 00:48:11,280

uh the signature of that helium 2 and at

1208

00:48:17,109 --> 00:48:14,720

the top you can see

1209

00:48:23,030 --> 00:48:17,119

uh you can see um

1210

00:48:29,270 --> 00:48:24,870

can you still can you still hear me

1211

00:48:35,109 --> 00:48:31,990

so at the top we can still hear you

1212

00:48:36,150 --> 00:48:35,119

thanks um so at the top of these two

1213

00:48:38,150 --> 00:48:36,160

spectra

1214

00:48:39,910 --> 00:48:38,160

the

1215

00:48:42,390 --> 00:48:39,920

spectra that are taken

1216

00:48:45,190 --> 00:48:42,400

with the vlt and the keck telescopes

1217

00:48:47,589 --> 00:48:45,200

that white dot is what corresponds to

1218

00:48:49,430 --> 00:48:47,599

the emission line at the bottom

1219

00:48:52,069 --> 00:48:49,440

that indicates the presence of a

1220

00:48:53,990 --> 00:48:52,079

supermassive black hole probably at the

1221

00:48:56,230 --> 00:48:54,000

bottom here you see another example this

1222

00:48:59,030 --> 00:48:56,240

is nitrogen five

1223

00:48:59,829 --> 00:48:59,040

another line which is not easily excited

1224

00:49:01,510 --> 00:48:59,839

by

1225

00:49:03,670 --> 00:49:01,520

star forming

1226

00:49:06,390 --> 00:49:03,680

galaxies with just normal stars but it

1227

00:49:09,510 --> 00:49:06,400

needs some extra energetic input so the

1228

00:49:11,190 --> 00:49:09,520

presence of these three lines suggests

1229

00:49:12,630 --> 00:49:11,200

that there might be some other

1230

00:49:15,109 --> 00:49:12,640

contribution

1231

00:49:17,430 --> 00:49:15,119

to ionize these lines other than just

1232

00:49:19,829 --> 00:49:17,440

regular star-forming

1233

00:49:23,190 --> 00:49:19,839

sources more likely supermassive black

1234

00:49:28,150 --> 00:49:25,109

another question then that we can also

1235

00:49:31,589 --> 00:49:28,160

ask is do these galaxies harbor a lot of

1236

00:49:34,309 --> 00:49:31,599

dust so dust is expected to come from

1237

00:49:37,829 --> 00:49:34,319

supernovae which comes from the

1238

00:49:40,470 --> 00:49:37,839

death of massive stars when they explode

1239

00:49:43,190 --> 00:49:40,480

their enriched guts so to speak

1240

00:49:44,710 --> 00:49:43,200

spread form and spread dust as well as

1241

00:49:45,910 --> 00:49:44,720

heavy metals into the interstellar

1242

00:49:48,470 --> 00:49:45,920

medium

1243

00:49:49,750 --> 00:49:48,480

and young galaxies are not expected

1244

00:49:52,309 --> 00:49:49,760

necessarily

1245

00:49:54,470 --> 00:49:52,319

to have copious amounts of dust

1246

00:49:55,589 --> 00:49:54,480

which is indicative of more of a mature

1247

00:49:59,430 --> 00:49:55,599

system

1248

00:50:01,750 --> 00:49:59,440

but nonetheless we set out with

1249

00:50:03,349 --> 00:50:01,760

the alma telescope in chile that's what

1250

00:50:06,309 --> 00:50:03,359

you can see at the bottom right over

1251

00:50:10,390 --> 00:50:06,319

here to try and look for this signature

1252

00:50:12,870 --> 00:50:10,400

of dust alma is a submillimeter

1253

00:50:14,470 --> 00:50:12,880

telescope you can see these arrays over

1254

00:50:16,710 --> 00:50:14,480

here it's characterized by these

1255

00:50:19,190 --> 00:50:16,720

individual arrays which work together to

1256

00:50:21,750 --> 00:50:19,200

create one much more massive uh

1257

00:50:24,470 --> 00:50:21,760

telescope and that's what you can see at

1258

00:50:26,950 --> 00:50:24,480

the top here we did find dust in a very

1259

00:50:29,750 --> 00:50:26,960

distant galaxy galaxy at eight point of

1260

00:50:32,150 --> 00:50:29,760

redshift of 8.4 corresponding to only

1261

00:50:33,990 --> 00:50:32,160

about four percent of the present age of

1262

00:50:36,069 --> 00:50:34,000

the universe and you can see on the left

1263

00:50:38,470 --> 00:50:36,079

this detection here in sort of white and

1264

00:50:40,549 --> 00:50:38,480

green of dust and if you over plot it

1265

00:50:41,829 --> 00:50:40,559

with the hubble image of the telescope

1266

00:50:43,750 --> 00:50:41,839

here on the right you can see that it

1267

00:50:45,349 --> 00:50:43,760

matches up perfectly

1268

00:50:47,589 --> 00:50:45,359

the same thing happens with another

1269

00:50:50,069 --> 00:50:47,599

galaxy at a redshift of eight or so and

1270

00:50:52,470 --> 00:50:50,079

you can see the exact same here at the

1271

00:50:54,390 --> 00:50:52,480

bottom independently verified by a

1272

00:50:58,390 --> 00:50:54,400

different team for another galaxy so it

1273

00:51:00,710 --> 00:50:58,400

seems like perhaps uh early galaxies uh

1274

00:51:03,030 --> 00:51:00,720

have more dust than we initially

1275

00:51:05,109 --> 00:51:03,040

expected so is this more evidence for

1276

00:51:08,790 --> 00:51:05,119

perhaps some sort of mature stellar

1277

00:51:11,270 --> 00:51:08,800

population uh in these galaxies

1278

00:51:13,190 --> 00:51:11,280

it seems ah like it might

1279

00:51:15,510 --> 00:51:13,200

another thing we can see is these

1280

00:51:17,589 --> 00:51:15,520

galaxies when we look at them at uh in

1281

00:51:21,670 --> 00:51:17,599

the local universe appear to have this

1282

00:51:23,270 --> 00:51:21,680

well-defined structure of spiral arms um

1283

00:51:25,670 --> 00:51:23,280

but when we look at more distant

1284

00:51:27,829 --> 00:51:25,680

galaxies they appear to be just blobs

1285

00:51:30,150 --> 00:51:27,839

they don't appear to have much of a disc

1286

00:51:31,910 --> 00:51:30,160

like structure uh or any kind of

1287

00:51:34,470 --> 00:51:31,920

rotation they're more dominated by

1288

00:51:36,790 --> 00:51:34,480

mergers galaxies colliding together this

1289

00:51:39,030 --> 00:51:36,800

sort of thing and if we take our

1290

00:51:40,790 --> 00:51:39,040

telescopes and we point several times at

1291

00:51:42,790 --> 00:51:40,800

different portions of the galaxy we can

1292

00:51:44,870 --> 00:51:42,800

get an emission line that looks like

1293

00:51:47,670 --> 00:51:44,880

this on the right you can see this peak

1294

00:51:50,390 --> 00:51:47,680

and that then tells us the redshift of

1295

00:51:52,470 --> 00:51:50,400

the galaxy at different parts of it

1296

00:51:53,750 --> 00:51:52,480

essentially now when we look at the

1297

00:51:57,030 --> 00:51:53,760

differences

1298

00:52:00,870 --> 00:51:57,040

um in the position of those lines across

1299

00:52:03,190 --> 00:52:00,880

the galaxy we can see whether the stars

1300

00:52:04,630 --> 00:52:03,200

and the or the gas in that galaxy is

1301
00:52:07,030 --> 00:52:04,640
moving in some way and for these

1302
00:52:08,870 --> 00:52:07,040
galaxies we might expect random motion

1303
00:52:10,630 --> 00:52:08,880
but we actually don't so what you see

1304
00:52:13,270 --> 00:52:10,640
over here each pixel

1305
00:52:15,190 --> 00:52:13,280
has a red shift measured and if it's red

1306
00:52:16,710 --> 00:52:15,200
it's going away from us whilst if it's

1307
00:52:19,270 --> 00:52:16,720
blue it's coming towards us and you can

1308
00:52:21,829 --> 00:52:19,280
see this very clear gradient in both of

1309
00:52:24,549 --> 00:52:21,839
these cases which suggests some clear

1310
00:52:27,190 --> 00:52:24,559
rotation of the galaxy not this kind of

1311
00:52:29,430 --> 00:52:27,200
turbulent motion which you might expect

1312
00:52:31,270 --> 00:52:29,440
if the galaxy didn't have a disk and

1313
00:52:33,750 --> 00:52:31,280

coming back to jd1 this very distant

1314

00:52:36,230 --> 00:52:33,760

galaxy that has mature stars you again

1315

00:52:37,910 --> 00:52:36,240

see this gradient over here so that begs

1316

00:52:40,390 --> 00:52:37,920

the question you know are galaxies all

1317

00:52:43,430 --> 00:52:40,400

really really young or actually do they

1318

00:52:45,109 --> 00:52:43,440

have some kind of structure um you know

1319

00:52:47,829 --> 00:52:45,119

are they really just small galaxies that

1320

00:52:49,430 --> 00:52:47,839

they may be a bit more massive they also

1321

00:52:51,109 --> 00:52:49,440

have young stars but they also have

1322

00:52:53,109 --> 00:52:51,119

older stars as well

1323

00:52:55,190 --> 00:52:53,119

they appear to have dust in them which

1324

00:52:57,510 --> 00:52:55,200

we wouldn't necessarily expect for very

1325

00:52:59,670 --> 00:52:57,520

young galaxies they also appear to have

1326
00:53:01,349 --> 00:52:59,680
signatures of supermassive black holes

1327
00:53:02,150 --> 00:53:01,359
and ultimately some disk structure as

1328
00:53:04,150 --> 00:53:02,160
well

1329
00:53:06,230 --> 00:53:04,160
but we've sort of reached now the limit

1330
00:53:09,510 --> 00:53:06,240
of what we can do with the hubble space

1331
00:53:12,549 --> 00:53:09,520
telescope and with spectroscopy from the

1332
00:53:16,230 --> 00:53:12,559
ground the reason for this is hubble uh

1333
00:53:19,349 --> 00:53:16,240
only probes up to about 1.6 microns

1334
00:53:20,549 --> 00:53:19,359
in its imaging capabilities and distant

1335
00:53:22,309 --> 00:53:20,559
galaxies

1336
00:53:23,990 --> 00:53:22,319
emits the majority of their light and

1337
00:53:25,510 --> 00:53:24,000
the majority of signatures from their

1338
00:53:27,510 --> 00:53:25,520

stars and their gas

1339

00:53:29,430 --> 00:53:27,520

at even longer wavelengths in what we

1340

00:53:31,510 --> 00:53:29,440

call the rest frame optical so hubble

1341

00:53:34,790 --> 00:53:31,520

can't probe galaxies further than it

1342

00:53:37,030 --> 00:53:34,800

currently is at redshifts of 10 or so

1343

00:53:39,190 --> 00:53:37,040

on the ground if we look at if we try

1344

00:53:42,549 --> 00:53:39,200

and get spectroscopy with infrared

1345

00:53:44,790 --> 00:53:42,559

telescopes we only probe uh about

1346

00:53:48,710 --> 00:53:44,800

up to about one to two microns or so but

1347

00:53:51,190 --> 00:53:48,720

we are uh affected strongly by

1348

00:53:53,430 --> 00:53:51,200

the atmosphere with of the earth which

1349

00:53:55,990 --> 00:53:53,440

is blocking a lot of the infrared light

1350

00:53:59,510 --> 00:53:56,000

so there is a need then for space-based

1351
00:54:01,109 --> 00:53:59,520
spectroscopy in the infrared um and lo

1352
00:54:01,990 --> 00:54:01,119
and behold then that

1353
00:54:04,309 --> 00:54:02,000
is

1354
00:54:05,589 --> 00:54:04,319
where the james webb space telescope

1355
00:54:07,750 --> 00:54:05,599
then um

1356
00:54:08,829 --> 00:54:07,760
comes into play so

1357
00:54:14,710 --> 00:54:08,839
uh

1358
00:54:16,950 --> 00:54:14,720
telescope is a much larger telescope

1359
00:54:18,710 --> 00:54:16,960
than the hubble space telescope um

1360
00:54:20,230 --> 00:54:18,720
created with 18 different mirror

1361
00:54:22,230 --> 00:54:20,240
segments as you can see in this little

1362
00:54:24,950 --> 00:54:22,240
movie over here the

1363
00:54:27,990 --> 00:54:24,960

uh the

1364

00:54:30,710 --> 00:54:28,000

mirror segments are protected by a five

1365

00:54:33,349 --> 00:54:30,720

layered heat shield uh the james webb

1366

00:54:35,990 --> 00:54:33,359

space telescope because it looks in the

1367

00:54:39,670 --> 00:54:36,000

infrared wavelengths has to be protected

1368

00:54:41,589 --> 00:54:39,680

by all sources of uh infrared radiation

1369

00:54:43,109 --> 00:54:41,599

including from the sun and including

1370

00:54:45,910 --> 00:54:43,119

from the earth because if you're trying

1371

00:54:47,829 --> 00:54:45,920

to look for extremely distant sources uh

1372

00:54:49,910 --> 00:54:47,839

in the early universe in the infrared

1373

00:54:52,069 --> 00:54:49,920

even small bits of infrared light that

1374

00:54:53,510 --> 00:54:52,079

hit the mirror could be interpreted as a

1375

00:54:56,470 --> 00:54:53,520

distant galaxy

1376

00:54:58,309 --> 00:54:56,480

since the web is such a big telescope it

1377

00:55:00,230 --> 00:54:58,319

was folded up as you can see here in

1378

00:55:03,109 --> 00:55:00,240

this little schematic and it was fit

1379

00:55:05,030 --> 00:55:03,119

then at the top of an ariane 5

1380

00:55:06,630 --> 00:55:05,040

rocket this is a european

1381

00:55:08,309 --> 00:55:06,640

rocket and it

1382

00:55:10,870 --> 00:55:08,319

blasted off then

1383

00:55:13,109 --> 00:55:10,880

on christmas last year

1384

00:55:14,710 --> 00:55:13,119

where it then started its one day

1385

00:55:16,789 --> 00:55:14,720

journey up to

1386

00:55:19,270 --> 00:55:16,799

what we call lagrange point two this

1387

00:55:21,589 --> 00:55:19,280

point in space uh where the orbits of

1388

00:55:24,230 --> 00:55:21,599

the planet create an essentially uh

1389

00:55:26,789 --> 00:55:24,240

neutral uh gravitational pull and the

1390

00:55:29,349 --> 00:55:26,799

telescope during its its month-long

1391

00:55:33,430 --> 00:55:29,359

journey to that point unfolded into what

1392

00:55:37,030 --> 00:55:33,440

you can see here uh in the uh video

1393

00:55:39,109 --> 00:55:37,040

uh and then began its six-month uh long

1394

00:55:41,109 --> 00:55:39,119

um commissioning to try and make sure

1395

00:55:42,950 --> 00:55:41,119

that everything had aligned properly

1396

00:55:45,270 --> 00:55:42,960

everything had unfolded properly and all

1397

00:55:46,470 --> 00:55:45,280

of the instruments uh were working uh

1398

00:55:48,950 --> 00:55:46,480

optimally

1399

00:55:51,589 --> 00:55:48,960

so you can see here just a nice

1400

00:55:53,670 --> 00:55:51,599

illustration of just how much bigger the

1401
00:55:56,549 --> 00:55:53,680
james webb space telescope is compared

1402
00:55:59,030 --> 00:55:56,559
to the hubble space telescope it has a

1403
00:56:01,589 --> 00:55:59,040
mirror that is about 6.5 meters in

1404
00:56:03,430 --> 00:56:01,599
diameter compared to hubble's 2.4 and

1405
00:56:06,710 --> 00:56:03,440
this is crucial because it allows for

1406
00:56:10,390 --> 00:56:06,720
about six times more collecting area uh

1407
00:56:12,549 --> 00:56:10,400
to to collect these uh infrared photons

1408
00:56:14,710 --> 00:56:12,559
it has um

1409
00:56:18,069 --> 00:56:14,720
four different primary uh instruments

1410
00:56:19,430 --> 00:56:18,079
over here of which uh we can use uh for

1411
00:56:21,589 --> 00:56:19,440
both um

1412
00:56:24,789 --> 00:56:21,599
uh spectroscopy in the infrared as well

1413
00:56:26,549 --> 00:56:24,799

as imaging in the infrared so to list

1414

00:56:28,549 --> 00:56:26,559

these four over here you can see near

1415

00:56:31,190 --> 00:56:28,559

cam here in the middle where you see

1416

00:56:33,910 --> 00:56:31,200

these uh sort of two larger segments

1417

00:56:36,309 --> 00:56:33,920

which are divided in four this is um

1418

00:56:38,150 --> 00:56:36,319

this is the flagship imager let's say in

1419

00:56:41,190 --> 00:56:38,160

the near in the the

1420

00:56:44,390 --> 00:56:41,200

infrared wavelength um bands from james

1421

00:56:47,750 --> 00:56:44,400

webb it extends what hubble is able to

1422

00:56:50,309 --> 00:56:47,760

see out to about 4.4 microns then we

1423

00:56:52,150 --> 00:56:50,319

have near spec on the left over here

1424

00:56:54,470 --> 00:56:52,160

again four different quadrants but this

1425

00:56:56,950 --> 00:56:54,480

is primarily um

1426

00:56:58,390 --> 00:56:56,960

a multi-object

1427

00:57:00,710 --> 00:56:58,400

spectrograph where

1428

00:57:02,390 --> 00:57:00,720

inside each of these quadrants we can

1429

00:57:04,230 --> 00:57:02,400

put uh

1430

00:57:05,510 --> 00:57:04,240

quite a lot of galaxies hundreds of

1431

00:57:07,829 --> 00:57:05,520

galaxies

1432

00:57:09,270 --> 00:57:07,839

and take a spectrum out from anywhere

1433

00:57:11,910 --> 00:57:09,280

between

1434

00:57:15,349 --> 00:57:11,920

about 0.6 to 5 microns thereby getting

1435

00:57:17,510 --> 00:57:15,359

the full rest frame uv and full and most

1436

00:57:18,630 --> 00:57:17,520

of the rest frame optical of distant

1437

00:57:21,430 --> 00:57:18,640

galaxies

1438

00:57:23,829 --> 00:57:21,440

we also have nearest over here nearest

1439

00:57:26,470 --> 00:57:23,839

is a slitless spectrograph an imager and

1440

00:57:28,549 --> 00:57:26,480

what this means is you don't

1441

00:57:30,870 --> 00:57:28,559

position the spectrograph on a

1442

00:57:32,789 --> 00:57:30,880

particular galaxy you point it at a

1443

00:57:36,230 --> 00:57:32,799

particular point in space and you end up

1444

00:57:38,789 --> 00:57:36,240

getting a spectrum for each object that

1445

00:57:41,670 --> 00:57:38,799

is in that field of view

1446

00:57:44,870 --> 00:57:41,680

last one over here is miri miri

1447

00:57:47,430 --> 00:57:44,880

is a far infrared uh imager and low

1448

00:57:50,150 --> 00:57:47,440

resolution spectrograph it can do these

1449

00:57:53,510 --> 00:57:50,160

it can take images and take spectroscopy

1450

00:57:55,829 --> 00:57:53,520

up from about 5 microns to 25 microns so

1451

00:57:58,309 --> 00:57:55,839

it's really extending everything that

1452

00:58:01,030 --> 00:57:58,319

we've been able to do so far with hubble

1453

00:58:03,109 --> 00:58:01,040

and uh with um

1454

00:58:05,829 --> 00:58:03,119

with our ground-based telescopes like

1455

00:58:06,870 --> 00:58:05,839

keck and the vlt for instance

1456

00:58:09,270 --> 00:58:06,880

and so

1457

00:58:11,910 --> 00:58:09,280

uh this is a nice illustration i think

1458

00:58:14,069 --> 00:58:11,920

what we're able to get now with the

1459

00:58:16,470 --> 00:58:14,079

james webb space telescope since it

1460

00:58:19,270 --> 00:58:16,480

probes these much needed uh infrared

1461

00:58:21,190 --> 00:58:19,280

regions so this is an example spectrum

1462

00:58:24,630 --> 00:58:21,200

of a very distant galaxy a galaxy at

1463

00:58:27,510 --> 00:58:24,640

about redshift 7.5 or so and all of a

1464

00:58:30,069 --> 00:58:27,520

sudden all of these features here which

1465

00:58:32,470 --> 00:58:30,079

we couldn't access before are now

1466

00:58:34,630 --> 00:58:32,480

available to us so we can get

1467

00:58:37,510 --> 00:58:34,640

information about ionized bubbles so

1468

00:58:39,750 --> 00:58:37,520

whether the galaxy has ionized its uh

1469

00:58:42,230 --> 00:58:39,760

immediate surroundings via this lyman

1470

00:58:44,069 --> 00:58:42,240

alpha line and the lyman break which you

1471

00:58:46,789 --> 00:58:44,079

can see over here we can also get

1472

00:58:48,549 --> 00:58:46,799

information whether this galaxy has

1473

00:58:50,789 --> 00:58:48,559

super massive black holes in the middle

1474

00:58:53,349 --> 00:58:50,799

from these high excitation lines like

1475

00:58:55,190 --> 00:58:53,359

helium 2 and nitrogen 5. we can get the

1476

00:58:56,950 --> 00:58:55,200

star formation rates of the galaxies by

1477

00:58:57,990 --> 00:58:56,960

this sort of empty portion of the

1478

00:59:00,470 --> 00:58:58,000

spectrum

1479

00:59:03,190 --> 00:59:00,480

number of ionizing photons the stellar

1480

00:59:05,109 --> 00:59:03,200

ages of these galaxies over here uh

1481

00:59:08,309 --> 00:59:05,119

whether the galaxies harbor heavy metals

1482

00:59:10,069 --> 00:59:08,319

or not and also the stellar masses of

1483

00:59:13,349 --> 00:59:10,079

these galaxies

1484

00:59:14,950 --> 00:59:13,359

um so i was fortunate enough to be at

1485

00:59:17,109 --> 00:59:14,960

the launch of the james webb space

1486

00:59:20,630 --> 00:59:17,119

telescope and on the day

1487

00:59:21,670 --> 00:59:20,640

you go out uh onto this uh platform this

1488

00:59:23,430 --> 00:59:21,680

sort of

1489

00:59:25,190 --> 00:59:23,440

rainy gray day hoping that the launch

1490

00:59:27,349 --> 00:59:25,200

isn't gonna be uh

1491

00:59:30,150 --> 00:59:27,359

scrapped and then you

1492

00:59:32,309 --> 00:59:30,160

uh wait three seconds for that countdown

1493

00:59:35,430 --> 00:59:32,319

and after three seconds you see this

1494

00:59:36,870 --> 00:59:35,440

great big ball of flame emerge from

1495

00:59:38,870 --> 00:59:36,880

the horizon

1496

00:59:40,950 --> 00:59:38,880

you tend to experience a little bit of a

1497

00:59:43,670 --> 00:59:40,960

roller coaster of emotions for many this

1498

00:59:44,390 --> 00:59:43,680

is a lifetime uh of work and dedication

1499

00:59:48,309 --> 00:59:44,400

so

1500

00:59:51,109 --> 00:59:48,319

nervousness

1501
00:59:52,870 --> 00:59:51,119
even fear to a certain degree are all

1502
00:59:55,430 --> 00:59:52,880
very palpable

1503
00:59:57,990 --> 00:59:55,440
and uh the launch only really lasts a

1504
01:00:00,950 --> 00:59:58,000
few seconds

1505
01:00:03,750 --> 01:00:00,960
but the rumble you know of the ariane 5

1506
01:00:06,870 --> 01:00:03,760
rockets really continues uh for minutes

1507
01:00:09,270 --> 01:00:06,880
uh until you know even after the um the

1508
01:00:10,870 --> 01:00:09,280
telescope has or the rocket has uh

1509
01:00:14,390 --> 01:00:10,880
cleared the clouds

1510
01:00:16,710 --> 01:00:14,400
and um once the james webb then arrived

1511
01:00:19,030 --> 01:00:16,720
at its destination and started taking

1512
01:00:21,990 --> 01:00:19,040
images it revealed images that we could

1513
01:00:24,069 --> 01:00:22,000

only dream of this is an image taken a

1514

01:00:25,910 --> 01:00:24,079

test exposure taken with the james webb

1515

01:00:28,309 --> 01:00:25,920

fine guidance sensor so the instrument

1516

01:00:31,349 --> 01:00:28,319

that it uses to make sure it's pointing

1517

01:00:33,270 --> 01:00:31,359

at the right uh area of the sky and it

1518

01:00:36,150 --> 01:00:33,280

became instantly after i think this was

1519

01:00:38,470 --> 01:00:36,160

a 32-hour exposure one of the sharpest

1520

01:00:40,549 --> 01:00:38,480

and one of the deepest infrared images

1521

01:00:43,430 --> 01:00:40,559

uh taken at the time and again you can

1522

01:00:46,549 --> 01:00:43,440

see there are a few stars over here

1523

01:00:48,870 --> 01:00:46,559

but primarily what you see is this

1524

01:00:50,789 --> 01:00:48,880

this sea of galaxies in the background

1525

01:00:53,030 --> 01:00:50,799

of which no doubt there will be some

1526

01:00:55,430 --> 01:00:53,040

extremely distant galaxies and just to

1527

01:00:58,870 --> 01:00:55,440

highlight

1528

01:01:01,109 --> 01:00:58,880

quite starkly i think how the resolution

1529

01:01:03,750 --> 01:01:01,119

of hubble's spatial resolution of

1530

01:01:05,589 --> 01:01:03,760

hubble's capabilities has it has already

1531

01:01:07,270 --> 01:01:05,599

revolutionized sorry of the james webb

1532

01:01:09,589 --> 01:01:07,280

space telescope has already

1533

01:01:11,670 --> 01:01:09,599

revolutionized what we can see on here

1534

01:01:13,589 --> 01:01:11,680

you at the bottom you can see a

1535

01:01:16,470 --> 01:01:13,599

comparison between our previous

1536

01:01:18,630 --> 01:01:16,480

telescopes and james webb miri on the

1537

01:01:20,630 --> 01:01:18,640

right you have spitzer in the middle and

1538

01:01:22,710 --> 01:01:20,640

on the left you have the wise

1539

01:01:24,390 --> 01:01:22,720

telescope and you can see how on the

1540

01:01:26,309 --> 01:01:24,400

left you see a few of the brightest

1541

01:01:28,470 --> 01:01:26,319

sources but there's insufficient

1542

01:01:30,630 --> 01:01:28,480

resolution to um

1543

01:01:32,549 --> 01:01:30,640

to look for anything over there but then

1544

01:01:34,309 --> 01:01:32,559

james webb you get a whole lot more

1545

01:01:37,190 --> 01:01:34,319

detail

1546

01:01:39,190 --> 01:01:37,200

so on july 11th the first science grade

1547

01:01:41,910 --> 01:01:39,200

images were revealed the web's first

1548

01:01:44,950 --> 01:01:41,920

deep field and this image was truly

1549

01:01:47,670 --> 01:01:44,960

stunning about 12.5 hours of near cam

1550

01:01:49,589 --> 01:01:47,680

imaging over a galaxy cluster over here

1551

01:01:52,390 --> 01:01:49,599

you can see these uh

1552

01:01:54,230 --> 01:01:52,400

so-called einstein rings which is

1553

01:01:55,349 --> 01:01:54,240

essentially background galaxies which

1554

01:01:57,510 --> 01:01:55,359

are being

1555

01:02:00,390 --> 01:01:57,520

stretched and amplified due to the

1556

01:02:02,789 --> 01:02:00,400

strong gravitational pull of these

1557

01:02:05,029 --> 01:02:02,799

galaxies here in the middle

1558

01:02:07,349 --> 01:02:05,039

and not only did james webb look with

1559

01:02:09,589 --> 01:02:07,359

neocam it also looked with near spec and

1560

01:02:12,230 --> 01:02:09,599

this highlights exactly what i was

1561

01:02:14,710 --> 01:02:12,240

trying to uh showcase beforehand where

1562

01:02:17,829 --> 01:02:14,720

all of a sudden we now don't rely just

1563

01:02:20,309 --> 01:02:17,839

on this lyman alpha line at about one

1564

01:02:22,309 --> 01:02:20,319

micron or so to confirm the distance of

1565

01:02:24,470 --> 01:02:22,319

these ultra distant galaxies but now

1566

01:02:26,789 --> 01:02:24,480

we're all of a sudden getting oxygen

1567

01:02:29,990 --> 01:02:26,799

hydrogen even neon

1568

01:02:31,589 --> 01:02:30,000

and all of these now serve as indicators

1569

01:02:33,430 --> 01:02:31,599

to confirm the redshifts or the

1570

01:02:35,829 --> 01:02:33,440

distances to these galaxies and tell us

1571

01:02:38,230 --> 01:02:35,839

something about their ages as well as

1572

01:02:40,549 --> 01:02:38,240

the metalistics um you know and a

1573

01:02:42,150 --> 01:02:40,559

plethora of other things and just to

1574

01:02:44,950 --> 01:02:42,160

show you a comparison this is one of the

1575

01:02:47,109 --> 01:02:44,960

best spectra we have of a redshift uh

1576

01:02:49,270 --> 01:02:47,119

eight galaxy so the same redshift as

1577

01:02:51,670 --> 01:02:49,280

this particular galaxy here and you can

1578

01:02:53,990 --> 01:02:51,680

see the difference both in quality and

1579

01:02:56,309 --> 01:02:54,000

in terms of indicators that we get so

1580

01:02:58,150 --> 01:02:56,319

james webb is already blowing things out

1581

01:03:00,870 --> 01:02:58,160

of the water

1582

01:03:04,150 --> 01:03:00,880

so i am part of the

1583

01:03:05,190 --> 01:03:04,160

through the looking glass jwst ers

1584

01:03:09,430 --> 01:03:05,200

program

1585

01:03:13,190 --> 01:03:09,440

first and the deepest extra extra

1586

01:03:15,910 --> 01:03:13,200

galactic data of the entire ers campaign

1587

01:03:17,190 --> 01:03:15,920

the idea is to target another galaxy

1588

01:03:18,950 --> 01:03:17,200

cluster which you can see here on the

1589

01:03:21,190 --> 01:03:18,960

left with nearest and near spec

1590

01:03:24,710 --> 01:03:21,200

spectroscopy um

1591

01:03:26,549 --> 01:03:24,720

as well as near cam imaging of a um of a

1592

01:03:28,789 --> 01:03:26,559

blank field that's offset from this

1593

01:03:30,390 --> 01:03:28,799

galaxy center and we take advantage of

1594

01:03:31,860 --> 01:03:30,400

this effect called

1595

01:03:33,270 --> 01:03:31,870

galaxy lensing

1596

01:03:35,430 --> 01:03:33,280

[Music]

1597

01:03:37,990 --> 01:03:35,440

where we're able to spot ultra distant

1598

01:03:39,910 --> 01:03:38,000

galaxies that are a bit fainter

1599

01:03:42,230 --> 01:03:39,920

this is the data that we got so on the

1600

01:03:44,390 --> 01:03:42,240

left you can see the nearest image where

1601
01:03:46,789 --> 01:03:44,400
everything within the field of view

1602
01:03:49,589 --> 01:03:46,799
we get a spectrum and on the right we

1603
01:03:51,829 --> 01:03:49,599
see the neocam seven um

1604
01:03:53,750 --> 01:03:51,839
seven band image

1605
01:03:56,150 --> 01:03:53,760
compressed together so we have three

1606
01:03:57,990 --> 01:03:56,160
different images uh across wavelengths

1607
01:03:59,270 --> 01:03:58,000
which we've combined

1608
01:04:01,029 --> 01:03:59,280
here on the left

1609
01:04:04,309 --> 01:04:01,039
and then seven different bands for near

1610
01:04:08,150 --> 01:04:06,549
so with 13 hours of nearest we already

1611
01:04:09,829 --> 01:04:08,160
confirmed two of the most distant

1612
01:04:11,990 --> 01:04:09,839
galaxies that we

1613
01:04:14,150 --> 01:04:12,000

currently know of you can see this

1614

01:04:16,309 --> 01:04:14,160

characteristic lineman break once more

1615

01:04:18,309 --> 01:04:16,319

now it's not shown with imaging but it's

1616

01:04:19,990 --> 01:04:18,319

shown with spectra you can see these

1617

01:04:21,829 --> 01:04:20,000

spectra here at the top and then at the

1618

01:04:24,230 --> 01:04:21,839

bottom you see the 1d

1619

01:04:26,069 --> 01:04:24,240

spectrum and you clearly see that break

1620

01:04:28,630 --> 01:04:26,079

and that break once again tells you the

1621

01:04:31,029 --> 01:04:28,640

redshift or the distance to the galaxies

1622

01:04:32,630 --> 01:04:31,039

and at the same time we then did a first

1623

01:04:36,470 --> 01:04:32,640

search for the most distant galaxies we

1624

01:04:38,150 --> 01:04:36,480

could see and we found uh two um

1625

01:04:39,910 --> 01:04:38,160

these two here at the top well we found

1626
01:04:42,470 --> 01:04:39,920
five other ones which are the red shifts

1627
01:04:44,150 --> 01:04:42,480
of nine to ten and then these other two

1628
01:04:46,069 --> 01:04:44,160
which were red shifts greater than ten

1629
01:04:48,069 --> 01:04:46,079
or so and you can again clearly see this

1630
01:04:49,670 --> 01:04:48,079
break but crucially i'm highlighting

1631
01:04:51,750 --> 01:04:49,680
here the filters that overlapped with

1632
01:04:53,510 --> 01:04:51,760
hubble and if you look at this one on

1633
01:04:56,470 --> 01:04:53,520
the right you see if we image this with

1634
01:04:59,430 --> 01:04:56,480
hubble we wouldn't see anything

1635
01:05:01,190 --> 01:04:59,440
glass is not the only ers program which

1636
01:05:04,630 --> 01:05:01,200
was recently

1637
01:05:07,910 --> 01:05:04,640
taken the sears survey was also taken

1638
01:05:10,390 --> 01:05:07,920

recently again a multi-band survey with

1639

01:05:12,630 --> 01:05:10,400

the near cam instruments um

1640

01:05:15,270 --> 01:05:12,640

on board the james webb space telescope

1641

01:05:17,589 --> 01:05:15,280

over a field that was previously known

1642

01:05:19,589 --> 01:05:17,599

with uh hubble previously imaged with

1643

01:05:22,150 --> 01:05:19,599

hubble again this is seven different

1644

01:05:25,270 --> 01:05:22,160

bands and you can see the mosaic over

1645

01:05:26,950 --> 01:05:25,280

here uh plotted throughout the screen uh

1646

01:05:29,190 --> 01:05:26,960

and um

1647

01:05:29,990 --> 01:05:29,200

researchers including ourselves had a

1648

01:05:33,910 --> 01:05:30,000

look

1649

01:05:34,829 --> 01:05:33,920

most distant galaxies we could

1650

01:05:39,029 --> 01:05:34,839

and

1651
01:05:43,190 --> 01:05:39,039
uh collaborators uh or the pis of sears

1652
01:05:45,589 --> 01:05:43,200
found this galaxy at a redshift of 14.3

1653
01:05:47,910 --> 01:05:45,599
this instantly breaks the records that

1654
01:05:50,470 --> 01:05:47,920
we previously had at a redshift of 11 or

1655
01:05:53,270 --> 01:05:50,480
so you can see this dropout nature over

1656
01:05:56,230 --> 01:05:53,280
here the the imaging is represented as

1657
01:05:58,630 --> 01:05:56,240
the circles here and our best fit model

1658
01:06:00,309 --> 01:05:58,640
of the galaxy as these lines

1659
01:06:02,549 --> 01:06:00,319
and you can see that it appears fairly

1660
01:06:04,390 --> 01:06:02,559
convincing and then

1661
01:06:06,950 --> 01:06:04,400
only a few days later

1662
01:06:09,510 --> 01:06:06,960
uh another galaxy that apparently broke

1663
01:06:12,390 --> 01:06:09,520

the distance record again at a redshift

1664

01:06:14,710 --> 01:06:12,400

of 16.6 so we're only looking at a few

1665

01:06:16,309 --> 01:06:14,720

hundred million years after the big bang

1666

01:06:18,230 --> 01:06:16,319

now and again you can see that

1667

01:06:19,430 --> 01:06:18,240

characteristic break and drop out

1668

01:06:22,390 --> 01:06:19,440

feature

1669

01:06:24,950 --> 01:06:22,400

but are we do we expect so many uh

1670

01:06:27,270 --> 01:06:24,960

distant galaxies um

1671

01:06:29,510 --> 01:06:27,280

our theory suggests perhaps not so over

1672

01:06:32,710 --> 01:06:29,520

here uh on the y-axis you see the

1673

01:06:34,309 --> 01:06:32,720

density of sources on the x-axis you see

1674

01:06:36,549 --> 01:06:34,319

the redshift and as you can see as you

1675

01:06:39,270 --> 01:06:36,559

go to higher and higher redshift you get

1676
01:06:41,589 --> 01:06:39,280
less and less sources and over here our

1677
01:06:43,750 --> 01:06:41,599
most distant known sources with hubble

1678
01:06:45,349 --> 01:06:43,760
seem to end at a redshift of 10 or so

1679
01:06:47,589 --> 01:06:45,359
suggesting that there's not really much

1680
01:06:50,230 --> 01:06:47,599
but james webb is now pushing this

1681
01:06:53,510 --> 01:06:50,240
frontier out to redshifts 12 13 and

1682
01:06:56,870 --> 01:06:53,520
nearly 17 suggesting perhaps uh that

1683
01:07:00,230 --> 01:06:56,880
star formation actually started um

1684
01:07:02,710 --> 01:07:00,240
at earlier times and not at later times

1685
01:07:05,029 --> 01:07:02,720
however all of these need to be verified

1686
01:07:07,750 --> 01:07:05,039
with spectroscopy um

1687
01:07:09,990 --> 01:07:07,760
the they remain galaxy candidates for

1688
01:07:11,829 --> 01:07:10,000

the moment until we can confirm them

1689

01:07:15,510 --> 01:07:11,839

with spectroscopy

1690

01:07:17,910 --> 01:07:15,520

and so one such programs uh that will be

1691

01:07:20,390 --> 01:07:17,920

doing so is my own one with james webb

1692

01:07:23,270 --> 01:07:20,400

where we'll be targeting 10 distant

1693

01:07:25,670 --> 01:07:23,280

galaxies for about 25 hours with near

1694

01:07:27,910 --> 01:07:25,680

spec so we'll be getting spectra from

1695

01:07:30,549 --> 01:07:27,920

0.6 microns all the way out to five

1696

01:07:32,069 --> 01:07:30,559

microns and we'll be able to detect all

1697

01:07:34,069 --> 01:07:32,079

of these features that i showed you

1698

01:07:36,150 --> 01:07:34,079

before including these strong emission

1699

01:07:39,029 --> 01:07:36,160

lines in only about an hour of

1700

01:07:40,950 --> 01:07:39,039

observations this is the near spec setup

1701

01:07:42,950 --> 01:07:40,960

so the galaxies will be placed in here

1702

01:07:44,789 --> 01:07:42,960

where you can get a spectrum for each of

1703

01:07:46,630 --> 01:07:44,799

the little slits that are in these

1704

01:07:48,789 --> 01:07:46,640

quadrants and this is the sort of

1705

01:07:51,109 --> 01:07:48,799

spectrum that we expect to get the 2d at

1706

01:07:52,710 --> 01:07:51,119

the top and if you collapse that you get

1707

01:07:54,789 --> 01:07:52,720

this beautiful spectrum here with all

1708

01:07:57,430 --> 01:07:54,799

these features

1709

01:07:59,510 --> 01:07:57,440

so i think i'm going to end it uh over

1710

01:08:01,349 --> 01:07:59,520

here my main takeaway messages is that

1711

01:08:03,510 --> 01:08:01,359

the ground and space-based facilities

1712

01:08:05,270 --> 01:08:03,520

that we've had up until now have really

1713

01:08:07,430 --> 01:08:05,280

pushed the frontier of the early galaxy

1714

01:08:09,510 --> 01:08:07,440

evolution we've discovered objects all

1715

01:08:11,829 --> 01:08:09,520

the way out to a redshift of 11 or so

1716

01:08:14,150 --> 01:08:11,839

we've constrained their distances their

1717

01:08:16,309 --> 01:08:14,160

masses and their star formation rates

1718

01:08:18,149 --> 01:08:16,319

and whilst in theory we would expect

1719

01:08:19,590 --> 01:08:18,159

these galaxies to be very young and

1720

01:08:20,550 --> 01:08:19,600

pristine

1721

01:08:22,550 --> 01:08:20,560

and

1722

01:08:24,550 --> 01:08:22,560

largely invisible to

1723

01:08:27,269 --> 01:08:24,560

uv imaging and spectroscopy

1724

01:08:29,430 --> 01:08:27,279

analyses with keck and the vlt for

1725

01:08:31,910 --> 01:08:29,440

instance suggest that actually these

1726

01:08:33,990 --> 01:08:31,920

galaxies might be

1727

01:08:35,510 --> 01:08:34,000

might be more massive more dusty than

1728

01:08:37,430 --> 01:08:35,520

previously thought and also formed

1729

01:08:40,709 --> 01:08:37,440

earlier than previously thought and

1730

01:08:43,189 --> 01:08:40,719

lastly the arrival of james webb uh is

1731

01:08:45,910 --> 01:08:43,199

now offering unprecedented imaging and

1732

01:08:47,590 --> 01:08:45,920

spectroscopic capabilities um you know

1733

01:08:49,189 --> 01:08:47,600

showing us images and spectra and

1734

01:08:52,709 --> 01:08:49,199

information about galaxies that we could

1735

01:08:54,789 --> 01:08:52,719

have only dreamed of up until now um

1736

01:08:57,749 --> 01:08:54,799

so i'll end it there thank you for your

1737

01:09:04,470 --> 01:09:01,189

and thank you guido this is uh an

1738

01:09:07,430 --> 01:09:04,480

intense look at not only what we have uh

1739

01:09:09,669 --> 01:09:07,440

previously discovered about this but a

1740

01:09:11,829 --> 01:09:09,679

sneak peek at what we are currently

1741

01:09:12,950 --> 01:09:11,839

discovering about these very early

1742

01:09:13,990 --> 01:09:12,960

galaxies

1743

01:09:16,070 --> 01:09:14,000

uh

1744

01:09:17,749 --> 01:09:16,080

the idea that we could push to redshift

1745

01:09:22,070 --> 01:09:17,759

16.5

1746

01:09:25,110 --> 01:09:22,080

as a totally unprecedented uh

1747

01:09:26,789 --> 01:09:25,120

not something that uh i got in the that

1748

01:09:29,910 --> 01:09:26,799

idea was not anywhere near in my head

1749

01:09:32,789 --> 01:09:29,920

when we were doing my graduate work

1750

01:09:34,709 --> 01:09:32,799

well dec a few decades ago

1751

01:09:36,470 --> 01:09:34,719

so you must be pleased with the uh the

1752

01:09:37,349 --> 01:09:36,480

progress we're getting we're making

1753

01:09:40,390 --> 01:09:37,359

there

1754

01:09:43,110 --> 01:09:40,400

it's wonderful i think uh none of us

1755

01:09:45,189 --> 01:09:43,120

we all expected to be surprised in some

1756

01:09:46,709 --> 01:09:45,199

shape or form but i don't think anyone

1757

01:09:49,910 --> 01:09:46,719

expected to be

1758

01:09:52,470 --> 01:09:49,920

uh surprised to this extent or this

1759

01:09:54,630 --> 01:09:52,480

quickly uh we've only had james webb for

1760

01:09:56,950 --> 01:09:54,640

about you know a month and a half or so

1761

01:09:58,709 --> 01:09:56,960

nearly two months uh it's already broken

1762

01:10:01,189 --> 01:09:58,719

the distance record

1763

01:10:03,350 --> 01:10:01,199

several times and it's already revealing

1764

01:10:05,990 --> 01:10:03,360

you know the physics of these early

1765

01:10:07,669 --> 01:10:06,000

galaxies in exquisite detail that we

1766

01:10:09,350 --> 01:10:07,679

could have only or you know that people

1767

01:10:10,630 --> 01:10:09,360

have been dreaming about for 10 to 20

1768

01:10:13,270 --> 01:10:10,640

years

1769

01:10:15,510 --> 01:10:13,280

okay well one of our uh

1770

01:10:18,470 --> 01:10:15,520

viewers on youtube was wondering okay

1771

01:10:21,590 --> 01:10:18,480

well you said hubble had a limit around

1772

01:10:24,790 --> 01:10:21,600

10 11 that it could go out to

1773

01:10:29,189 --> 01:10:24,800

uh if there were galaxies beyond these

1774

01:10:31,990 --> 01:10:29,199

14 and 16 just how far could

1775

01:10:33,590 --> 01:10:32,000

webb go if uh if if

1776

01:10:36,709 --> 01:10:33,600

if there are galaxies to observe at

1777

01:10:38,870 --> 01:10:36,719

those redshifts can it get to 1820

1778

01:10:41,510 --> 01:10:38,880

where is it is there a limit

1779

01:10:44,149 --> 01:10:41,520

uh in three yeah it can it can get to

1780

01:10:46,470 --> 01:10:44,159

1820 in fact you know there are there

1781

01:10:49,189 --> 01:10:46,480

are some results out there who uh you

1782

01:10:51,830 --> 01:10:49,199

know are suggesting that there might be

1783

01:10:54,229 --> 01:10:51,840

a couple of galaxies out at redshift20

1784

01:10:56,709 --> 01:10:54,239

this has to be verified and and

1785

01:10:59,350 --> 01:10:56,719

peer-reviewed uh but there are people

1786

01:11:01,270 --> 01:10:59,360

looking out as far as redshifts of 20.

1787

01:11:03,510 --> 01:11:01,280

of course you've pointed out a really

1788

01:11:05,669 --> 01:11:03,520

valid point though i think which is you

1789

01:11:07,270 --> 01:11:05,679

know we don't know whether they even

1790

01:11:08,310 --> 01:11:07,280

exist so

1791

01:11:10,950 --> 01:11:08,320

um

1792

01:11:13,990 --> 01:11:10,960

our models are a little doubtful let's

1793

01:11:16,550 --> 01:11:14,000

say of finding galaxies that far out

1794

01:11:18,709 --> 01:11:16,560

but if they do exist then in theory

1795

01:11:20,390 --> 01:11:18,719

james webb should be able to

1796

01:11:22,390 --> 01:11:20,400

find them the only thing is that we

1797

01:11:23,750 --> 01:11:22,400

wouldn't be able to look for the most

1798

01:11:26,070 --> 01:11:23,760

we'd only be able to look for the

1799

01:11:29,270 --> 01:11:26,080

brightest such sources because the faint

1800

01:11:30,870 --> 01:11:29,280

ones would still be out of uh i think

1801
01:11:32,550 --> 01:11:30,880
james webb's capabilities we'd have to

1802
01:11:34,950 --> 01:11:32,560
be looking at the sky for a very very

1803
01:11:37,430 --> 01:11:34,960
long time right and that's another thing

1804
01:11:39,510 --> 01:11:37,440
to point out to folks is that you know

1805
01:11:42,070 --> 01:11:39,520
what are we calling galaxies here i mean

1806
01:11:45,350 --> 01:11:42,080
these are sort of proto galaxies right i

1807
01:11:47,189 --> 01:11:45,360
mean um what is the masses are they are

1808
01:11:49,110 --> 01:11:47,199
are we getting down to like you know 10

1809
01:11:51,590 --> 01:11:49,120
to the eighth solar masses

1810
01:11:52,310 --> 01:11:51,600
uh type type range or

1811
01:11:55,189 --> 01:11:52,320
what

1812
01:11:56,790 --> 01:11:55,199
how large uh because they're certainly

1813
01:11:59,189 --> 01:11:56,800

not the size that they're not milky way

1814

01:12:01,590 --> 01:11:59,199

size galaxies they're not even you know

1815

01:12:03,350 --> 01:12:01,600

um dwarf they're not even the large

1816

01:12:05,270 --> 01:12:03,360

dwarfs that we know of in the local

1817

01:12:06,550 --> 01:12:05,280

universe what masses are we really

1818

01:12:08,229 --> 01:12:06,560

looking at when we're talking about

1819

01:12:10,470 --> 01:12:08,239

these very very so that's something

1820

01:12:12,950 --> 01:12:10,480

where we're actually able to

1821

01:12:15,590 --> 01:12:12,960

look at now for more or less the first

1822

01:12:17,750 --> 01:12:15,600

time uh most of the mass of these

1823

01:12:19,590 --> 01:12:17,760

galaxies is contained within the rest

1824

01:12:20,790 --> 01:12:19,600

frame optical which up until now we

1825

01:12:23,030 --> 01:12:20,800

could only see

1826

01:12:24,870 --> 01:12:23,040

with two bands with spitzer but these

1827

01:12:27,430 --> 01:12:24,880

bands were heavily contaminated by

1828

01:12:30,470 --> 01:12:27,440

emission lines and and features which

1829

01:12:32,070 --> 01:12:30,480

skewed let's say our results with um

1830

01:12:33,189 --> 01:12:32,080

james webb were able to do this more

1831

01:12:34,390 --> 01:12:33,199

efficiently

1832

01:12:36,390 --> 01:12:34,400

and people are finding that these

1833

01:12:38,709 --> 01:12:36,400

galaxies are more massive than we

1834

01:12:41,030 --> 01:12:38,719

thought 10 to the 9 10 to the 10 even in

1835

01:12:42,950 --> 01:12:41,040

some cases really so we're getting into

1836

01:12:45,189 --> 01:12:42,960

a billion solar masses and that is just

1837

01:12:48,830 --> 01:12:45,199

in baryons or is that baryons and dark

1838

01:12:51,590 --> 01:12:48,840

matter that's uh just baryons that's

1839

01:12:53,350 --> 01:12:51,600

just um all right wait wait for the

1840

01:12:55,270 --> 01:12:53,360

audience baryons is the normal matter

1841

01:12:57,590 --> 01:12:55,280

the hydrogen and the helium and stuff

1842

01:12:59,990 --> 01:12:57,600

it's amongst cosmologists baryons is

1843

01:13:01,830 --> 01:13:00,000

just what we use as our code word for

1844

01:13:03,750 --> 01:13:01,840

for that sort of that sort of stuff

1845

01:13:06,630 --> 01:13:03,760

gotta make sure that our public audience

1846

01:13:09,430 --> 01:13:06,640

recognizes those those jargon words

1847

01:13:10,149 --> 01:13:09,440

yeah yeah absolutely um i mean you know

1848

01:13:12,070 --> 01:13:10,159

the

1849

01:13:13,590 --> 01:13:12,080

regular matter we can see with james

1850

01:13:15,270 --> 01:13:13,600

webb dark matter we would have to

1851

01:13:17,430 --> 01:13:15,280

constrain indirectly through

1852

01:13:18,870 --> 01:13:17,440

gravitational effects we can't see that

1853

01:13:21,350 --> 01:13:18,880

directly

1854

01:13:24,390 --> 01:13:21,360

and so here we're talking normal matter

1855

01:13:26,790 --> 01:13:24,400

let's say you know the stars and gas

1856

01:13:29,430 --> 01:13:26,800

and in some cases we seem to be seeing

1857

01:13:31,510 --> 01:13:29,440

galaxies that are more massive than

1858

01:13:33,990 --> 01:13:31,520

previously thought you know we already

1859

01:13:37,189 --> 01:13:34,000

looked at this a little bit with uh with

1860

01:13:38,709 --> 01:13:37,199

spitzer and alma this jd1 galaxy for

1861

01:13:40,310 --> 01:13:38,719

instance which is

1862

01:13:42,630 --> 01:13:40,320

supposed to be a lot older and a lot

1863

01:13:44,470 --> 01:13:42,640

more massive than previously thought but

1864

01:13:46,550 --> 01:13:44,480

james webb is really taking this to

1865

01:13:49,110 --> 01:13:46,560

another level the only

1866

01:13:52,310 --> 01:13:49,120

the only caveat i will add to this in

1867

01:13:53,750 --> 01:13:52,320

terms of these distant galaxies is we

1868

01:13:55,350 --> 01:13:53,760

know how to

1869

01:13:56,870 --> 01:13:55,360

um

1870

01:13:58,550 --> 01:13:56,880

we know how to search for distant

1871

01:14:01,189 --> 01:13:58,560

galaxies and characterize them

1872

01:14:04,149 --> 01:14:01,199

reasonably well what we don't know very

1873

01:14:07,110 --> 01:14:04,159

well yet is the uh is how the

1874

01:14:09,910 --> 01:14:07,120

instruments of james webb behave and so

1875

01:14:12,870 --> 01:14:09,920

a very important uh component of all of

1876

01:14:15,350 --> 01:14:12,880

this is essentially learning on the fly

1877

01:14:16,950 --> 01:14:15,360

how these instruments respond and making

1878

01:14:19,510 --> 01:14:16,960

sure that they respond in a way that we

1879

01:14:21,590 --> 01:14:19,520

understand and so what we then interpret

1880

01:14:23,350 --> 01:14:21,600

of these galaxies is accurate and that

1881

01:14:25,430 --> 01:14:23,360

will take a little bit of time still

1882

01:14:27,270 --> 01:14:25,440

exactly experience i mean

1883

01:14:28,709 --> 01:14:27,280

i remember several times in hubble's

1884

01:14:30,550 --> 01:14:28,719

history that we've had to recalibrate

1885

01:14:32,630 --> 01:14:30,560

all go back through and you know do

1886

01:14:34,709 --> 01:14:32,640

recalibrations of the all the data sets

1887

01:14:37,270 --> 01:14:34,719

in the archive just because we've

1888

01:14:39,430 --> 01:14:37,280

learned more about how uh how the

1889

01:14:40,149 --> 01:14:39,440

instruments are are responding

1890

01:14:42,870 --> 01:14:40,159

so

1891

01:14:45,910 --> 01:14:42,880

even if we have fantastic observations

1892

01:14:47,110 --> 01:14:45,920

of fantastic results right now

1893

01:14:48,390 --> 01:14:47,120

they all they have to be taken with a

1894

01:14:51,350 --> 01:14:48,400

grain of salt until we have the

1895

01:14:53,750 --> 01:14:51,360

experience with webb's instruments uh to

1896

01:14:56,870 --> 01:14:53,760

really validate them

1897

01:14:59,590 --> 01:14:56,880

that's right but part of part of uh

1898

01:15:00,550 --> 01:14:59,600

the excitement of james webb is also

1899

01:15:06,310 --> 01:15:00,560

you know

1900

01:15:07,990 --> 01:15:06,320

we expect we expect our results to be

1901

01:15:10,709 --> 01:15:08,000

extended to a certain extent we always

1902

01:15:11,750 --> 01:15:10,719

expect to find more distant galaxies i

1903

01:15:13,430 --> 01:15:11,760

think but

1904

01:15:15,990 --> 01:15:13,440

part of the enjoyment of all of this is

1905

01:15:18,229 --> 01:15:16,000

really being surprised in in ways which

1906

01:15:21,430 --> 01:15:18,239

we didn't really imagine

1907

01:15:23,110 --> 01:15:21,440

and that forces us then to

1908

01:15:25,270 --> 01:15:23,120

rethink you know perhaps some of our

1909

01:15:26,950 --> 01:15:25,280

models or our techniques and uh rethink

1910

01:15:29,110 --> 01:15:26,960

what we know and that's a wonderful part

1911

01:15:30,149 --> 01:15:29,120

of astronomy and science in general i

1912

01:15:32,310 --> 01:15:30,159

think

1913

01:15:34,550 --> 01:15:32,320

wonderful yeah i will definitely say

1914

01:15:35,990 --> 01:15:34,560

that you know 14 and 16 right in the

1915

01:15:38,229 --> 01:15:36,000

first month is

1916

01:15:39,830 --> 01:15:38,239

definitely qualify as a surprise all

1917

01:15:41,830 --> 01:15:39,840

right there was one other question i saw

1918

01:15:43,430 --> 01:15:41,840

that i wanted to ask you um

1919

01:15:46,310 --> 01:15:43,440

and it's trying to relate the local

1920

01:15:48,229 --> 01:15:46,320

universe to the distant universe and so

1921

01:15:50,229 --> 01:15:48,239

they asked a question that i translated

1922

01:15:52,630 --> 01:15:50,239

into two different questions one

1923

01:15:55,350 --> 01:15:52,640

are galaxies being formed today

1924

01:15:58,149 --> 01:15:55,360

um and are they similar to these very

1925

01:15:59,750 --> 01:15:58,159

early galaxies i presume sort of saying

1926

01:16:01,430 --> 01:15:59,760

hey if what

1927

01:16:03,030 --> 01:16:01,440

what is what we see in the local

1928

01:16:04,950 --> 01:16:03,040

universe similar to what we're seeing in

1929

01:16:08,149 --> 01:16:04,960

the distant universe just at much much

1930

01:16:15,189 --> 01:16:12,630

uh that's that's a very good question um

1931

01:16:17,830 --> 01:16:15,199

yes is the answer we have

1932

01:16:20,790 --> 01:16:17,840

uh so there are galaxies forming forming

1933

01:16:23,750 --> 01:16:20,800

today uh and there are galaxies also

1934

01:16:25,189 --> 01:16:23,760

that uh look very similar to

1935

01:16:27,270 --> 01:16:25,199

um

1936

01:16:29,830 --> 01:16:27,280

to what we see in the distance distant

1937

01:16:32,149 --> 01:16:29,840

universe obviously everything we look at

1938

01:16:34,709 --> 01:16:32,159

is you know a snapshot of the past in a

1939

01:16:37,910 --> 01:16:34,719

way we can't see this in real time but

1940

01:16:39,750 --> 01:16:37,920

this is actually a very big part of um

1941

01:16:42,470 --> 01:16:39,760

studies of the early universe because

1942

01:16:45,590 --> 01:16:42,480

these faraway galaxies are so difficult

1943

01:16:47,270 --> 01:16:45,600

to find and confirm we often look at the

1944

01:16:49,590 --> 01:16:47,280

local universe

1945

01:16:51,750 --> 01:16:49,600

looking for what we call uh lower

1946

01:16:53,910 --> 01:16:51,760

redshift analogues of high wretched

1947

01:16:56,390 --> 01:16:53,920

galaxies so galaxies in the local

1948

01:16:58,709 --> 01:16:56,400

universe that we think resemble very

1949

01:17:00,630 --> 01:16:58,719

distant galaxies to try and understand

1950

01:17:03,669 --> 01:17:00,640

more about the properties and conditions

1951

01:17:06,310 --> 01:17:03,679

of those galaxies so yes and yes is the

1952

01:17:09,030 --> 01:17:06,320

answer to that i think and i guess i

1953

01:17:11,189 --> 01:17:09,040

would think that there is a significant

1954

01:17:12,790 --> 01:17:11,199

difference between them in that these

1955

01:17:14,630 --> 01:17:12,800

galaxies we're seeing in the very early

1956

01:17:16,149 --> 01:17:14,640

universe you know if they're forming so

1957

01:17:18,070 --> 01:17:16,159

quickly they're going to continue to

1958

01:17:20,470 --> 01:17:18,080

form and and probably end up as you know

1959

01:17:22,070 --> 01:17:20,480

giant elliptical galaxies whereas the

1960

01:17:23,750 --> 01:17:22,080

ones in the local universe are going to

1961

01:17:25,590 --> 01:17:23,760

be these dwarf small galaxies and

1962

01:17:27,270 --> 01:17:25,600

they're never going to get to be the

1963

01:17:29,110 --> 01:17:27,280

giant ellipticals i mean the things that

1964

01:17:32,709 --> 01:17:29,120

don't form first are the highest density

1965

01:17:34,709 --> 01:17:32,719

peaks of the density distribution so

1966

01:17:36,870 --> 01:17:34,719

there's that small difference i've

1967

01:17:38,790 --> 01:17:36,880

always kept in my head is that

1968

01:17:40,310 --> 01:17:38,800

reasonable

1969

01:17:42,870 --> 01:17:40,320

yeah i think that sounds that's

1970

01:17:45,189 --> 01:17:42,880

definitely reasonable obviously we don't

1971

01:17:47,830 --> 01:17:45,199

in our lifetimes we won't know how these

1972

01:17:50,790 --> 01:17:47,840

currently forming galaxies are going to

1973

01:17:52,149 --> 01:17:50,800

going to evolve but i think one one

1974

01:17:54,310 --> 01:17:52,159

thing that's important to consider of

1975

01:17:56,149 --> 01:17:54,320

course when doing these studies is uh

1976

01:17:58,390 --> 01:17:56,159

you know it is very well and good to

1977

01:18:01,110 --> 01:17:58,400

compare these galaxies across across

1978

01:18:02,950 --> 01:18:01,120

cosmic time but we should keep in mind

1979

01:18:05,669 --> 01:18:02,960

that the conditions of the universe have

1980

01:18:07,189 --> 01:18:05,679

changed you know across 13 billion years

1981

01:18:09,990 --> 01:18:07,199

so the conditions in which the first

1982

01:18:12,550 --> 01:18:10,000

galaxies form are different to the

1983

01:18:15,030 --> 01:18:12,560

conditions in which the galaxies today

1984

01:18:17,189 --> 01:18:15,040

are forming uh nonetheless you know if

1985

01:18:19,350 --> 01:18:17,199

you compare apples to apples in terms of

1986

01:18:20,149 --> 01:18:19,360

specific properties that i think one can

1987

01:18:22,550 --> 01:18:20,159

do

1988

01:18:24,870 --> 01:18:22,560

but for sure uh the conditions around

1989

01:18:27,350 --> 01:18:24,880

those galaxies has changed and no doubt

1990

01:18:29,110 --> 01:18:27,360

that would have some sort of impact uh

1991

01:18:31,910 --> 01:18:29,120

on the structure the large-scale

1992

01:18:34,149 --> 01:18:31,920

structures of galaxies at least right

1993

01:18:37,030 --> 01:18:34,159

okay well grant justice has been paying

1994

01:18:39,110 --> 01:18:37,040

attention to the questions in the chat

1995

01:18:41,750 --> 01:18:39,120

grant why don't you turn on your video

1996

01:18:44,070 --> 01:18:41,760

and uh welcome and tell us what

1997

01:18:46,229 --> 01:18:44,080

questions you found in in the chat

1998

01:18:48,630 --> 01:18:46,239

sure absolutely actually following up

1999

01:18:51,750 --> 01:18:48,640

kind of from the last one uh in your

2000

01:18:54,870 --> 01:18:51,760

observations have you found that

2001

01:18:57,270 --> 01:18:54,880

uh early galaxies tend to have

2002

01:18:59,510 --> 01:18:57,280

uh larger or smaller

2003

01:19:02,950 --> 01:18:59,520

stars compared to recently formed one is

2004

01:19:08,310 --> 01:19:05,270

so we don't have we don't have the

2005

01:19:11,830 --> 01:19:08,320

resolution to look at individual stars

2006

01:19:14,550 --> 01:19:11,840

in these distant galaxies

2007

01:19:17,430 --> 01:19:14,560

galaxies that are closer by we can see

2008

01:19:19,030 --> 01:19:17,440

clusters of of galaxies but we don't

2009

01:19:21,830 --> 01:19:19,040

quite have the resolution to look at

2010

01:19:25,430 --> 01:19:21,840

stars individual stars outside of our

2011

01:19:27,430 --> 01:19:25,440

own galaxy what we can do though is

2012

01:19:29,030 --> 01:19:27,440

we can compare the sizes of galaxies

2013

01:19:31,750 --> 01:19:29,040

themselves or we can try and estimate

2014

01:19:34,390 --> 01:19:31,760

the ages of the stars within and we do

2015

01:19:35,270 --> 01:19:34,400

find that some of these distant galaxies

2016

01:19:37,750 --> 01:19:35,280

have

2017

01:19:39,750 --> 01:19:37,760

older stars the stars that we see today

2018

01:19:41,669 --> 01:19:39,760

are much much older because

2019

01:19:44,950 --> 01:19:41,679

galaxies have had a lot more time to

2020

01:19:47,030 --> 01:19:44,960

evolve uh than those early ones um but

2021

01:19:50,070 --> 01:19:47,040

if you compare for instance with these

2022

01:19:52,229 --> 01:19:50,080

so-called local analogs then we see

2023

01:19:53,669 --> 01:19:52,239

we can see some similar traits across

2024

01:19:55,669 --> 01:19:53,679

the two different populations but we

2025

01:19:58,390 --> 01:19:55,679

can't we don't have the resolution even

2026
01:20:00,870 --> 01:19:58,400
with james webb to uh image individual

2027
01:20:02,790 --> 01:20:00,880
stars in these distant galaxies okay so

2028
01:20:05,030 --> 01:20:02,800
that brings up a side question that you

2029
01:20:07,270 --> 01:20:05,040
mentioned a bit in your talk that we got

2030
01:20:09,110 --> 01:20:07,280
the redshift for a galaxy to know

2031
01:20:10,709 --> 01:20:09,120
what redshift we're seeing it at and

2032
01:20:12,550 --> 01:20:10,719
then we can age date you know that

2033
01:20:14,709 --> 01:20:12,560
you've got some stars within them that

2034
01:20:15,430 --> 01:20:14,719
are like a few hundred million years old

2035
01:20:17,910 --> 01:20:15,440
so

2036
01:20:19,830 --> 01:20:17,920
are we getting a good estimate for when

2037
01:20:22,229 --> 01:20:19,840
this first stars in in the universe

2038
01:20:24,070 --> 01:20:22,239

formed how how close to the big bang

2039

01:20:26,870 --> 01:20:24,080

we're getting there

2040

01:20:28,790 --> 01:20:26,880

that that's an excellent question so

2041

01:20:30,870 --> 01:20:28,800

when we get the light from the galaxies

2042

01:20:33,430 --> 01:20:30,880

we're seeing them as they were then and

2043

01:20:36,310 --> 01:20:33,440

if we can measure the age of those stars

2044

01:20:38,470 --> 01:20:36,320

then what we can do is rewind the clock

2045

01:20:41,910 --> 01:20:38,480

the way we do this essentially is we

2046

01:20:44,149 --> 01:20:41,920

recreate the history of how this galaxy

2047

01:20:46,629 --> 01:20:44,159

formed those stars by trying to match

2048

01:20:48,790 --> 01:20:46,639

the light profile but this is and we do

2049

01:20:52,310 --> 01:20:48,800

this with models of galaxies but this is

2050

01:20:54,390 --> 01:20:52,320

an extremely uncertain uh practice it's

2051
01:20:57,030 --> 01:20:54,400
the only way we can do things for the

2052
01:20:57,910 --> 01:20:57,040
moment in the absence of spectroscopy

2053
01:21:00,310 --> 01:20:57,920
um

2054
01:21:02,390 --> 01:21:00,320
it was the only way to do it so you can

2055
01:21:05,830 --> 01:21:02,400
pinpoint then a

2056
01:21:08,470 --> 01:21:05,840
um a time at which these galaxies uh

2057
01:21:10,229 --> 01:21:08,480
were born or these stars were born but

2058
01:21:12,390 --> 01:21:10,239
it'll still have a very large error bar

2059
01:21:15,350 --> 01:21:12,400
it's very uncertain what you need is

2060
01:21:17,510 --> 01:21:15,360
spectroscopy to be able to look at this

2061
01:21:19,510 --> 01:21:17,520
so-called bomber break again this jump

2062
01:21:21,590 --> 01:21:19,520
that you see which is due to those

2063
01:21:23,750 --> 01:21:21,600

mature stars and if you can directly

2064

01:21:26,070 --> 01:21:23,760

measure that jump you'll have a much

2065

01:21:28,390 --> 01:21:26,080

better handle on the ages of those stars

2066

01:21:31,189 --> 01:21:28,400

than just from imaging alone

2067

01:21:33,270 --> 01:21:31,199

okay but it does sound like we're

2068

01:21:35,830 --> 01:21:33,280

finding that you know the first stars

2069

01:21:38,149 --> 01:21:35,840

are forming uh within 500 million years

2070

01:21:39,750 --> 01:21:38,159

after the big bang yeah yeah so we're

2071

01:21:41,350 --> 01:21:39,760

getting getting it exact it's going to

2072

01:21:43,110 --> 01:21:41,360

be

2073

01:21:45,350 --> 01:21:43,120

something to look forward to

2074

01:21:47,350 --> 01:21:45,360

that's right that's right um

2075

01:21:50,149 --> 01:21:47,360

we know gen we know at this point in

2076
01:21:52,390 --> 01:21:50,159
time now just due to distances alone i

2077
01:21:54,709 --> 01:21:52,400
mean confirming distances to early

2078
01:21:56,229 --> 01:21:54,719
galaxies the most direct way to

2079
01:21:58,629 --> 01:21:56,239
essentially figure out when the first

2080
01:22:00,790 --> 01:21:58,639
stars and galaxies formed and that alone

2081
01:22:02,470 --> 01:22:00,800
is telling us that the first stars and

2082
01:22:03,590 --> 01:22:02,480
galaxies probably formed within the

2083
01:22:05,830 --> 01:22:03,600
first

2084
01:22:07,270 --> 01:22:05,840
two to 400 million years after the big

2085
01:22:10,550 --> 01:22:07,280
bang or so

2086
01:22:12,709 --> 01:22:10,560
roughly 96 97 percent of the universe's

2087
01:22:13,910 --> 01:22:12,719
present age

2088
01:22:15,510 --> 01:22:13,920

all right

2089

01:22:17,990 --> 01:22:15,520

okay else we got

2090

01:22:21,910 --> 01:22:18,000

i i actually love this one we're gonna

2091

01:22:24,550 --> 01:22:21,920

pull back the the curtain a little bit

2092

01:22:26,709 --> 01:22:24,560

is it common to incorrectly date such

2093

01:22:28,310 --> 01:22:26,719

early distant galaxies

2094

01:22:32,390 --> 01:22:28,320

it's nothing short of incredible that

2095

01:22:37,270 --> 01:22:35,030

that's a great question the answer is

2096

01:22:39,510 --> 01:22:37,280

the answer is probably but we don't know

2097

01:22:41,110 --> 01:22:39,520

until we actually confirm

2098

01:22:43,990 --> 01:22:41,120

those you know the dates of these

2099

01:22:46,709 --> 01:22:44,000

galaxies um there's there's a very large

2100

01:22:48,870 --> 01:22:46,719

error bar on these estimates so whether

2101
01:22:51,750 --> 01:22:48,880
we've pinpointed the exact age or not

2102
01:22:54,390 --> 01:22:51,760
remains to be seen but there's a very

2103
01:22:56,950 --> 01:22:54,400
gray area there let's say um

2104
01:22:59,910 --> 01:22:56,960
you know a big margin ferreira um yeah

2105
01:23:01,750 --> 01:22:59,920
but so don't sell yourself short because

2106
01:23:03,910 --> 01:23:01,760
error bars have been decreasing from

2107
01:23:05,590 --> 01:23:03,920
being really huge now you know you're

2108
01:23:07,270 --> 01:23:05,600
just saying okay earth they're here and

2109
01:23:10,229 --> 01:23:07,280
they should they really want them to be

2110
01:23:12,629 --> 01:23:10,239
here but you're doing fantastic

2111
01:23:14,709 --> 01:23:12,639
absolutely thank you i mean uh you know

2112
01:23:16,790 --> 01:23:14,719
these telescopes really are allowing us

2113
01:23:19,110 --> 01:23:16,800

to push the frontier of what we can do i

2114

01:23:20,390 --> 01:23:19,120

mean it is it is marvelous that we're

2115

01:23:23,110 --> 01:23:20,400

even able to

2116

01:23:25,270 --> 01:23:23,120

attempt this sort of thing um but

2117

01:23:27,830 --> 01:23:25,280

ultimately getting sort of direct

2118

01:23:29,430 --> 01:23:27,840

confirmation is what we want to do uh

2119

01:23:31,110 --> 01:23:29,440

but that's extremely challenging one of

2120

01:23:33,510 --> 01:23:31,120

the things that you know people have

2121

01:23:35,430 --> 01:23:33,520

been wanting to do for a long time is is

2122

01:23:38,229 --> 01:23:35,440

the detection confirmation of what we

2123

01:23:40,950 --> 01:23:38,239

call population three stars these these

2124

01:23:42,790 --> 01:23:40,960

first generation of stars uh they're the

2125

01:23:45,910 --> 01:23:42,800

very first ones that formed from

2126

01:23:48,229 --> 01:23:45,920

pristine hydrogen gas they don't have

2127

01:23:49,110 --> 01:23:48,239

any heavy metals like carbon or oxygen

2128

01:23:51,110 --> 01:23:49,120

in them

2129

01:23:53,030 --> 01:23:51,120

and those are the ones that we know with

2130

01:23:54,629 --> 01:23:53,040

the very first ones to form and direct

2131

01:23:57,030 --> 01:23:54,639

detection is much

2132

01:23:59,110 --> 01:23:57,040

clearer let's say than rewinding the

2133

01:24:01,350 --> 01:23:59,120

clock as such but for the moment it's

2134

01:24:03,510 --> 01:24:01,360

the only thing we really can do

2135

01:24:05,990 --> 01:24:03,520

right and for those pop three stars it's

2136

01:24:07,830 --> 01:24:06,000

uh you know i've seen different

2137

01:24:11,110 --> 01:24:07,840

arguments as to how quickly those might

2138

01:24:12,629 --> 01:24:11,120

form um uh once the after after

2139

01:24:14,229 --> 01:24:12,639

re-ionization

2140

01:24:16,790 --> 01:24:14,239

that's right

2141

01:24:20,550 --> 01:24:16,800

recombination sorry

2142

01:24:23,590 --> 01:24:20,560

okay grant what next thank you um yeah

2143

01:24:26,070 --> 01:24:23,600

do indications of dust in these deeply

2144

01:24:30,149 --> 01:24:26,080

redshifted galaxies upset prediction

2145

01:24:34,229 --> 01:24:30,159

models of early star formation

2146

01:24:37,270 --> 01:24:34,239

again a good good question uh

2147

01:24:39,350 --> 01:24:37,280

yes to a certain extent for a very long

2148

01:24:41,110 --> 01:24:39,360

time uh the assumption with these

2149

01:24:43,430 --> 01:24:41,120

galaxies was that they didn't have any

2150

01:24:45,990 --> 01:24:43,440

dust at all in fact in a lot of our

2151
01:24:47,350 --> 01:24:46,000
analyses and our models dust was never

2152
01:24:50,870 --> 01:24:47,360
included

2153
01:24:53,350 --> 01:24:50,880
which has a significant impact on how we

2154
01:24:56,390 --> 01:24:53,360
interpret the data because dust in

2155
01:24:58,550 --> 01:24:56,400
effect shields uh a lot of the light

2156
01:24:59,910 --> 01:24:58,560
from young stars so for instance if

2157
01:25:02,310 --> 01:24:59,920
there's a lot of dust in these young

2158
01:25:03,910 --> 01:25:02,320
galaxies we might be under counting the

2159
01:25:05,510 --> 01:25:03,920
number of stars that they're forming and

2160
01:25:08,870 --> 01:25:05,520
that's really important for our models

2161
01:25:10,950 --> 01:25:08,880
of early galaxy evolution

2162
01:25:13,110 --> 01:25:10,960
so we hadn't been including that because

2163
01:25:16,070 --> 01:25:13,120

we assumed there was no stars

2164

01:25:19,270 --> 01:25:16,080

there was no dust sorry alma has really

2165

01:25:20,870 --> 01:25:19,280

been revolutionizing uh this picture uh

2166

01:25:22,550 --> 01:25:20,880

in the sense that it's an extremely

2167

01:25:24,390 --> 01:25:22,560

sensitive telescope in the sub

2168

01:25:26,870 --> 01:25:24,400

millimeter uh

2169

01:25:30,070 --> 01:25:26,880

range of wavelengths and that is where

2170

01:25:32,229 --> 01:25:30,080

galaxies tend to emit light from dust so

2171

01:25:34,070 --> 01:25:32,239

the dust gets heated up it absorbs uv

2172

01:25:35,910 --> 01:25:34,080

light and then re-emits it at infrared

2173

01:25:38,470 --> 01:25:35,920

wavelengths or sub-millimeter

2174

01:25:40,550 --> 01:25:38,480

wavelengths rather uh and alma is

2175

01:25:42,790 --> 01:25:40,560

finding in these very distant galaxies

2176

01:25:44,229 --> 01:25:42,800

that there seems to be a fair amount of

2177

01:25:46,229 --> 01:25:44,239

dust and so

2178

01:25:48,310 --> 01:25:46,239

what we need to do now is look back on

2179

01:25:50,149 --> 01:25:48,320

our theory on how this dust is produced

2180

01:25:52,070 --> 01:25:50,159

in terms of supernovae

2181

01:25:54,070 --> 01:25:52,080

or not and whether supernovae come from

2182

01:25:56,070 --> 01:25:54,080

these massive stars or not so yes it is

2183

01:25:58,470 --> 01:25:56,080

upsetting a little bit let's say our

2184

01:26:00,629 --> 01:25:58,480

original theories but that's great it

2185

01:26:02,709 --> 01:26:00,639

means we still have a lot to learn

2186

01:26:04,310 --> 01:26:02,719

yes i always like to say when you

2187

01:26:05,990 --> 01:26:04,320

uncover something you didn't expect it

2188

01:26:08,149 --> 01:26:06,000

just shows you you've got another

2189

01:26:10,790 --> 01:26:08,159

another project to pursue to understand

2190

01:26:13,270 --> 01:26:10,800

that result and um we love being

2191

01:26:15,590 --> 01:26:13,280

ignorant because that gives us more to

2192

01:26:18,149 --> 01:26:15,600

to understand about the universe

2193

01:26:21,189 --> 01:26:19,110

right

2194

01:26:23,430 --> 01:26:21,199

um so

2195

01:26:26,470 --> 01:26:23,440

given that you have so much more

2196

01:26:27,669 --> 01:26:26,480

available to you coming up now with jwst

2197

01:26:29,830 --> 01:26:27,679

we've spoken a little bit about the

2198

01:26:31,270 --> 01:26:29,840

instruments and like becoming familiar

2199

01:26:33,030 --> 01:26:31,280

with them but

2200

01:26:35,990 --> 01:26:33,040

what are you most excited for like

2201
01:26:38,390 --> 01:26:36,000
technique wise for dating early objects

2202
01:26:41,830 --> 01:26:38,400
or exploring a little further into your

2203
01:26:43,350 --> 01:26:41,840
speed like your specialty

2204
01:26:45,590 --> 01:26:43,360
that might be my favorite question i

2205
01:26:47,590 --> 01:26:45,600
think so far purely because

2206
01:26:49,590 --> 01:26:47,600
i think

2207
01:26:51,830 --> 01:26:49,600
what

2208
01:26:54,310 --> 01:26:51,840
the nice thing about james webb now and

2209
01:26:56,470 --> 01:26:54,320
having these capabilities which we could

2210
01:27:00,709 --> 01:26:56,480
only dream about

2211
01:27:02,950 --> 01:27:00,719
for a long time is it's no longer

2212
01:27:05,189 --> 01:27:02,960
the frontier is no longer just extending

2213
01:27:06,229 --> 01:27:05,199

what we've done so far the frontier now

2214

01:27:08,629 --> 01:27:06,239

i think

2215

01:27:11,430 --> 01:27:08,639

is becoming creative with

2216

01:27:14,070 --> 01:27:11,440

the capabilities that we've that we have

2217

01:27:15,669 --> 01:27:14,080

and learning how to combine the

2218

01:27:18,229 --> 01:27:15,679

instrument the data from these various

2219

01:27:20,229 --> 01:27:18,239

instruments uh in terms of trying to

2220

01:27:22,709 --> 01:27:20,239

understand what we see and where we

2221

01:27:24,310 --> 01:27:22,719

combine you know these different uh

2222

01:27:26,709 --> 01:27:24,320

indicators for instance what does that

2223

01:27:28,870 --> 01:27:26,719

tell us about galaxy evolution so it's

2224

01:27:30,950 --> 01:27:28,880

the unexpected let's say and and the

2225

01:27:32,870 --> 01:27:30,960

unknown which i think is really

2226

01:27:35,910 --> 01:27:32,880

interesting and i think the challenge

2227

01:27:37,510 --> 01:27:35,920

really now is to get creative uh with

2228

01:27:38,950 --> 01:27:37,520

the instruments and the data sets and

2229

01:27:41,669 --> 01:27:38,960

this is something that we're trying to

2230

01:27:43,830 --> 01:27:41,679

do with the glass crs program in terms

2231

01:27:45,910 --> 01:27:43,840

of uh you know looking at this galaxy

2232

01:27:47,910 --> 01:27:45,920

cluster not just with the nearest

2233

01:27:50,070 --> 01:27:47,920

instrument which is going to give us

2234

01:27:51,990 --> 01:27:50,080

which has given us a spectra of

2235

01:27:53,669 --> 01:27:52,000

everything in the field of view but also

2236

01:27:55,189 --> 01:27:53,679

then following it up at different

2237

01:27:56,709 --> 01:27:55,199

wavelengths with the near spec

2238

01:27:58,950 --> 01:27:56,719

instrument so that we can directly

2239

01:28:00,470 --> 01:27:58,960

compare different wavelengths and just

2240

01:28:03,270 --> 01:28:00,480

different instruments and see how to

2241

01:28:05,830 --> 01:28:03,280

best optimize them to learn as much as

2242

01:28:07,910 --> 01:28:05,840

we can about these distant objects

2243

01:28:10,229 --> 01:28:07,920

yeah and you had a great point about

2244

01:28:12,629 --> 01:28:10,239

using observations with alma

2245

01:28:14,629 --> 01:28:12,639

right and getting into the millimeter

2246

01:28:16,709 --> 01:28:14,639

and the radio waves which have

2247

01:28:18,470 --> 01:28:16,719

very fine resolution as well

2248

01:28:20,709 --> 01:28:18,480

um you know

2249

01:28:23,510 --> 01:28:20,719

uh hubble and webb are the kings of the

2250

01:28:25,910 --> 01:28:23,520

sky of the or uh the space telescopes

2251
01:28:27,590 --> 01:28:25,920
and getting the resolution but uh going

2252
01:28:29,590 --> 01:28:27,600
to the uh

2253
01:28:31,350 --> 01:28:29,600
millimeter and radio wavelengths where

2254
01:28:33,590 --> 01:28:31,360
you can get these big arrays to have the

2255
01:28:35,189 --> 01:28:33,600
really fine resolution um i'm sure

2256
01:28:36,790 --> 01:28:35,199
you'll be able to figure out some cool

2257
01:28:40,070 --> 01:28:36,800
ways to involve them

2258
01:28:42,149 --> 01:28:40,080
into adding more to the the information

2259
01:28:43,990 --> 01:28:42,159
uh that you get to sort and to find out

2260
01:28:46,070 --> 01:28:44,000
the input absolutely

2261
01:28:48,790 --> 01:28:46,080
so there's already you know this this

2262
01:28:50,550 --> 01:28:48,800
james webb alma synergy is something

2263
01:28:52,229 --> 01:28:50,560

that everybody is really looking forward

2264

01:28:55,110 --> 01:28:52,239

to because alma

2265

01:28:57,510 --> 01:28:55,120

probes physical mechanisms and you know

2266

01:29:00,709 --> 01:28:57,520

frequencies or wavelengths that james

2267

01:29:02,790 --> 01:29:00,719

webb does not probe and so you know one

2268

01:29:05,830 --> 01:29:02,800

example for instance of how

2269

01:29:08,629 --> 01:29:05,840

two examples let's say of how we want to

2270

01:29:11,030 --> 01:29:08,639

use this synergy is uh let's say the

2271

01:29:13,350 --> 01:29:11,040

confirmation for instance of

2272

01:29:15,910 --> 01:29:13,360

redshifts or distances you know as an

2273

01:29:18,629 --> 01:29:15,920

example if we if we get a so-called

2274

01:29:21,189 --> 01:29:18,639

dropout galaxy like i showed with james

2275

01:29:23,990 --> 01:29:21,199

webb which does not show we we do not

2276

01:29:25,750 --> 01:29:24,000

have spectroscopy for that one avenue is

2277

01:29:27,750 --> 01:29:25,760

possibly we can try and get a spectrum

2278

01:29:29,270 --> 01:29:27,760

of lyman alpha which might not show

2279

01:29:31,510 --> 01:29:29,280

because it might be

2280

01:29:33,990 --> 01:29:31,520

absorbed by the intervening hydrogen at

2281

01:29:36,390 --> 01:29:34,000

that epoch so we might look for emission

2282

01:29:38,229 --> 01:29:36,400

lines with alma which looks for oxygen

2283

01:29:40,950 --> 01:29:38,239

traces for instance like i had shown

2284

01:29:42,950 --> 01:29:40,960

before and that oxygen is not

2285

01:29:44,470 --> 01:29:42,960

affected by the surrounding medium of

2286

01:29:47,669 --> 01:29:44,480

those galaxies so

2287

01:29:50,149 --> 01:29:47,679

james webb would would find these

2288

01:29:53,189 --> 01:29:50,159

distant candidates alma might confirm

2289

01:29:56,390 --> 01:29:53,199

another one again is dust uh you know um

2290

01:29:59,910 --> 01:29:56,400

alma really probes uh the dusts that

2291

01:30:01,669 --> 01:29:59,920

james webb cannot and so trying to um

2292

01:30:03,430 --> 01:30:01,679

maximize the synergy between the two

2293

01:30:05,669 --> 01:30:03,440

telescopes to try and understand where

2294

01:30:06,550 --> 01:30:05,679

this dust is coming from and how much is

2295

01:30:08,870 --> 01:30:06,560

there

2296

01:30:09,830 --> 01:30:08,880

is really really important

2297

01:30:11,830 --> 01:30:09,840

all right

2298

01:30:14,229 --> 01:30:11,840

i think we're gonna let you have one

2299

01:30:16,390 --> 01:30:14,239

more question so grant uh find a good

2300

01:30:17,669 --> 01:30:16,400

one to end with here

2301

01:30:20,149 --> 01:30:17,679

because all right

2302

01:30:21,430 --> 01:30:20,159

we've gone on long enough here

2303

01:30:24,070 --> 01:30:21,440

that's fair

2304

01:30:26,709 --> 01:30:24,080

i'm noticing an ongoing theme to these

2305

01:30:29,669 --> 01:30:26,719

questions as well um so you did mention

2306

01:30:31,669 --> 01:30:29,679

that you had some that obviously we've

2307

01:30:34,870 --> 01:30:31,679

always had some issues observing and

2308

01:30:37,030 --> 01:30:34,880

quantifying dark matter but

2309

01:30:39,510 --> 01:30:37,040

he said some dwarf galaxies appear to

2310

01:30:41,830 --> 01:30:39,520

have little or no dark matter associated

2311

01:30:43,669 --> 01:30:41,840

based on observation so far

2312

01:30:48,870 --> 01:30:43,679

do you find this to be a theme with

2313

01:30:54,310 --> 01:30:51,750

that's a good question uh this isn't

2314

01:30:57,750 --> 01:30:54,320

something that we've

2315

01:30:58,870 --> 01:30:57,760

explored with james webb uh yet

2316

01:31:01,189 --> 01:30:58,880

um

2317

01:31:03,350 --> 01:31:01,199

not directly at least what

2318

01:31:05,350 --> 01:31:03,360

the one thing i'll say with that is is

2319

01:31:06,709 --> 01:31:05,360

if we compare so the the standard

2320

01:31:09,189 --> 01:31:06,719

assumption is that

2321

01:31:12,550 --> 01:31:09,199

galaxies form within halos of dark

2322

01:31:14,310 --> 01:31:12,560

matter that the the dark matter and and

2323

01:31:16,229 --> 01:31:14,320

the evolution of the dark matter halo

2324

01:31:19,510 --> 01:31:16,239

and of the galaxy itself this so-called

2325

01:31:21,350 --> 01:31:19,520

regular matter is linked together

2326

01:31:23,910 --> 01:31:21,360

and our models and our observations with

2327

01:31:26,550 --> 01:31:23,920

hubble appear to agree

2328

01:31:28,709 --> 01:31:26,560

however this age dating let's say of the

2329

01:31:31,590 --> 01:31:28,719

stars and the fact that we're finding

2330

01:31:35,110 --> 01:31:31,600

now a lot more distant galaxies with

2331

01:31:36,870 --> 01:31:35,120

james webb does not agree with our

2332

01:31:39,669 --> 01:31:36,880

models of the evolution of dark matter

2333

01:31:41,590 --> 01:31:39,679

halos so it suggests that there could be

2334

01:31:45,110 --> 01:31:41,600

some something we don't understand some

2335

01:31:46,950 --> 01:31:45,120

apparent decoupling let's say um

2336

01:31:49,270 --> 01:31:46,960

so that's where the uncertainty sort of

2337

01:31:51,030 --> 01:31:49,280

arises we don't know if our models of

2338

01:31:52,950 --> 01:31:51,040

dark matter

2339

01:31:54,310 --> 01:31:52,960

perhaps are missing something it's

2340

01:31:56,310 --> 01:31:54,320

entirely possible we're missing

2341

01:31:57,510 --> 01:31:56,320

something or else

2342

01:31:59,430 --> 01:31:57,520

you know maybe we're looking at a

2343

01:32:01,669 --> 01:31:59,440

particular patch of the sky which seems

2344

01:32:03,030 --> 01:32:01,679

to have a lot of distant galaxies that

2345

01:32:04,950 --> 01:32:03,040

is representative

2346

01:32:07,270 --> 01:32:04,960

or something something's gone wrong we

2347

01:32:09,189 --> 01:32:07,280

don't know or you know it's it's great

2348

01:32:10,310 --> 01:32:09,199

that we have this to figure out but in

2349

01:32:12,629 --> 01:32:10,320

terms of

2350

01:32:15,270 --> 01:32:12,639

these dwarf galaxies which you mentioned

2351
01:32:17,350 --> 01:32:15,280
we have not done this sort of analysis

2352
01:32:18,709 --> 01:32:17,360
with these ultra distant characters

2353
01:32:19,910 --> 01:32:18,719
that's not something we've looked at

2354
01:32:23,030 --> 01:32:19,920
directly

2355
01:32:26,390 --> 01:32:23,040
only on a statistical level right

2356
01:32:28,149 --> 01:32:26,400
you know the as we assemble all these

2357
01:32:30,149 --> 01:32:28,159
all these observations and uh do

2358
01:32:31,910 --> 01:32:30,159
multiple fields and everything as the

2359
01:32:34,550 --> 01:32:31,920
statistics are going to get larger and

2360
01:32:36,950 --> 01:32:34,560
larger uh and we'll be able to tell are

2361
01:32:38,390 --> 01:32:36,960
we looking at special regions are we not

2362
01:32:40,550 --> 01:32:38,400
um

2363
01:32:43,189 --> 01:32:40,560

we're seeing a lot of galaxies all that

2364

01:32:45,750 --> 01:32:43,199

just all i can say is that uh that makes

2365

01:32:47,669 --> 01:32:45,760

it very exciting and so they're

2366

01:32:51,590 --> 01:32:47,679

i do not expect it to fit with what i

2367

01:32:55,270 --> 01:32:53,510

all right but it's wonderful that that

2368

01:32:56,629 --> 01:32:55,280

we're learning new things

2369

01:32:58,149 --> 01:32:56,639

that's what's great about it that is

2370

01:33:00,310 --> 01:32:58,159

science right if we didn't learn new

2371

01:33:01,990 --> 01:33:00,320

things we wouldn't be doing our job

2372

01:33:03,910 --> 01:33:02,000

that's right so after webb's been up for

2373

01:33:05,830 --> 01:33:03,920

a bit we'll have to have part two so

2374

01:33:07,750 --> 01:33:05,840

what you're saying most definitely this

2375

01:33:10,870 --> 01:33:07,760

this this is not the last we're going to

2376

01:33:12,709 --> 01:33:10,880

hear from guido on this on this

2377

01:33:15,270 --> 01:33:12,719

side that's right our next data set will

2378

01:33:17,830 --> 01:33:15,280

be arriving end of october or november

2379

01:33:23,590 --> 01:33:19,510

all right uh

2380

01:33:24,470 --> 01:33:23,600

until such time uh you also stay tuned

2381

01:33:28,229 --> 01:33:24,480

um

2382

01:33:32,629 --> 01:33:28,239

next month on october 4th the universe

2383

01:33:33,910 --> 01:33:32,639

of dante alighieri please join us until

2384

01:33:36,470 --> 01:33:33,920

that time