

1
00:00:00,030 --> 00:00:05,040
you've got one of these our lithographed

2
00:00:02,490 --> 00:00:10,410
we're doing tonight is the bubble nebula

3
00:00:05,040 --> 00:00:13,048
also know this NGC 76 35 and it's a

4
00:00:10,410 --> 00:00:16,170
beautiful beautiful blue bubble of a

5
00:00:13,048 --> 00:00:18,570
nebula blown by that star in the center

6
00:00:16,170 --> 00:00:20,970
there if you want to understand how this

7
00:00:18,570 --> 00:00:23,698
all happens you can turn over on the

8
00:00:20,969 --> 00:00:26,848
back and there are there are a few

9
00:00:23,699 --> 00:00:30,449
paragraphs explaining what's going on in

10
00:00:26,849 --> 00:00:34,409
this nebula tonight's talk will be

11
00:00:30,449 --> 00:00:37,230
initial exoplanet discoveries with Tess

12
00:00:34,409 --> 00:00:39,119
and I will say that I heard a whole

13
00:00:37,229 --> 00:00:41,398
bunch about the test discoveries last

14
00:00:39,119 --> 00:00:43,289
week I'm waiting for Scott here tonight

15
00:00:41,399 --> 00:00:46,079
to clarify them for me so I really

16
00:00:43,289 --> 00:00:47,549
really understand them because it was at

17
00:00:46,079 --> 00:00:49,980
the American Astronomical Society

18
00:00:47,549 --> 00:00:52,159
meeting last week and it's a whirlwind

19
00:00:49,979 --> 00:00:54,209
week you get presented so many results

20
00:00:52,159 --> 00:00:57,179
it'll be nice to be able to sit back and

21
00:00:54,210 --> 00:00:58,070
relax and really enjoy Scott's talk

22
00:00:57,179 --> 00:01:01,079
tonight

23
00:00:58,070 --> 00:01:04,530
next month February we have your place

24
00:01:01,079 --> 00:01:07,978
in the stars from mi Amoro Martin here

25
00:01:04,530 --> 00:01:12,239
at Space Telescope and in March and

26
00:01:07,978 --> 00:01:14,429
April we have the infamous TBA which

27
00:01:12,239 --> 00:01:17,368
means actually that is very hard to

28
00:01:14,430 --> 00:01:19,860
pigeonhole astronomers to commit before

29

00:01:17,368 --> 00:01:21,780
the holidays so now that it's past the

30
00:01:19,859 --> 00:01:23,700
holidays and past the double-a s meeting

31
00:01:21,780 --> 00:01:25,560
I could actually start getting them to

32
00:01:23,700 --> 00:01:27,420
commit and I will fill out the calendar

33
00:01:25,560 --> 00:01:30,060
for the rest of the year all right

34
00:01:27,420 --> 00:01:33,659
please check the website Oh what website

35
00:01:30,060 --> 00:01:35,790
you say well here this is our website

36
00:01:33,659 --> 00:01:37,200
for the public lecture series if you go

37
00:01:35,790 --> 00:01:39,810
to your favorite search engine and type

38
00:01:37,200 --> 00:01:44,250
in Space Telescope public lecture series

39
00:01:39,810 --> 00:01:46,439
you'll find this which has which has the

40
00:01:44,250 --> 00:01:50,069
link to the upcoming lectures over here

41
00:01:46,438 --> 00:01:53,398
it has our links to our live webcasting

42
00:01:50,069 --> 00:01:56,459
as well as our past lectures all the way

43
00:01:53,399 --> 00:01:58,680

back to 2005 for some of them although

44

00:01:56,459 --> 00:02:02,218

those are low resolution stuff the stuff

45

00:01:58,680 --> 00:02:06,180

since 2014 is all the high resolution HD

46

00:02:02,218 --> 00:02:09,149

stuff and you can also sign up for our

47

00:02:06,180 --> 00:02:11,870

email list speaking of our email list

48

00:02:09,149 --> 00:02:13,969

these are just announcements that we do

49

00:02:11,870 --> 00:02:16,069

once or twice a month to

50

00:02:13,969 --> 00:02:17,330

tell you of the next lecture and where

51

00:02:16,069 --> 00:02:20,180

the other liked lectures when the

52

00:02:17,330 --> 00:02:22,670

lectures are webcast and archive is

53

00:02:20,180 --> 00:02:26,599

posted etc and so far we haven't had any

54

00:02:22,669 --> 00:02:29,209

span if you have comments or questions

55

00:02:26,599 --> 00:02:34,039

and you can send them to us at public

56

00:02:29,210 --> 00:02:37,189

lecture at STScI dot edu ok ah social

57

00:02:34,039 --> 00:02:38,359

media Hubbell the James Webb Space

58
00:02:37,189 --> 00:02:40,129
Telescope and the Space Telescope

59
00:02:38,360 --> 00:02:42,230
Science Institute have the variety of

60
00:02:40,129 --> 00:02:44,840
Facebook and Twitter and YouTube and

61
00:02:42,229 --> 00:02:47,840
Instagram and myself I do a tiny bit on

62
00:02:44,840 --> 00:02:50,719
Facebook Google+ and Twitter if you are

63
00:02:47,840 --> 00:02:52,280
so interested now across the street we

64
00:02:50,719 --> 00:02:56,209
have the Maryland Space Grant

65
00:02:52,280 --> 00:02:58,209
Observatory and every month we ask them

66
00:02:56,209 --> 00:03:01,189
are you going to be open tonight

67
00:02:58,209 --> 00:03:03,860
unfortunately tonight there is ice on

68
00:03:01,189 --> 00:03:06,530
the roof that leads to the observatory

69
00:03:03,860 --> 00:03:09,290
and they were told they cannot have a

70
00:03:06,530 --> 00:03:10,909
public group like this come over when

71
00:03:09,289 --> 00:03:13,969
there's ice until they get that gets

72
00:03:10,909 --> 00:03:16,549
cleared off so they do have open houses

73
00:03:13,969 --> 00:03:18,979
on Friday evenings if you go to MD dot

74
00:03:16,550 --> 00:03:20,840
space grant RG

75
00:03:18,979 --> 00:03:22,488
you will find you can find this web page

76
00:03:20,840 --> 00:03:25,640
where they talk about the observatory

77
00:03:22,489 --> 00:03:27,890
status and by like 5:30 on Friday

78
00:03:25,639 --> 00:03:30,199
evenings they post whether or not though

79
00:03:27,889 --> 00:03:32,268
we doing observing there so sorry no

80
00:03:30,199 --> 00:03:35,689
observing tonight but please check the

81
00:03:32,269 --> 00:03:40,159
website for more and now our news from

82
00:03:35,689 --> 00:03:43,939
the universe for January 2019 get to say

83
00:03:40,159 --> 00:03:47,139
a new year 2019 all right our first

84
00:03:43,939 --> 00:03:49,879
story tonight star clusters within

85
00:03:47,139 --> 00:03:51,649
galaxy clusters I was actually just

86

00:03:49,879 --> 00:03:53,719
having a discussion with one of our

87
00:03:51,650 --> 00:03:55,219
writers today she was just getting

88
00:03:53,719 --> 00:03:57,590
annoyed with having to write the word

89
00:03:55,219 --> 00:03:59,750
cluster so many times and it can mean so

90
00:03:57,590 --> 00:04:02,360
many different things well let's start

91
00:03:59,750 --> 00:04:05,599
with these star clusters because this is

92
00:04:02,360 --> 00:04:07,400
the globular star cluster Messier 80 and

93
00:04:05,599 --> 00:04:10,609
these globular star clusters are the

94
00:04:07,400 --> 00:04:12,469
really rich big star clusters that you

95
00:04:10,610 --> 00:04:14,720
contain as few as like ten thousand

96
00:04:12,469 --> 00:04:17,750
stars as many as a hundred thousand

97
00:04:14,719 --> 00:04:21,139
stars or even a few million stars these

98
00:04:17,750 --> 00:04:24,319
are giant star clusters and there

99
00:04:21,139 --> 00:04:26,329
are these are really good tracers of

100
00:04:24,319 --> 00:04:28,069

star clusters because there's there's

101

00:04:26,329 --> 00:04:31,459
because they can be so mass

102

00:04:28,069 --> 00:04:34,430
they can be seen very bright okay now

103

00:04:31,459 --> 00:04:36,288
when we're talking galaxy clusters one

104

00:04:34,430 --> 00:04:40,400
of the most famous is the Coma Cluster

105

00:04:36,288 --> 00:04:42,949
of galaxies kcoma is one of the biggest

106

00:04:40,399 --> 00:04:45,258
galaxy clusters out there it can galaxy

107

00:04:42,949 --> 00:04:48,499
clusters contain hundreds to thousands

108

00:04:45,259 --> 00:04:50,810
to even 10,000 galaxies kcoma contains

109

00:04:48,499 --> 00:04:53,659
several thousand galaxies and it's

110

00:04:50,810 --> 00:04:57,050
located about 300 million light-years

111

00:04:53,658 --> 00:04:59,389
away so what's the connection between

112

00:04:57,050 --> 00:05:04,189
these star clusters and these galaxy

113

00:04:59,389 --> 00:05:07,250
clusters well inside galaxy clusters we

114

00:05:04,189 --> 00:05:11,479
get a lot of this galaxy collisions

115
00:05:07,250 --> 00:05:13,879
because you have a dense environment for

116
00:05:11,478 --> 00:05:17,959
galaxies the galaxies can interact they

117
00:05:13,879 --> 00:05:20,930
can collide okay and two things happen

118
00:05:17,959 --> 00:05:23,299
one we have evidence from computer

119
00:05:20,930 --> 00:05:25,310
simulations this is a visualization of a

120
00:05:23,300 --> 00:05:28,728
computer simulation that during these

121
00:05:25,310 --> 00:05:31,579
galaxy collisions globular star cluster

122
00:05:28,728 --> 00:05:34,250
like things can be created so in the

123
00:05:31,579 --> 00:05:36,620
title tail of this galaxy here you can

124
00:05:34,250 --> 00:05:38,478
see these white dots okay and in this

125
00:05:36,620 --> 00:05:41,149
title tail you can see these white dots

126
00:05:38,478 --> 00:05:44,930
and the computer simulations show that

127
00:05:41,149 --> 00:05:46,698
these look like globular clusters so

128
00:05:44,930 --> 00:05:49,189
that you can create clobber your

129
00:05:46,699 --> 00:05:50,960
clusters during galaxy collisions the

130
00:05:49,189 --> 00:05:53,000
other thing that happens in galaxy

131
00:05:50,959 --> 00:05:56,239
collisions is that these star clusters

132
00:05:53,000 --> 00:05:59,028
actually become disassociated with the

133
00:05:56,240 --> 00:06:01,460
galaxies because they can actually get

134
00:05:59,028 --> 00:06:03,769
flung out to large distances and they

135
00:06:01,459 --> 00:06:06,168
are no longer bound to an individual

136
00:06:03,769 --> 00:06:10,128
galaxy but instead they're spread

137
00:06:06,168 --> 00:06:14,870
throughout the galaxy cluster so could

138
00:06:10,129 --> 00:06:18,770
we look for four star clusters within

139
00:06:14,870 --> 00:06:20,468
galaxy clusters and remember coma is 300

140
00:06:18,769 --> 00:06:24,438
million light years away

141
00:06:20,468 --> 00:06:27,829
what telescope could possibly have the

142
00:06:24,439 --> 00:06:31,039
incredibly exquisite resolution to be

143

00:06:27,829 --> 00:06:32,870
able to see globular clusters in a

144
00:06:31,038 --> 00:06:34,088
galaxy cluster 300 million light-years

145
00:06:32,870 --> 00:06:37,870
away

146
00:06:34,088 --> 00:06:42,399
of course it's everyone's favorite Oh

147
00:06:37,870 --> 00:06:44,470
this image is what is it this image is

148
00:06:42,399 --> 00:06:47,529
like twenty five thousand by sixteen

149
00:06:44,470 --> 00:06:50,590
thousand pixels so that orange rectangle

150
00:06:47,529 --> 00:06:53,978
I put there that is a full HD two

151
00:06:50,589 --> 00:06:55,750
million school pixel 1920 by 1080

152
00:06:53,978 --> 00:06:57,728
resolution let me blow that out for you

153
00:06:55,750 --> 00:07:00,370
so I blow up that orange rectangle there

154
00:06:57,728 --> 00:07:03,159
this is what Hubble actually sees at

155
00:07:00,370 --> 00:07:05,040
full resolution that's kind of cool for

156
00:07:03,160 --> 00:07:07,840
something 300 million light years away

157
00:07:05,040 --> 00:07:10,240

now can you see anything that might be a

158

00:07:07,839 --> 00:07:13,119

globular star cluster there are all

159

00:07:10,240 --> 00:07:14,889

these little dots there and and they

160

00:07:13,120 --> 00:07:16,329

could be stars in our own Milky Way

161

00:07:14,889 --> 00:07:18,910

galaxy that just happened to be in the

162

00:07:16,329 --> 00:07:21,969

foreground they could be star clusters

163

00:07:18,910 --> 00:07:25,930

in coma or they could be galaxies way in

164

00:07:21,970 --> 00:07:28,960

the background who knows well a research

165

00:07:25,930 --> 00:07:31,720

group went in and they did a cluster

166

00:07:28,959 --> 00:07:34,769

finding algorithm to determine what all

167

00:07:31,720 --> 00:07:39,240

these little dots are and the answer is

168

00:07:34,769 --> 00:07:43,029

most of them are globular star clusters

169

00:07:39,240 --> 00:07:45,879

yes every green circle identifies one

170

00:07:43,029 --> 00:07:49,179

globular star cluster in the Coma

171

00:07:45,879 --> 00:07:51,639

Cluster of galaxies so that's just one

172
00:07:49,180 --> 00:07:55,060
small portion of that image here we go

173
00:07:51,639 --> 00:07:59,639
out to the entire image there are 22

174
00:07:55,060 --> 00:08:03,160
thousand 429 globular star clusters

175
00:07:59,639 --> 00:08:06,819
found in the coma cluster with this new

176
00:08:03,160 --> 00:08:09,099
survey that's kind of cool we're looking

177
00:08:06,819 --> 00:08:12,189
300 million light years away and we're

178
00:08:09,098 --> 00:08:15,219
finding over 22,000 globular star

179
00:08:12,189 --> 00:08:17,168
clusters that's a huge population to

180
00:08:15,220 --> 00:08:20,620
study you can do all sorts of cool

181
00:08:17,168 --> 00:08:24,310
things with that kind of population but

182
00:08:20,620 --> 00:08:26,470
as I said before these star clusters

183
00:08:24,310 --> 00:08:29,110
have disassociated from their individual

184
00:08:26,470 --> 00:08:31,450
galaxies and they're now associated with

185
00:08:29,110 --> 00:08:34,538
the whole cluster and that gives you

186
00:08:31,449 --> 00:08:37,950
something else you can do which is our

187
00:08:34,538 --> 00:08:43,269
second story so the second story is

188
00:08:37,950 --> 00:08:44,770
visible tracers of dark matter so we're

189
00:08:43,269 --> 00:08:46,958
not going to talk about the Coma Cluster

190
00:08:44,769 --> 00:08:49,120
although this can be done for the Coma

191
00:08:46,958 --> 00:08:51,379
Cluster - we're going to talk about the

192
00:08:49,120 --> 00:08:54,269
galaxy cluster Abell

193
00:08:51,379 --> 00:08:59,129
s106 three it's part of the frontier

194
00:08:54,269 --> 00:09:01,169
fields program okay and this is a galaxy

195
00:08:59,129 --> 00:09:04,080
cluster that's so massive it has

196
00:09:01,169 --> 00:09:07,169
gravitational lensing there's so much

197
00:09:04,080 --> 00:09:09,300
mass mass warps the space and you can

198
00:09:07,169 --> 00:09:12,120
see these streaky are key things here

199
00:09:09,299 --> 00:09:14,429
those are gravitational lenses now

200

00:09:12,120 --> 00:09:16,470
gravitational lenses are due to the mass

201
00:09:14,429 --> 00:09:18,989
and if you measure the amount of

202
00:09:16,470 --> 00:09:21,870
gravitational lensing you can understand

203
00:09:18,990 --> 00:09:25,139
the mass so here is the cluster as seen

204
00:09:21,870 --> 00:09:27,269
from the Hubble image here is a map

205
00:09:25,139 --> 00:09:29,789
showing you a lot of the gravitational

206
00:09:27,269 --> 00:09:32,730
lensing effects that they've uncovered

207
00:09:29,789 --> 00:09:34,589
here and from those measurements of

208
00:09:32,730 --> 00:09:37,980
gravitational lensing they can then

209
00:09:34,590 --> 00:09:40,500
create a mass map of the cluster and

210
00:09:37,980 --> 00:09:43,860
this is the mass map of the cluster

211
00:09:40,500 --> 00:09:47,700
showing you the the contour lines of the

212
00:09:43,860 --> 00:09:52,649
mass inside the cluster now the cluster

213
00:09:47,700 --> 00:09:56,190
mass is dominated 80% by dark matter

214
00:09:52,649 --> 00:09:58,919

right the galaxies are tracers of it in

215

00:09:56,190 --> 00:10:02,160

some way but they're only 20% of their

216

00:09:58,919 --> 00:10:04,079

normal matter is at most 20% of the

217

00:10:02,159 --> 00:10:06,029

material in this cluster so we're trying

218

00:10:04,080 --> 00:10:08,370

to figure out where this dark matter is

219

00:10:06,029 --> 00:10:11,490

so by using gravitational lensing we can

220

00:10:08,370 --> 00:10:13,200

get an idea of where it is but that's

221

00:10:11,490 --> 00:10:14,730

sort of an indirect method because we're

222

00:10:13,200 --> 00:10:17,490

measuring the gravitational lensing to

223

00:10:14,730 --> 00:10:21,120

infer the mass distribution wouldn't it

224

00:10:17,490 --> 00:10:23,039

be cool if we had some some light

225

00:10:21,120 --> 00:10:25,049

luminous stuff that sort of spread

226

00:10:23,039 --> 00:10:27,569

across the entire and galaxy cluster

227

00:10:25,049 --> 00:10:30,870

that could tell us what the potential of

228

00:10:27,570 --> 00:10:33,839

the cluster is like those star clusters

229
00:10:30,870 --> 00:10:37,019
we just discussed so what the team did

230
00:10:33,839 --> 00:10:39,690
is they went into that Hubble image and

231
00:10:37,019 --> 00:10:41,730
they went very carefully into it to try

232
00:10:39,690 --> 00:10:44,700
and get rid of all the under normal

233
00:10:41,730 --> 00:10:47,039
light and pull out that very faint

234
00:10:44,700 --> 00:10:48,450
background light a very faint in truck

235
00:10:47,039 --> 00:10:50,819
cluster like the light between the

236
00:10:48,450 --> 00:10:54,780
galaxies okay and when they did that

237
00:10:50,820 --> 00:10:57,780
they're able to pull out that blue map

238
00:10:54,779 --> 00:11:00,149
there so this is the the galaxy cluster

239
00:10:57,779 --> 00:11:03,419
image with that blue map being that

240
00:11:00,149 --> 00:11:04,709
intra cluster light inferred from things

241
00:11:03,419 --> 00:11:06,569
like the star

242
00:11:04,710 --> 00:11:10,950
clusters that are orbiting within the

243
00:11:06,570 --> 00:11:14,580
galaxy cluster and using this they could

244
00:11:10,950 --> 00:11:17,340
use this as a tracer of the mass because

245
00:11:14,580 --> 00:11:20,100
they also have a gravitational lensing

246
00:11:17,340 --> 00:11:22,379
mass map they can correlate the two and

247
00:11:20,100 --> 00:11:25,860
they find that it correlates extremely

248
00:11:22,379 --> 00:11:29,220
well so this very faint intra cluster

249
00:11:25,860 --> 00:11:31,470
light that they can in certain clusters

250
00:11:29,220 --> 00:11:34,259
of galaxies relate to the mass map by a

251
00:11:31,470 --> 00:11:36,450
gravitational lensing shoes uses that as

252
00:11:34,259 --> 00:11:38,220
a calibration to show that for other

253
00:11:36,450 --> 00:11:40,470
clusters they can take that inter

254
00:11:38,220 --> 00:11:43,230
cluster light and then use that as a

255
00:11:40,470 --> 00:11:48,389
visible tracer of the dark matter in

256
00:11:43,230 --> 00:11:51,379
galaxy clusters cool all right finally

257

00:11:48,389 --> 00:11:54,149
our third story which I could not ignore

258
00:11:51,379 --> 00:11:58,379
contact in the Kuiper belt

259
00:11:54,149 --> 00:12:02,699
so yeah the New Horizons mission was

260
00:11:58,379 --> 00:12:04,919
launched in 2006 and it went past

261
00:12:02,700 --> 00:12:07,680
Jupiter and it spent basically almost

262
00:12:04,919 --> 00:12:11,819
ten years nine years getting out to the

263
00:12:07,679 --> 00:12:15,929
Pluto Charon system and in July of 2015

264
00:12:11,820 --> 00:12:19,080
they flyby of Pluto and Charon and Nix

265
00:12:15,929 --> 00:12:23,759
and Hydra and I figure what the other

266
00:12:19,080 --> 00:12:26,550
ones are called fix and Kerberos yes all

267
00:12:23,759 --> 00:12:28,830
six objects in the Pluto Charon system

268
00:12:26,549 --> 00:12:30,689
and they're able to get amazing things

269
00:12:28,830 --> 00:12:31,950
and they've had a great success and

270
00:12:30,690 --> 00:12:34,020
they're out there and they're out

271
00:12:31,950 --> 00:12:36,330

exploring the Kuiper belt and they said

272

00:12:34,019 --> 00:12:38,579

we want to do more okay because this is

273

00:12:36,330 --> 00:12:41,610

actually the first mission to the Kuiper

274

00:12:38,580 --> 00:12:44,280

belt okay and they said please please

275

00:12:41,610 --> 00:12:45,600

can we do more and well NASA of course

276

00:12:44,279 --> 00:12:49,470

says well what are you gonna look at

277

00:12:45,600 --> 00:12:52,800

they go oh yeah okay Hubble can you help

278

00:12:49,470 --> 00:12:54,690

us so Hubble went and looked and Hubble

279

00:12:52,799 --> 00:12:57,299

went out and found a bunch of Kuiper

280

00:12:54,690 --> 00:12:59,790

belt objects these ones in the green

281

00:12:57,299 --> 00:13:01,740

circles here this is the motion of those

282

00:12:59,789 --> 00:13:03,449

objects over a period of time

283

00:13:01,740 --> 00:13:05,399

that's how Hubble finds things in the

284

00:13:03,450 --> 00:13:07,290

solar system it just looks and anything

285

00:13:05,399 --> 00:13:10,470

that stays stationary is way distant

286
00:13:07,289 --> 00:13:12,329
anything that starts moving is inside

287
00:13:10,470 --> 00:13:14,910
the solar system it found a couple

288
00:13:12,330 --> 00:13:17,100
candidate Kuiper belt objects and

289
00:13:14,909 --> 00:13:18,149
eventually they found one that worked

290
00:13:17,100 --> 00:13:19,830
for the cut for the

291
00:13:18,149 --> 00:13:21,600
horizons mission so they didn't have to

292
00:13:19,830 --> 00:13:25,080
use too much fuel to steer towards it

293
00:13:21,600 --> 00:13:28,500
and appeared to be some object that

294
00:13:25,080 --> 00:13:31,740
might be of interest it was called 2014

295
00:13:28,500 --> 00:13:36,090
mu 69 yeah that just rolls off the

296
00:13:31,740 --> 00:13:37,649
tongue 2014 mu 69 yes so the folks who

297
00:13:36,090 --> 00:13:39,269
run the mission said you know what we

298
00:13:37,649 --> 00:13:43,490
want to give it a nickname they ran a

299
00:13:39,269 --> 00:13:46,110
contest and its nickname is old tomorrow

300
00:13:43,490 --> 00:13:47,669
I have no idea if that's how you

301
00:13:46,110 --> 00:13:49,139
pronounce it I was supposed to be

302
00:13:47,669 --> 00:13:52,459
pronounced but it's just so much fun to

303
00:13:49,139 --> 00:13:56,159
say it's a tumor

304
00:13:52,460 --> 00:14:01,460
so they redirected the mission to pass

305
00:13:56,159 --> 00:14:06,990
by 2014 and you 69 when on January 1st

306
00:14:01,460 --> 00:14:09,120
2019 but they still wanted to know what

307
00:14:06,990 --> 00:14:11,190
they were going to go if they were going

308
00:14:09,120 --> 00:14:13,049
to find they had guys with Pluto we had

309
00:14:11,190 --> 00:14:14,760
you know 60 years of observations to

310
00:14:13,049 --> 00:14:16,559
understand what we were gonna find we

311
00:14:14,759 --> 00:14:19,139
had almost no observations you saw the

312
00:14:16,559 --> 00:14:23,309
dots right yeah it doesn't tell you much

313
00:14:19,139 --> 00:14:26,610
so what they did is they went around the

314

00:14:23,309 --> 00:14:29,939
globe and they found places where mu 69

315
00:14:26,610 --> 00:14:32,100
would actually occult a star alright and

316
00:14:29,940 --> 00:14:33,870
the stars light would drop when it

317
00:14:32,100 --> 00:14:37,560
passed it over and then rise back up and

318
00:14:33,870 --> 00:14:40,560
so they actually had teams at different

319
00:14:37,559 --> 00:14:43,229
latitudes watching during the

320
00:14:40,559 --> 00:14:45,449
occultation and those down here didn't

321
00:14:43,230 --> 00:14:47,970
see any occultation those up here didn't

322
00:14:45,450 --> 00:14:49,230
see any occultation here it's they saw

323
00:14:47,970 --> 00:14:52,170
an authorization from here to here here

324
00:14:49,230 --> 00:14:55,800
to here here to here and what you get is

325
00:14:52,169 --> 00:14:58,949
an actual map of the shape of Ultima

326
00:14:55,799 --> 00:15:01,589
Thule on the earth from the occupations

327
00:14:58,950 --> 00:15:03,750
they went down and they map out the

328
00:15:01,590 --> 00:15:07,860

shape the expected shape multi-mode too

329

00:15:03,750 --> 00:15:09,659

late using occultation x' an amazing

330

00:15:07,860 --> 00:15:12,360

work mark view he gave a talk here a few

331

00:15:09,659 --> 00:15:15,419

weeks ago and he actually was so

332

00:15:12,360 --> 00:15:17,669

confident this he made a 3d model of

333

00:15:15,419 --> 00:15:21,209

what he expected Ultima Thule to look

334

00:15:17,669 --> 00:15:23,549

like before the encounter and when the

335

00:15:21,210 --> 00:15:27,170

encounter happened here he is showing

336

00:15:23,549 --> 00:15:31,359

his model against the observations

337

00:15:27,169 --> 00:15:34,039

is this guy good or what okay

338

00:15:31,360 --> 00:15:36,740

unbelievable that a predicted very

339

00:15:34,039 --> 00:15:39,259

accurately using these occupations the

340

00:15:36,740 --> 00:15:41,810

shape of Ultima Thule that's one of the

341

00:15:39,259 --> 00:15:43,730

low resolutions image from Lori on the

342

00:15:41,809 --> 00:15:46,809

way in but when they had time to get

343
00:15:43,730 --> 00:15:50,778
more data here's what it looked like

344
00:15:46,809 --> 00:15:54,109
that is our that is our snowman in the

345
00:15:50,778 --> 00:15:56,659
Kuiper belt basically it is a contact

346
00:15:54,110 --> 00:15:59,329
binary why I call um so it means that

347
00:15:56,659 --> 00:16:01,879
this object here and this object here

348
00:15:59,328 --> 00:16:05,120
obviously formed separately but then

349
00:16:01,879 --> 00:16:07,220
Smok together like two snowballs and

350
00:16:05,120 --> 00:16:09,528
formed a snowman that's floating around

351
00:16:07,220 --> 00:16:13,339
in the Kuiper belt four billion miles

352
00:16:09,528 --> 00:16:16,370
away from you and the real hope here is

353
00:16:13,339 --> 00:16:18,079
that the study of this will teach us a

354
00:16:16,370 --> 00:16:20,209
bit about the early solar system because

355
00:16:18,078 --> 00:16:22,429
when we have comets that come into the

356
00:16:20,208 --> 00:16:25,729
inner solar system they melt and that

357
00:16:22,429 --> 00:16:28,699
gases flow away the ices flow away and

358
00:16:25,730 --> 00:16:30,860
they've been changed a lot this object

359
00:16:28,700 --> 00:16:34,040
hopefully it's sitting out there in the

360
00:16:30,860 --> 00:16:36,949
main Kuiper belt out it's you know what

361
00:16:34,039 --> 00:16:40,219
40 astronomical units away probably has

362
00:16:36,948 --> 00:16:41,448
not undergone that much change in its in

363
00:16:40,220 --> 00:16:44,329
the four and half billion year history

364
00:16:41,448 --> 00:16:47,539
of the solar system so the hope is when

365
00:16:44,328 --> 00:16:49,429
they study what the surface of the

366
00:16:47,539 --> 00:16:51,588
information from the surface of this

367
00:16:49,429 --> 00:16:53,569
that they will begin to understand a bit

368
00:16:51,589 --> 00:16:56,570
about the proto solar nebula and the

369
00:16:53,570 --> 00:16:59,959
initial composition of the objects that

370
00:16:56,570 --> 00:17:01,730
formed in the solar system okay and just

371

00:16:59,958 --> 00:17:04,159
because it's contact binary and they

372
00:17:01,730 --> 00:17:07,220
could they nicknamed the small one Thule

373
00:17:04,160 --> 00:17:08,720
and the large one Ultima okay so our

374
00:17:07,220 --> 00:17:11,029
snowman has has a nickname

375
00:17:08,720 --> 00:17:14,120
well not call him parson brown we'll

376
00:17:11,029 --> 00:17:16,939
call them Ultima Thule all right and

377
00:17:14,119 --> 00:17:20,149
just for comparison here is that same

378
00:17:16,939 --> 00:17:22,400
image of Ultima Thule compared to comet

379
00:17:20,150 --> 00:17:24,769
nuclei the most famous being this is the

380
00:17:22,400 --> 00:17:27,290
nuclei of comet Halley it's nine point

381
00:17:24,769 --> 00:17:30,889
three miles across where this is 21

382
00:17:27,289 --> 00:17:33,579
miles across okay temple morally wild

383
00:17:30,890 --> 00:17:36,440
and Hartley 2 you can see it has these

384
00:17:33,579 --> 00:17:38,389
interesting shapes and that's really

385
00:17:36,440 --> 00:17:39,130

what the most of the objects in the

386

00:17:38,390 --> 00:17:41,920

Kuiper belt

387

00:17:39,130 --> 00:17:43,750

are they are what would be comet nuclei

388

00:17:41,920 --> 00:17:46,360

but they're way out at the edge of the

389

00:17:43,750 --> 00:17:48,339

solar system their icy and slightly

390

00:17:46,359 --> 00:17:50,229

rocky objects that if they got kicked

391

00:17:48,339 --> 00:17:52,809

into the inner solar system they would

392

00:17:50,230 --> 00:17:54,490

become comets okay so they're I guess

393

00:17:52,809 --> 00:17:58,059

you can call it a dormant commentary

394

00:17:54,490 --> 00:18:00,069

nuclei however this one being out there

395

00:17:58,059 --> 00:18:02,889

for all things hopefully it will teach

396

00:18:00,069 --> 00:18:04,720

us about the pristine solar system where

397

00:18:02,890 --> 00:18:07,480

all the things on the right teaches us

398

00:18:04,720 --> 00:18:09,960

about the solar system as its evolved

399

00:18:07,480 --> 00:18:13,450

through and over time and changed yeah

400
00:18:09,960 --> 00:18:16,329
so that was our new year's resolution

401
00:18:13,450 --> 00:18:23,740
that we got resolution of Ultima Thule

402
00:18:16,329 --> 00:18:25,809
an astronomy yes yeah like five thousand

403
00:18:23,740 --> 00:18:28,539
miles or something like that I can't I

404
00:18:25,809 --> 00:18:31,960
mean this is not the highest resolution

405
00:18:28,539 --> 00:18:35,920
image it will have back the data rate

406
00:18:31,960 --> 00:18:40,620
from deep from 40 astronomical units is

407
00:18:35,920 --> 00:18:40,620
much less than America Online used to be

408
00:18:41,279 --> 00:18:46,629
yeah I mean we're getting bits per

409
00:18:44,079 --> 00:18:49,240
second not kilobits per second okay not

410
00:18:46,630 --> 00:18:53,620
even megabits per second it's per second

411
00:18:49,240 --> 00:18:55,089
type data rate so it will take 14 months

412
00:18:53,619 --> 00:18:58,149
for all of the data from the encounter

413
00:18:55,089 --> 00:19:02,109
to get down okay so they'll get some

414
00:18:58,150 --> 00:19:04,060
really good stuff starting soon it went

415
00:19:02,109 --> 00:19:05,500
behind the Sun in art from our

416
00:19:04,059 --> 00:19:07,269
perspective so we couldn't get data for

417
00:19:05,500 --> 00:19:10,359
a while it's now back they're starting

418
00:19:07,269 --> 00:19:12,460
to get the data coming down so be

419
00:19:10,359 --> 00:19:18,159
patient we'll know more about this in

420
00:19:12,460 --> 00:19:27,519
six to nine months like it does not

421
00:19:18,160 --> 00:19:30,610
shine on its own 48 48 you yes contact

422
00:19:27,519 --> 00:19:33,279
like the Jupiter kept things from

423
00:19:30,609 --> 00:19:37,229
forming Mars

424
00:19:33,279 --> 00:19:41,379
any planetary formations may be gone

425
00:19:37,230 --> 00:19:43,120
well the Kuiper belt at least the inner

426
00:19:41,380 --> 00:19:45,820
edge of it is heavily governed by

427
00:19:43,119 --> 00:19:47,769
Neptune's mass Neptune's at 38 you and

428

00:19:45,819 --> 00:19:50,379
we have a strong cutoff in the

429
00:19:47,769 --> 00:19:52,179
distribution of objects at 30 au there's

430
00:19:50,380 --> 00:19:56,230
also a strong cutoff

431
00:19:52,179 --> 00:19:57,659
da you and that's not as fully explained

432
00:19:56,230 --> 00:20:00,970
okay

433
00:19:57,659 --> 00:20:03,220
there could be another planetary type

434
00:20:00,970 --> 00:20:05,769
object folks know that there's a search

435
00:20:03,220 --> 00:20:07,389
on for Planet nine but that's in a

436
00:20:05,769 --> 00:20:09,159
totally different orbit I'm not sure

437
00:20:07,388 --> 00:20:11,308
that would affect the 50 au

438
00:20:09,159 --> 00:20:16,360
cutoff because that's way out there like

439
00:20:11,308 --> 00:20:19,538
7,500 au type thing I'm not a Kuiper

440
00:20:16,359 --> 00:20:21,819
belt specialist but I know in talking to

441
00:20:19,538 --> 00:20:22,839
one of them Mike Brown was a hit on went

442
00:20:21,819 --> 00:20:24,609

to graduate school together

443

00:20:22,839 --> 00:20:28,569

he was like no there really is a strong

444

00:20:24,609 --> 00:20:30,038

cutoff around 50 au and usually there's

445

00:20:28,569 --> 00:20:32,618

some gravitational interaction that will

446

00:20:30,038 --> 00:20:35,378

stop that will cause that I don't know

447

00:20:32,618 --> 00:20:41,558

one but maybe I'm just ignorant on that

448

00:20:35,378 --> 00:20:44,349

okay yes okay how does the Oort cloud

449

00:20:41,558 --> 00:20:47,378

relate to the area so the Kuiper belt is

450

00:20:44,349 --> 00:20:49,240

in the plane of the solar system and

451

00:20:47,378 --> 00:20:52,359

it's a it's a belt it's it's it's fluffy

452

00:20:49,240 --> 00:20:55,450

but it's it's mostly flat okay and that

453

00:20:52,359 --> 00:20:57,878

goes out thirty to fifty au Oort cloud

454

00:20:55,450 --> 00:21:01,028

is much much much much much bigger it

455

00:20:57,878 --> 00:21:04,269

starts around 2000 au and goes out to

456

00:21:01,028 --> 00:21:06,429

maybe 50,000 au and that's roughly

457
00:21:04,269 --> 00:21:10,149
spherical okay

458
00:21:06,429 --> 00:21:12,570
and the whereas the the Kuiper belt is

459
00:21:10,148 --> 00:21:15,459
the genesis of the short period comets

460
00:21:12,569 --> 00:21:18,908
the Oort cloud is the genesis of a long

461
00:21:15,460 --> 00:21:20,110
period comets comets that are more than

462
00:21:18,909 --> 00:21:22,419
200 years are called

463
00:21:20,109 --> 00:21:24,189
long period comets that have orbits less

464
00:21:22,419 --> 00:21:26,950
than 200 years are called short period

465
00:21:24,190 --> 00:21:28,480
comets so we believe the reservoir of

466
00:21:26,950 --> 00:21:30,369
where the short period comets come from

467
00:21:28,480 --> 00:21:33,610
is the Kuiper belt the long period

468
00:21:30,368 --> 00:21:35,168
comets come from the Oort cloud and a

469
00:21:33,609 --> 00:21:37,148
lot of the Oort cloud things basically

470
00:21:35,169 --> 00:21:39,220
how they got out there was there they're

471
00:21:37,148 --> 00:21:45,038
scattered out of a solar system by

472
00:21:39,220 --> 00:21:47,048
Jupiter I don't want to take up too much

473
00:21:45,038 --> 00:21:49,419
of Scott's time if you have more

474
00:21:47,048 --> 00:21:52,888
questions you can come down and ask me

475
00:21:49,419 --> 00:21:52,889
but let's see

476
00:21:57,500 --> 00:22:08,759
okay so are we up I'm gonna let you

477
00:22:07,679 --> 00:22:10,620
introduce yourself because I've already

478
00:22:08,759 --> 00:22:12,629
talked way too long here ladies and

479
00:22:10,619 --> 00:22:14,278
gentlemen the incredible the inimitable

480
00:22:12,630 --> 00:22:23,399
he's gonna talk about some really cool

481
00:22:14,278 --> 00:22:24,298
things dr. Scott Fleming thank you very

482
00:22:23,398 --> 00:22:27,148
much everyone

483
00:22:24,298 --> 00:22:30,388
looks like my mikes good so I want to

484
00:22:27,148 --> 00:22:32,489
echo Frank's thanks for all you coming

485

00:22:30,388 --> 00:22:36,418
out on a cold night in January to hear

486
00:22:32,490 --> 00:22:38,069
about a very new mission TESS and also I

487
00:22:36,419 --> 00:22:41,250
want to say hello and welcome to people

488
00:22:38,069 --> 00:22:45,649
watching online I also want to thank

489
00:22:41,250 --> 00:22:47,388
Frank for a fantastic my accident

490
00:22:45,650 --> 00:22:49,860
[Applause]

491
00:22:47,388 --> 00:22:51,599
background information on comets and

492
00:22:49,859 --> 00:22:53,009
clusters because believe it or not even

493
00:22:51,599 --> 00:22:54,599
though I'll be presenting the most

494
00:22:53,009 --> 00:22:56,638
exciting results on exoplanets I have

495
00:22:54,599 --> 00:23:00,000
slides involving clusters and comets as

496
00:22:56,638 --> 00:23:02,509
well so now that was a fantastic job so

497
00:23:00,000 --> 00:23:04,950
tonight I'll be sharing with you some

498
00:23:02,509 --> 00:23:07,079
information on the test spacecraft I

499
00:23:04,950 --> 00:23:09,990

figured I would start by describing the

500

00:23:07,079 --> 00:23:12,178

spacecraft and showing explaining what

501

00:23:09,990 --> 00:23:14,730

the spacecrafts doing now and how it's

502

00:23:12,179 --> 00:23:16,950

doing it's science I'll do a very quick

503

00:23:14,730 --> 00:23:18,839

summary of some of the very early

504

00:23:16,950 --> 00:23:21,269

results and I'll highlight with the

505

00:23:18,839 --> 00:23:23,459

first three exoplanets the test has not

506

00:23:21,269 --> 00:23:27,419

only found but confirmed to be actual

507

00:23:23,460 --> 00:23:31,440

objects first though some boring stuff

508

00:23:27,419 --> 00:23:33,149

me I figured I would introduce myself a

509

00:23:31,440 --> 00:23:34,860

little bit because space telescopes very

510

00:23:33,148 --> 00:23:36,808

large there's more than five hundred and

511

00:23:34,859 --> 00:23:39,000

some-odd people here at the minimum it's

512

00:23:36,808 --> 00:23:40,408

growing it seems like everyday so I

513

00:23:39,000 --> 00:23:42,329

figured I'd explain what my role is here

514
00:23:40,409 --> 00:23:44,789
at Space Telescope before we get into

515
00:23:42,329 --> 00:23:46,710
the mission so Space Telescope does a

516
00:23:44,788 --> 00:23:48,450
number of things most of you probably

517
00:23:46,710 --> 00:23:49,620
know that we're the science operations

518
00:23:48,450 --> 00:23:51,450
center for the Hubble Space Telescope

519
00:23:49,619 --> 00:23:54,028
we're going to be the Operations Center

520
00:23:51,450 --> 00:23:56,970
for the James Webb Space Telescope we

521
00:23:54,028 --> 00:23:58,679
have an outreach department that does a

522
00:23:56,970 --> 00:24:00,419
lot to communicate a lot of the science

523
00:23:58,679 --> 00:24:02,370
results being discovered by telescopes

524
00:24:00,419 --> 00:24:04,889
we have a lot of software developers who

525
00:24:02,369 --> 00:24:07,569
are making astronomy software for

526
00:24:04,888 --> 00:24:09,159
astronomers to use to analyze data

527
00:24:07,569 --> 00:24:11,799
another thing we do is actually serve as

528
00:24:09,160 --> 00:24:15,130
an archive which is where I work for

529
00:24:11,799 --> 00:24:17,409
data from a variety of missions so I

530
00:24:15,130 --> 00:24:18,730
work at the Mikulski archive for Space

531
00:24:17,410 --> 00:24:21,670
Telescope's it's part of the Space

532
00:24:18,730 --> 00:24:24,279
Telescope Science Institute and it

533
00:24:21,670 --> 00:24:26,560
actually has data from more than 20

534
00:24:24,279 --> 00:24:30,369
different missions most of them NASA

535
00:24:26,559 --> 00:24:33,099
missions that flew in space we have data

536
00:24:30,369 --> 00:24:35,109
ranging all the way from the 1970s with

537
00:24:33,099 --> 00:24:38,829
the International ultraviolet Explorer

538
00:24:35,109 --> 00:24:42,129
all the way to tests now which just had

539
00:24:38,829 --> 00:24:43,990
its first data release six weeks ago so

540
00:24:42,130 --> 00:24:45,790
part of my job working with more than 30

541
00:24:43,990 --> 00:24:48,519
different astronomers developers and

542

00:24:45,789 --> 00:24:51,399
engineers in my branch is to make sure

543
00:24:48,519 --> 00:24:53,319
that all this data are kept not only for

544
00:24:51,400 --> 00:24:55,780
a few weeks or a few years but for

545
00:24:53,319 --> 00:24:58,329
decades and available for people all

546
00:24:55,779 --> 00:25:00,839
around the world to make use of from all

547
00:24:58,329 --> 00:25:03,460
these different missions that we collect

548
00:25:00,839 --> 00:25:05,819
so let's talk about test it wouldn't be

549
00:25:03,460 --> 00:25:07,990
a NASA mission without in acronyms and

550
00:25:05,819 --> 00:25:09,669
tests is indeed an acronym it's not as

551
00:25:07,990 --> 00:25:12,370
far as I know named after an individual

552
00:25:09,670 --> 00:25:14,980
it stands for the transiting exoplanet

553
00:25:12,369 --> 00:25:17,859
survey satellite and in fact the acronym

554
00:25:14,980 --> 00:25:19,900
is a great summary of what test is it's

555
00:25:17,859 --> 00:25:22,359
a satellite it's a specific specifically

556
00:25:19,900 --> 00:25:25,480

a Space Telescope conducting a survey

557

00:25:22,359 --> 00:25:28,209

for transiting exoplanets and I refer to

558

00:25:25,480 --> 00:25:30,730

the word exoplanet or extrasolar planet

559

00:25:28,210 --> 00:25:33,329

what I'm referring to our planets

560

00:25:30,730 --> 00:25:35,410

orbiting stars outside our solar system

561

00:25:33,329 --> 00:25:37,449

just so that everyone's clear and what I

562

00:25:35,410 --> 00:25:40,150

mean by that there's a couple of primary

563

00:25:37,450 --> 00:25:43,330

science objectives one of them is to

564

00:25:40,150 --> 00:25:47,320

search more than 200,000 nearby stars to

565

00:25:43,329 --> 00:25:48,849

detect new extrasolar planets and the

566

00:25:47,319 --> 00:25:50,519

key word is nearby and we'll talk about

567

00:25:48,849 --> 00:25:53,709

that more toward the ends of the talk

568

00:25:50,519 --> 00:25:57,129

another objective is using ground-based

569

00:25:53,710 --> 00:25:59,289

follow-up data to measure the masses for

570

00:25:57,130 --> 00:26:00,850

at least 50 planets that are smaller

571
00:25:59,289 --> 00:26:03,309
than about four times the size of the

572
00:26:00,849 --> 00:26:05,919
earth that's another objective and the

573
00:26:03,309 --> 00:26:08,740
third objective is actually to play a

574
00:26:05,920 --> 00:26:11,039
sort of in collaboration with the James

575
00:26:08,740 --> 00:26:14,769
Webb Space Telescope tests will identify

576
00:26:11,039 --> 00:26:17,769
some of the best exoplanets orbiting the

577
00:26:14,769 --> 00:26:19,839
brightest nearby stars so that when

578
00:26:17,769 --> 00:26:21,430
James Webb launches in a couple of years

579
00:26:19,839 --> 00:26:24,099
it will be able

580
00:26:21,430 --> 00:26:27,519
to do one of its key science drivers to

581
00:26:24,099 --> 00:26:29,139
not only study the exoplanets as a whole

582
00:26:27,519 --> 00:26:31,690
but to measure some of their chemical

583
00:26:29,140 --> 00:26:33,730
compositions in their atmospheres a very

584
00:26:31,690 --> 00:26:35,740
challenging measurement one that we have

585
00:26:33,730 --> 00:26:37,809
done from the ground and even with

586
00:26:35,740 --> 00:26:40,269
Hubble Space Telescope but James Webb

587
00:26:37,809 --> 00:26:42,369
because of the size and the type of data

588
00:26:40,269 --> 00:26:45,129
that will get will revolutionize our

589
00:26:42,369 --> 00:26:45,909
ability to not only detect planets

590
00:26:45,130 --> 00:26:48,460
around other stars

591
00:26:45,910 --> 00:26:51,519
but measure what their atmospheres are

592
00:26:48,460 --> 00:26:53,350
like and this is a key step in

593
00:26:51,519 --> 00:26:57,730
understanding the broader question of

594
00:26:53,349 --> 00:26:59,980
life in our universe real quick there's

595
00:26:57,730 --> 00:27:02,799
a variety of institutions involved in

596
00:26:59,980 --> 00:27:05,980
the mission the science operations are

597
00:27:02,799 --> 00:27:09,039
controlled by primarily MIT and Harvard

598
00:27:05,980 --> 00:27:11,049
but there are also dozens of astronomers

599

00:27:09,039 --> 00:27:12,670
in dozens of institutions around the

600
00:27:11,049 --> 00:27:14,940
world working together to do the science

601
00:27:12,670 --> 00:27:18,550
operations of the spacecraft spacecraft

602
00:27:14,940 --> 00:27:20,529
Northrop Grumman was responsible for the

603
00:27:18,549 --> 00:27:23,579
sort of the the payload and engineering

604
00:27:20,529 --> 00:27:25,569
parts of it and then Space Telescope

605
00:27:23,579 --> 00:27:27,009
working with our friends at the NASA

606
00:27:25,569 --> 00:27:29,980
exoplanet Science Institute in

607
00:27:27,009 --> 00:27:32,079
California serve as the archives the

608
00:27:29,980 --> 00:27:34,120
final resting place for this valuable

609
00:27:32,079 --> 00:27:37,449
data the spacecraft is collecting

610
00:27:34,119 --> 00:27:39,519
downloading and being made public so I

611
00:27:37,450 --> 00:27:47,650
had to start with one of my favorite

612
00:27:39,519 --> 00:27:54,599
things still a launch eight seven six

613
00:27:47,650 --> 00:27:56,519

five four three two one zero

614

00:27:54,599 --> 00:27:59,909

[Applause]

615

00:27:56,519 --> 00:28:02,250

liftoff the SpaceX Falcon 9 carrying

616

00:27:59,910 --> 00:28:04,200

tests a planet-hunting spacecraft that

617

00:28:02,250 --> 00:28:06,390

will search for new worlds beyond our

618

00:28:04,200 --> 00:28:08,429

solar system so that was just a quick

619

00:28:06,390 --> 00:28:12,300

clip of the launch which happened in

620

00:28:08,429 --> 00:28:14,640

April just about a few months ago it was

621

00:28:12,299 --> 00:28:17,190

a nearly flawless launch by SpaceX it

622

00:28:14,640 --> 00:28:19,679

was actually the first time SpaceX

623

00:28:17,190 --> 00:28:23,039

launched a science telescope for NASA

624

00:28:19,679 --> 00:28:25,410

previously most if not all of its supply

625

00:28:23,039 --> 00:28:28,289

missions had been deliveries to the

626

00:28:25,410 --> 00:28:31,800

International Space Station but it was a

627

00:28:28,289 --> 00:28:35,220

perfect launch and the spacecraft is is

628
00:28:31,799 --> 00:28:36,960
healthy and in a great spot but there's

629
00:28:35,220 --> 00:28:38,460
a second launch and that's when this is

630
00:28:36,960 --> 00:28:40,470
where we come in this is when the data

631
00:28:38,460 --> 00:28:43,308
go public so this is some social media

632
00:28:40,470 --> 00:28:46,470
tweets that I collected in my scrapbook

633
00:28:43,308 --> 00:28:48,599
we had the first launch of data from the

634
00:28:46,470 --> 00:28:51,870
test mission to the astronomical

635
00:28:48,599 --> 00:28:55,109
community just this past December just

636
00:28:51,869 --> 00:28:56,879
about about six weeks ago you can see

637
00:28:55,109 --> 00:29:00,329
some people were trying to call it test

638
00:28:56,880 --> 00:29:03,750
miss since it happened a few weeks

639
00:29:00,329 --> 00:29:06,240
before Christmas and people were hungry

640
00:29:03,750 --> 00:29:08,819
for this data you can see people

641
00:29:06,240 --> 00:29:11,519
tweeting their screenshots of the page I

642
00:29:08,819 --> 00:29:13,109
wrote with their coffee say where is it

643
00:29:11,519 --> 00:29:16,500
and I'm saying it's come in give me a

644
00:29:13,109 --> 00:29:19,789
second December 6th was very busy for us

645
00:29:16,500 --> 00:29:21,779
but everything went successfully

646
00:29:19,789 --> 00:29:24,210
astronomers around the world we're

647
00:29:21,779 --> 00:29:26,339
waiting for this if as anybody heard the

648
00:29:24,210 --> 00:29:28,470
Zooniverse project or planet hunters or

649
00:29:26,339 --> 00:29:30,480
any of the citizen science projects and

650
00:29:28,470 --> 00:29:33,420
in the past if any of you are familiar

651
00:29:30,480 --> 00:29:37,380
with those there's a group in Oxford in

652
00:29:33,420 --> 00:29:40,640
Finland who are making the data public

653
00:29:37,380 --> 00:29:44,040
for citizen scientists to be able to

654
00:29:40,640 --> 00:29:45,870
look at the data and help us classify

655
00:29:44,039 --> 00:29:47,490
all the interesting signals and they

656

00:29:45,869 --> 00:29:50,250
were able to download data from us and

657
00:29:47,490 --> 00:29:52,079
get data in there sort of interface on

658
00:29:50,250 --> 00:29:54,509
the web for citizen scientists to look

659
00:29:52,079 --> 00:29:55,919
at within four hours of us going live

660
00:29:54,509 --> 00:29:58,829
it's a record

661
00:29:55,920 --> 00:30:00,630
it's amazing other fun stuff about a

662
00:29:58,829 --> 00:30:04,589
week later this is where the comets come

663
00:30:00,630 --> 00:30:05,700
in some group at Washington was trying

664
00:30:04,589 --> 00:30:08,139
to figure out what's going on with one

665
00:30:05,700 --> 00:30:11,680
particular star and this poor star

666
00:30:08,140 --> 00:30:13,240
not only does it end up having it's

667
00:30:11,680 --> 00:30:15,700
sitting there trying to you know shine

668
00:30:13,240 --> 00:30:17,769
and measure its brightness but what they

669
00:30:15,700 --> 00:30:20,830
found was not only does this star have

670
00:30:17,769 --> 00:30:23,109

one after I come across and sort of get

671

00:30:20,829 --> 00:30:25,059

in the way but then later during the

672

00:30:23,109 --> 00:30:27,759

same observation a completely

673

00:30:25,059 --> 00:30:29,970

independent and second asteroid comes

674

00:30:27,759 --> 00:30:32,650

across right in from the starker and

675

00:30:29,970 --> 00:30:34,750

ruins their ability to measure the the

676

00:30:32,650 --> 00:30:36,280

flux of the star but the bonus science

677

00:30:34,750 --> 00:30:37,660

is people interested in studying comets

678

00:30:36,279 --> 00:30:40,779

and asteroids get all these nice

679

00:30:37,660 --> 00:30:44,230

pictures to be able to study asteroids

680

00:30:40,779 --> 00:30:47,379

and comets so it was a fantastic launch

681

00:30:44,230 --> 00:30:49,240

in the first week we estimate we

682

00:30:47,380 --> 00:30:51,940

delivered at least a hundred terabytes

683

00:30:49,240 --> 00:30:55,559

of test data to more than 950

684

00:30:51,940 --> 00:30:55,559

astronomers around the entire globe

685
00:30:56,160 --> 00:31:01,509
let's go back to the spacecraft this is

686
00:30:58,960 --> 00:31:03,700
a movie that shows where tests how tests

687
00:31:01,509 --> 00:31:06,700
sort of orbits around the earth which is

688
00:31:03,700 --> 00:31:10,299
located here in the center of your of

689
00:31:06,700 --> 00:31:13,090
your screen and then the moon is this

690
00:31:10,299 --> 00:31:17,379
gray orbit here and you'll notice that

691
00:31:13,089 --> 00:31:18,819
Tests orbits inclined relative to the

692
00:31:17,380 --> 00:31:21,220
earth on the moon so it sort of dips

693
00:31:18,819 --> 00:31:23,439
above and below the plane of the Earth

694
00:31:21,220 --> 00:31:25,000
Moon system Wow the other thing you'll

695
00:31:23,440 --> 00:31:27,009
notice is that the orbit is not circular

696
00:31:25,000 --> 00:31:29,470
somewhat elliptical and this is by

697
00:31:27,009 --> 00:31:32,920
design it's actually a very stable orbit

698
00:31:29,470 --> 00:31:35,259
and during the blue parts of the orbit

699
00:31:32,920 --> 00:31:36,910
test is staring at one part of the sky

700
00:31:35,259 --> 00:31:38,890
collecting lots of data on the

701
00:31:36,910 --> 00:31:41,080
brightness of all the targets in its

702
00:31:38,890 --> 00:31:44,080
field of view and then when it dips down

703
00:31:41,079 --> 00:31:48,189
to the I'm sorry when it dips down to

704
00:31:44,079 --> 00:31:50,439
the orange part of the orbit it actually

705
00:31:48,190 --> 00:31:54,820
downloads its data to earth as fast as

706
00:31:50,440 --> 00:31:57,910
possible where the bandwidth between us

707
00:31:54,819 --> 00:32:00,700
and the radio stations is is maximized

708
00:31:57,910 --> 00:32:03,790
not quite as hard of a problem as New

709
00:32:00,700 --> 00:32:06,370
Horizons but there's a lot of data it

710
00:32:03,789 --> 00:32:09,159
takes about two weeks for the spacecraft

711
00:32:06,369 --> 00:32:11,649
to go all the way around one orbit so it

712
00:32:09,160 --> 00:32:14,470
does one pass downloads two weeks of

713

00:32:11,650 --> 00:32:16,300
data does another loop downloads two

714
00:32:14,470 --> 00:32:18,789
more weeks of data and then it moves on

715
00:32:16,299 --> 00:32:21,339
to a new part of the sky and currently

716
00:32:18,789 --> 00:32:21,920
Tess has just begun its seventh section

717
00:32:21,339 --> 00:32:23,509
of the sky

718
00:32:21,920 --> 00:32:25,970
so it's about halfway done with the

719
00:32:23,509 --> 00:32:27,500
first year of the two-year prime mission

720
00:32:25,970 --> 00:32:35,960
just so everyone's aware of what the

721
00:32:27,500 --> 00:32:39,170
status of the spacecraft mission that's

722
00:32:35,960 --> 00:32:41,269
Travis so here's the spacecraft you can

723
00:32:39,170 --> 00:32:45,410
see the solar panels on the on the ways

724
00:32:41,269 --> 00:32:47,059
the dome on the back is the radio that

725
00:32:45,410 --> 00:32:49,220
it uses to communicate with earth and

726
00:32:47,059 --> 00:32:51,049
download its data and the most important

727
00:32:49,220 --> 00:32:54,980

part of the spacecraft are these four

728

00:32:51,049 --> 00:32:57,409

cameras in the cone this is what Tess

729

00:32:54,980 --> 00:33:00,920

uses to measure all the fluxes and look

730

00:32:57,410 --> 00:33:03,230

for exoplanets how does it detect

731

00:33:00,920 --> 00:33:06,680

exoplanets it uses a technique called

732

00:33:03,230 --> 00:33:08,660

the transit method and conceptually it's

733

00:33:06,680 --> 00:33:11,539

one of the simplest ways we can discover

734

00:33:08,660 --> 00:33:14,840

new planets around stars we measure the

735

00:33:11,539 --> 00:33:17,599

brightness of stars very very very

736

00:33:14,839 --> 00:33:19,730

carefully and literally wait for an

737

00:33:17,599 --> 00:33:23,329

exoplanet to cross in front of it and

738

00:33:19,730 --> 00:33:25,759

get in the way the challenge is that the

739

00:33:23,329 --> 00:33:28,129

amount of light that a planet blocks is

740

00:33:25,759 --> 00:33:31,250

very very tiny so you have to be able to

741

00:33:28,130 --> 00:33:33,650

measure brightnesses of stars very very

742
00:33:31,250 --> 00:33:35,359
carefully it's taking decades of us to

743
00:33:33,650 --> 00:33:37,450
get to where we are today but we're able

744
00:33:35,359 --> 00:33:39,829
to do so with a lot of great success

745
00:33:37,450 --> 00:33:41,690
you'll notice in this animation there's

746
00:33:39,829 --> 00:33:43,069
two different planets sort of as to show

747
00:33:41,690 --> 00:33:44,539
you what what the signals might look

748
00:33:43,069 --> 00:33:45,889
like this is sort of what happens if

749
00:33:44,539 --> 00:33:47,750
someone walks in front of a projector

750
00:33:45,890 --> 00:33:49,460
and a movie theater they'll block out

751
00:33:47,750 --> 00:33:50,990
part of the light and you'll see that

752
00:33:49,460 --> 00:33:53,150
the screen that was brightest somewhat

753
00:33:50,990 --> 00:33:55,430
less bright but you'll notice that we

754
00:33:53,150 --> 00:33:57,650
can actually model a lot of the

755
00:33:55,430 --> 00:34:00,289
interesting parts of a planetary system

756
00:33:57,650 --> 00:34:03,410
just by looking at the shape the depth

757
00:34:00,289 --> 00:34:06,829
of the transit decrease in brightness

758
00:34:03,410 --> 00:34:09,349
how long it lasts even details like the

759
00:34:06,829 --> 00:34:11,989
shapes of the beginning and ends can

760
00:34:09,349 --> 00:34:17,269
tell us a lot about the planets the

761
00:34:11,989 --> 00:34:19,089
Stars and the orbits of those planets so

762
00:34:17,269 --> 00:34:21,619
let's go back to the cameras real quick

763
00:34:19,090 --> 00:34:24,470
there's four of them like I mentioned in

764
00:34:21,619 --> 00:34:26,989
that count area and each one is

765
00:34:24,469 --> 00:34:29,569
surveying a large chunk of the sky I

766
00:34:26,989 --> 00:34:31,219
really want to focus on how big tessa is

767
00:34:29,570 --> 00:34:33,590
because it's very very different from

768
00:34:31,219 --> 00:34:35,509
other telescopes like Hubble each camera

769
00:34:33,590 --> 00:34:37,880
is 24 by 24

770

00:34:35,510 --> 00:34:39,620
Riis on the sky and there are four of

771
00:34:37,880 --> 00:34:42,889
them aligned so that they stack on top

772
00:34:39,619 --> 00:34:44,929
of each other on the sky so when Tess is

773
00:34:42,889 --> 00:34:47,329
collecting data it's quite really

774
00:34:44,929 --> 00:34:50,929
observing this orange wedge that's more

775
00:34:47,329 --> 00:34:52,909
than 90 degrees of the sky at a time so

776
00:34:50,929 --> 00:34:55,579
we'll do this with our four cameras for

777
00:34:52,909 --> 00:34:58,220
two weeks download the data do it again

778
00:34:55,579 --> 00:35:00,559
for two weeks and then after it's done

779
00:34:58,219 --> 00:35:02,629
with two orbits of collecting data with

780
00:35:00,559 --> 00:35:04,880
its cameras and it starts the next

781
00:35:02,630 --> 00:35:07,039
sector as we call it it will actually

782
00:35:04,880 --> 00:35:11,059
move a little bit on the sky and end up

783
00:35:07,039 --> 00:35:13,639
surveying this hemisphere on the sky so

784
00:35:11,059 --> 00:35:15,799

it'll take about one year to do the

785

00:35:13,639 --> 00:35:18,170

southern hemisphere starting sometime

786

00:35:15,800 --> 00:35:20,269

this summer it will finish the first

787

00:35:18,170 --> 00:35:23,150

year we'll literally flip around and

788

00:35:20,269 --> 00:35:27,769

we'll survey the northern part of the

789

00:35:23,150 --> 00:35:30,500

sky one key part to notice is that as

790

00:35:27,769 --> 00:35:33,019

its sweeping out and observing lots of

791

00:35:30,500 --> 00:35:36,139

stars along the sky one of the cameras

792

00:35:33,019 --> 00:35:38,659

camera number 4 actually stays in the

793

00:35:36,139 --> 00:35:42,529

same part of the sky every single time

794

00:35:38,659 --> 00:35:44,629

Tess observes this one camera is always

795

00:35:42,530 --> 00:35:46,760

going to be at the pole on the bottom

796

00:35:44,630 --> 00:35:49,610

and when it flips around to the north

797

00:35:46,760 --> 00:35:53,000

it'll be in the northern Pole this means

798

00:35:49,610 --> 00:35:56,809

that any target stars galaxies whatever

799
00:35:53,000 --> 00:35:59,599
that happen to lie in camera four will

800
00:35:56,809 --> 00:36:02,960
get observations every single month and

801
00:35:59,599 --> 00:36:04,880
will get a full year of continuous data

802
00:36:02,960 --> 00:36:07,190
we call this a continuous viewing zone

803
00:36:04,880 --> 00:36:09,829
and I bring it up because this sort of

804
00:36:07,190 --> 00:36:12,340
emphasizes the foresight of people

805
00:36:09,829 --> 00:36:15,469
planning tests working with James Webb

806
00:36:12,340 --> 00:36:18,050
because these continuous viewing zones

807
00:36:15,469 --> 00:36:21,049
that get a year of solid data in the

808
00:36:18,050 --> 00:36:23,420
north and south overlap with James

809
00:36:21,050 --> 00:36:25,760
Webb's continuous viewing zones and this

810
00:36:23,420 --> 00:36:28,220
was very much done on purpose so that

811
00:36:25,760 --> 00:36:31,480
when James Webb launches it will be able

812
00:36:28,219 --> 00:36:34,489
to observe any target in Tess's

813
00:36:31,480 --> 00:36:37,190
continuous viewing zones anytime the

814
00:36:34,489 --> 00:36:39,529
schedulers decide it makes sense this is

815
00:36:37,190 --> 00:36:42,260
an example of a synergy between tests

816
00:36:39,530 --> 00:36:46,519
the tiny planet finder and Webb the

817
00:36:42,260 --> 00:36:46,860
giant planet characterized er so this is

818
00:36:46,519 --> 00:36:49,739
well

819
00:36:46,860 --> 00:36:52,349
to do one more comparison with the with

820
00:36:49,739 --> 00:36:54,119
Hubble in this case and and tests so

821
00:36:52,349 --> 00:36:56,150
this is a picture of another star

822
00:36:54,119 --> 00:36:59,219
cluster Frank describes some of these

823
00:36:56,150 --> 00:37:01,440
clusters and before this particular

824
00:36:59,219 --> 00:37:04,109
image is a Hubble image of a cluster

825
00:37:01,440 --> 00:37:06,210
around the Large Magellanic Clouds this

826
00:37:04,110 --> 00:37:07,530
is a very nearby galaxy unlike some of

827

00:37:06,210 --> 00:37:09,659
the ones that Frank was talking about

828
00:37:07,530 --> 00:37:12,240
but it's still impressive that Hubble is

829
00:37:09,659 --> 00:37:15,199
able to actually resolve individual

830
00:37:12,239 --> 00:37:18,269
stars in this cluster around another

831
00:37:15,199 --> 00:37:21,689
calyx II albeit one that's very close to

832
00:37:18,269 --> 00:37:24,809
the Milky Way nevertheless to compare it

833
00:37:21,690 --> 00:37:27,019
for scale here's a picture taken from a

834
00:37:24,809 --> 00:37:29,360
ground-based telescope of the entire

835
00:37:27,019 --> 00:37:31,800
Magellanic galaxy so this is a

836
00:37:29,360 --> 00:37:34,289
neighboring companion galaxy to the note

837
00:37:31,800 --> 00:37:37,080
II Milky Way and what you previous

838
00:37:34,289 --> 00:37:39,179
previously saw in the Hubble image that

839
00:37:37,079 --> 00:37:41,460
I have since shrunk and stuck over here

840
00:37:39,179 --> 00:37:43,559
in the corner that nice beautiful

841
00:37:41,460 --> 00:37:46,800

picture of all these stars is really

842

00:37:43,559 --> 00:37:49,710

coming from just one little bright bump

843

00:37:46,800 --> 00:37:52,050

in this ground-based telescope picture

844

00:37:49,710 --> 00:37:54,090

of the entire galaxy all these bumps are

845

00:37:52,050 --> 00:37:57,120

things like stars and star formation

846

00:37:54,090 --> 00:38:00,030

regions and star clusters and a bunch of

847

00:37:57,119 --> 00:38:02,250

dust a lot of interesting structure so

848

00:38:00,030 --> 00:38:04,200

you can get a sense exactly how powerful

849

00:38:02,250 --> 00:38:10,619

the resolution is Hubble compared to the

850

00:38:04,199 --> 00:38:13,230

ground but test says hold my beer this

851

00:38:10,619 --> 00:38:16,079

is the four cameras from the first

852

00:38:13,230 --> 00:38:19,110

sector this is the entire Magellanic

853

00:38:16,079 --> 00:38:22,679

Cloud galaxies contained easily in one

854

00:38:19,110 --> 00:38:26,670

quarter of one of Tess's four cameras

855

00:38:22,679 --> 00:38:29,309

for scale this little blue over here in

856
00:38:26,670 --> 00:38:32,400
camera three is a small magellanic cloud

857
00:38:29,309 --> 00:38:34,559
and all of you seeing the little dot you

858
00:38:32,400 --> 00:38:37,110
see here every single one this is not

859
00:38:34,559 --> 00:38:39,630
noise these are not cosmic rays these

860
00:38:37,110 --> 00:38:41,730
are not television screen that cable

861
00:38:39,630 --> 00:38:44,760
went out on all they're saying the one

862
00:38:41,730 --> 00:38:47,309
is a star that might have a planet

863
00:38:44,760 --> 00:38:49,740
around it so you can see what the game

864
00:38:47,309 --> 00:38:52,170
the test is trying to play it's not

865
00:38:49,739 --> 00:38:57,829
going for high-definition it's going for

866
00:38:52,170 --> 00:39:01,280
screen size one last point on this

867
00:38:57,829 --> 00:39:03,289
this is the smallest dot I could small

868
00:39:01,280 --> 00:39:06,800
ask where I could draw with PowerPoint

869
00:39:03,289 --> 00:39:09,469
women let me draw a smaller one but this

870
00:39:06,800 --> 00:39:11,960
is supposed to represent this the area

871
00:39:09,469 --> 00:39:15,679
of sky that the Hubble Wide Field Camera

872
00:39:11,960 --> 00:39:19,280
3 now back in operation would see with

873
00:39:15,679 --> 00:39:23,599
its instrument the size of a test pixel

874
00:39:19,280 --> 00:39:26,240
on the sky is 525 times larger than the

875
00:39:23,599 --> 00:39:31,759
size of a woops III pixel on the sky and

876
00:39:26,239 --> 00:39:34,789
so that is this square so one pixel from

877
00:39:31,760 --> 00:39:38,240
Wide Field Camera 3 on Hubble is this

878
00:39:34,789 --> 00:39:41,179
much higher in the sky but on test one

879
00:39:38,239 --> 00:39:43,339
pixel from test is this much the sky

880
00:39:41,179 --> 00:39:44,899
they give you a sense and it's not

881
00:39:43,340 --> 00:39:47,300
really a game we're playing about which

882
00:39:44,900 --> 00:39:49,639
is better or worse they're different and

883
00:39:47,300 --> 00:39:51,830
for good reasons right I like to think

884

00:39:49,639 --> 00:39:55,039
of Hubble sort of operating like a

885
00:39:51,829 --> 00:39:58,009
powerful microscope does where it's

886
00:39:55,039 --> 00:39:59,389
being able to resolve and reveal things

887
00:39:58,010 --> 00:40:01,430
like tiny creatures in a drop of water

888
00:39:59,389 --> 00:40:04,129
while test is more like a surveyor

889
00:40:01,429 --> 00:40:06,649
that's really trying to chart the ocean

890
00:40:04,130 --> 00:40:11,119
itself different objectives different

891
00:40:06,650 --> 00:40:13,190
decisions on pixel sizes so let's go

892
00:40:11,119 --> 00:40:15,710
back to our first set of real data these

893
00:40:13,190 --> 00:40:17,630
are real images collected and downloaded

894
00:40:15,710 --> 00:40:19,250
and now public from the spacecraft you

895
00:40:17,630 --> 00:40:22,730
notice the Large Magellanic Cloud the

896
00:40:19,250 --> 00:40:24,949
small Magellanic Cloud lots of stars one

897
00:40:22,730 --> 00:40:27,860
of the things the bonus science that

898
00:40:24,949 --> 00:40:30,049

Tess is doing is that astronomers are

899

00:40:27,860 --> 00:40:32,480

looking at all kinds of other physics

900

00:40:30,050 --> 00:40:35,390

that are happening within these huge

901

00:40:32,480 --> 00:40:38,240

fields of view while Tess is looking for

902

00:40:35,389 --> 00:40:39,769

those transiting planets so I shared a

903

00:40:38,239 --> 00:40:41,899

couple of pictures of asteroids and

904

00:40:39,769 --> 00:40:43,969

comets there are going to be tons of

905

00:40:41,900 --> 00:40:46,070

asteroids and comets that astronomers

906

00:40:43,969 --> 00:40:48,379

will be analyzing from the test data

907

00:40:46,070 --> 00:40:52,160

another great example are supernovae

908

00:40:48,380 --> 00:40:54,500

exploding stars because Tess is staring

909

00:40:52,159 --> 00:40:57,139

at the sky and a huge part of the sky

910

00:40:54,500 --> 00:40:59,449

it doesn't care whether it's on time or

911

00:40:57,139 --> 00:41:01,849

late for a supernovae to happen it's

912

00:40:59,449 --> 00:41:04,159

just going to be in these huge fields of

913
00:41:01,849 --> 00:41:06,170
view and so one of the initial science

914
00:41:04,159 --> 00:41:08,779
results that were presented just last

915
00:41:06,170 --> 00:41:11,780
week at the double-a s were some of

916
00:41:08,780 --> 00:41:14,660
these supernovae that went off while

917
00:41:11,780 --> 00:41:17,840
test was observing there are actually

918
00:41:14,659 --> 00:41:19,909
six different supernovae that happened

919
00:41:17,840 --> 00:41:22,910
and discovered by telescopes on the

920
00:41:19,909 --> 00:41:24,440
ground specifically named the assassin

921
00:41:22,909 --> 00:41:28,129
survey which one of my favorite names

922
00:41:24,440 --> 00:41:31,280
for a survey and the Atlas survey and

923
00:41:28,130 --> 00:41:33,860
these telescopes found a supernovae by

924
00:41:31,280 --> 00:41:35,750
looking at relatively small parts of the

925
00:41:33,860 --> 00:41:37,750
sky compared to test and noticing that

926
00:41:35,750 --> 00:41:41,059
something here that wasn't there before

927

00:41:37,750 --> 00:41:43,880

and so they send out a alert to

928

00:41:41,059 --> 00:41:45,529

astronomers and so usually astronomers

929

00:41:43,880 --> 00:41:47,900

will rush to a telescope and try and get

930

00:41:45,530 --> 00:41:49,700

more data once the supernova happens but

931

00:41:47,900 --> 00:41:52,369

intestines cases don't worry about it

932

00:41:49,699 --> 00:41:55,489

I've been looking at this and everything

933

00:41:52,369 --> 00:41:56,480

else for a long time and so astronomers

934

00:41:55,489 --> 00:41:59,359

as soon as the data we're downloading

935

00:41:56,480 --> 00:42:01,639

are able to use the test light curves to

936

00:41:59,360 --> 00:42:04,579

get these beautiful plots of how the

937

00:42:01,639 --> 00:42:05,960

supernovae are changing over time this

938

00:42:04,579 --> 00:42:10,309

is just another example of what you can

939

00:42:05,960 --> 00:42:12,079

do with test data a lot of people

940

00:42:10,309 --> 00:42:15,710

probably heard of Kepler or k2

941

00:42:12,079 --> 00:42:19,639
I hope Kepler really revolutionized our

942
00:42:15,710 --> 00:42:21,429
understanding of exoplanets but the

943
00:42:19,639 --> 00:42:25,219
Kepler mission has since ended

944
00:42:21,429 --> 00:42:28,039
spacecraft was retired and shut down due

945
00:42:25,219 --> 00:42:30,169
to a loss of its gyros and the ability

946
00:42:28,039 --> 00:42:32,360
to control itself but it's really a

947
00:42:30,170 --> 00:42:33,559
bittersweet ending because the timing

948
00:42:32,360 --> 00:42:35,960
couldn't have been better it actually

949
00:42:33,559 --> 00:42:38,750
lasted much longer than the original

950
00:42:35,960 --> 00:42:42,050
mission was originally funded for and it

951
00:42:38,750 --> 00:42:45,349
ended not too long before tests started

952
00:42:42,050 --> 00:42:47,120
and so really Kepler and k2 are sort of

953
00:42:45,349 --> 00:42:49,460
that mission sort of passing the

954
00:42:47,119 --> 00:42:51,230
exoplanet torch to the next NASA mission

955
00:42:49,460 --> 00:42:53,809

which is tests and I mean that quite

956

00:42:51,230 --> 00:42:56,360

literally because the test data

957

00:42:53,809 --> 00:42:59,210

reduction pipeline is actually mostly

958

00:42:56,360 --> 00:43:00,769

the Kepler pipeline with tweets that's

959

00:42:59,210 --> 00:43:06,440

how much Kepler revolutionized our

960

00:43:00,769 --> 00:43:08,539

ability to measure these planets just to

961

00:43:06,440 --> 00:43:11,599

highlight again the impact Kepler had

962

00:43:08,539 --> 00:43:13,909

this is a little cartoon that sort of

963

00:43:11,599 --> 00:43:17,380

shows all the multi-planet systems

964

00:43:13,909 --> 00:43:20,119

Kepler found over its four plus years of

965

00:43:17,380 --> 00:43:22,730

operations and you can see it discovered

966

00:43:20,119 --> 00:43:25,250

all kinds of interesting planetary

967

00:43:22,730 --> 00:43:25,699

systems some of them having two planets

968

00:43:25,250 --> 00:43:29,110

some one

969

00:43:25,699 --> 00:43:31,189

four or five six different sizes

970
00:43:29,110 --> 00:43:34,460
different distances from their host

971
00:43:31,190 --> 00:43:39,050
stars and it's just really a cornucopia

972
00:43:34,460 --> 00:43:41,059
of exoplanets that were detected by the

973
00:43:39,050 --> 00:43:43,700
Kepler and then later the k2 mission

974
00:43:41,059 --> 00:43:49,219
which was sort of Kepler recycled you

975
00:43:43,699 --> 00:43:51,710
will but test is going to really go one

976
00:43:49,219 --> 00:43:55,009
step further so this is the Kepler field

977
00:43:51,710 --> 00:43:57,619
of view in yellow that's one camera from

978
00:43:55,010 --> 00:43:59,570
Tess one camera is twice the size of

979
00:43:57,619 --> 00:44:01,639
Kepler's entire field of view there's

980
00:43:59,570 --> 00:44:04,280
four of them for every single wedge

981
00:44:01,639 --> 00:44:06,559
every month we get basically eight times

982
00:44:04,280 --> 00:44:10,340
the size of Kepler we're good to up for

983
00:44:06,559 --> 00:44:13,400
two years across the entire sky so while

984
00:44:10,340 --> 00:44:17,480
Kepler detected a lot of exoplanets

985
00:44:13,400 --> 00:44:19,820
looking very deeply at these gold areas

986
00:44:17,480 --> 00:44:22,400
of the sky TESS is going to know the

987
00:44:19,820 --> 00:44:25,940
lawn and discover all kinds of planets

988
00:44:22,400 --> 00:44:30,320
around the wide part of the sky but

989
00:44:25,940 --> 00:44:33,590
around brighter stars so here are the

990
00:44:30,320 --> 00:44:36,620
first three systems that have been not

991
00:44:33,590 --> 00:44:39,610
only discovered but verified and I'll go

992
00:44:36,619 --> 00:44:43,549
through each one in turn you can see the

993
00:44:39,610 --> 00:44:46,519
locations of the house stars on the FF

994
00:44:43,550 --> 00:44:51,550
fives which are these full-frame images

995
00:44:46,519 --> 00:44:55,250
for short here's PI menses location LH s

996
00:44:51,550 --> 00:44:57,320
3844 and HD - one seven two four nine

997
00:44:55,250 --> 00:44:59,510
you'd never be able to tell these apart

998

00:44:57,320 --> 00:45:01,580
from any other one unless you sit down

999
00:44:59,510 --> 00:45:03,530
and look at all the measurements and

1000
00:45:01,579 --> 00:45:05,119
figure out which ones of these things

1001
00:45:03,530 --> 00:45:06,620
are twinkling in ways that we care about

1002
00:45:05,119 --> 00:45:07,699
for exoplanets which ones are doing

1003
00:45:06,619 --> 00:45:10,940
other things which ones are doing

1004
00:45:07,699 --> 00:45:14,989
nothing that's the beauty of TESS so

1005
00:45:10,940 --> 00:45:17,630
let's start with hi men see so this is a

1006
00:45:14,989 --> 00:45:20,029
very interesting house star it's

1007
00:45:17,630 --> 00:45:20,809
actually pretty close by it's about 60

1008
00:45:20,030 --> 00:45:22,700
light years away

1009
00:45:20,809 --> 00:45:25,219
this is going to be a common theme by

1010
00:45:22,699 --> 00:45:26,989
the way for all three planets it's so

1011
00:45:25,219 --> 00:45:28,939
bright that if you're in the southern

1012
00:45:26,989 --> 00:45:30,889

hemisphere say you go to Chile or

1013

00:45:28,940 --> 00:45:33,440

Australia or something you can actually

1014

00:45:30,889 --> 00:45:35,000

see the star with your naked eye in the

1015

00:45:33,440 --> 00:45:37,700

southern mystery that's how bright and

1016

00:45:35,000 --> 00:45:39,619

close the star is this

1017

00:45:37,699 --> 00:45:41,960

itself is pretty similar to the Sun it's

1018

00:45:39,619 --> 00:45:44,960

about 10% larger in mass and size

1019

00:45:41,960 --> 00:45:47,000

compared to the Sun and the planet is

1020

00:45:44,960 --> 00:45:49,429

one of these really interesting examples

1021

00:45:47,000 --> 00:45:53,690

of something we don't have in the solar

1022

00:45:49,429 --> 00:45:55,429

system the planets radius the size is

1023

00:45:53,690 --> 00:45:57,920

about double that of the earth and the

1024

00:45:55,429 --> 00:45:59,480

planet mass is about 5 times the mass of

1025

00:45:57,920 --> 00:46:01,400

the earth there's no such example of

1026

00:45:59,480 --> 00:46:03,650

this in our solar system you sort of

1027
00:46:01,400 --> 00:46:06,710
jump from earth all the way up to the

1028
00:46:03,650 --> 00:46:08,420
ice giants Uranus and Neptune the

1029
00:46:06,710 --> 00:46:10,970
orbital period is one of these

1030
00:46:08,420 --> 00:46:13,909
characteristic short period planets it

1031
00:46:10,969 --> 00:46:16,039
takes about six days for it to do one

1032
00:46:13,909 --> 00:46:18,829
complete orbit around the star so it's

1033
00:46:16,039 --> 00:46:22,489
very close to its host star much closer

1034
00:46:18,829 --> 00:46:24,739
than mercury an important point is if

1035
00:46:22,489 --> 00:46:26,869
you can measure the mass and the radius

1036
00:46:24,739 --> 00:46:29,449
for the planet which we have done in

1037
00:46:26,869 --> 00:46:31,190
this case you can take mass divided by

1038
00:46:29,449 --> 00:46:33,799
the radius cubed and you get something

1039
00:46:31,190 --> 00:46:35,780
called density and this is sort of an

1040
00:46:33,800 --> 00:46:39,890
average density but it allows us to make

1041
00:46:35,780 --> 00:46:42,320
very basic claims about what the planet

1042
00:46:39,889 --> 00:46:44,599
might be made out of we can show for

1043
00:46:42,320 --> 00:46:46,820
example that based on our measurement of

1044
00:46:44,599 --> 00:46:49,190
the planet's mass and radius it cannot

1045
00:46:46,820 --> 00:46:51,410
be made entirely out of iron for example

1046
00:46:49,190 --> 00:46:53,990
it cannot be made entirely out of gas

1047
00:46:51,409 --> 00:46:56,359
for example in fact we are able to

1048
00:46:53,989 --> 00:46:59,049
identify that the planet is likely a

1049
00:46:56,360 --> 00:47:02,090
combination of rocky material and

1050
00:46:59,050 --> 00:47:03,170
probably some kind of gas we don't know

1051
00:47:02,090 --> 00:47:06,170
whether it's a hydrogen helium

1052
00:47:03,170 --> 00:47:08,750
atmosphere or perhaps a water or methane

1053
00:47:06,170 --> 00:47:10,970
atmosphere it might be thin might be

1054
00:47:08,750 --> 00:47:12,980
relatively thick this is where follow-up

1055

00:47:10,969 --> 00:47:16,219
observations are needed including from

1056
00:47:12,980 --> 00:47:18,260
James Webb the other mentioned the other

1057
00:47:16,219 --> 00:47:19,730
quick thing I'll mention is that there

1058
00:47:18,260 --> 00:47:22,520
was actually another planet that was

1059
00:47:19,730 --> 00:47:25,369
previously known around the star already

1060
00:47:22,519 --> 00:47:29,509
much farther away takes five years for

1061
00:47:25,369 --> 00:47:31,579
that planet to go around pieman star and

1062
00:47:29,510 --> 00:47:34,130
it's huge it's ten times the mass of

1063
00:47:31,579 --> 00:47:36,710
Jupiter it's almost a star in its own

1064
00:47:34,130 --> 00:47:39,920
right so the first exoplanet discovery

1065
00:47:36,710 --> 00:47:41,510
by Tess was actually a second planet in

1066
00:47:39,920 --> 00:47:43,730
a known system which is really

1067
00:47:41,510 --> 00:47:46,460
interesting and it's going to be a lot

1068
00:47:43,730 --> 00:47:49,099
more of these as time moves on and the

1069
00:47:46,460 --> 00:47:51,289

plot on the right is taken straight from

1070

00:47:49,099 --> 00:47:54,589
the paper that announced

1071

00:47:51,289 --> 00:47:56,329
the discovery of this on the axis up and

1072

00:47:54,590 --> 00:47:58,789
down is basically a measurement of the

1073

00:47:56,329 --> 00:48:01,009
brightness of the star as a function of

1074

00:47:58,789 --> 00:48:02,509
time and you can see if you remember

1075

00:48:01,010 --> 00:48:04,400
back when I showed the little animation

1076

00:48:02,510 --> 00:48:05,660
of what happens when a star goes in

1077

00:48:04,400 --> 00:48:08,269
front when a planet goes in front of the

1078

00:48:05,659 --> 00:48:12,019
star we see a very characteristic drop

1079

00:48:08,269 --> 00:48:13,610
in the flux while pieman C is going in

1080

00:48:12,019 --> 00:48:15,530
front and blocking all the light and

1081

00:48:13,610 --> 00:48:18,019
then it goes back to normal again so

1082

00:48:15,530 --> 00:48:20,180
this these kinds of plots which we call

1083

00:48:18,019 --> 00:48:22,219
white curves or what we really want to

1084
00:48:20,179 --> 00:48:24,859
get out of tests to then study and

1085
00:48:22,219 --> 00:48:28,579
measure properties of the planets that we

1086
00:48:24,860 --> 00:48:30,980
find here's the second planet and it

1087
00:48:28,579 --> 00:48:33,319
couldn't be more different so again we

1088
00:48:30,980 --> 00:48:34,699
have the characteristic shape of the

1089
00:48:33,320 --> 00:48:37,160
brightness of the star sort of sitting

1090
00:48:34,699 --> 00:48:39,559
there being find that up way that drops

1091
00:48:37,159 --> 00:48:42,440
down as a planet blocking this

1092
00:48:39,559 --> 00:48:45,980
particular star but the host star is

1093
00:48:42,440 --> 00:48:49,070
very very different from PI men LHS 3844

1094
00:48:45,980 --> 00:48:53,150
we call an M dwarf it's very very small

1095
00:48:49,070 --> 00:48:56,480
it's about 15% the mass of the Sun and

1096
00:48:53,150 --> 00:49:00,410
about 20% of the size it was very tiny

1097
00:48:56,480 --> 00:49:02,389
star it's red it's cool and they are

1098
00:49:00,409 --> 00:49:04,429
some of the most interesting targets for

1099
00:49:02,389 --> 00:49:06,859
exoplanets and habitability in our solar

1100
00:49:04,429 --> 00:49:08,929
system but the one thing it does share

1101
00:49:06,860 --> 00:49:11,000
in common with the previous planet and

1102
00:49:08,929 --> 00:49:13,190
it's close it's about 49 light years

1103
00:49:11,000 --> 00:49:15,500
away and it may seem far but when I

1104
00:49:13,190 --> 00:49:19,130
compare to other known planets it's

1105
00:49:15,500 --> 00:49:22,070
actually pretty close by the plot itself

1106
00:49:19,130 --> 00:49:24,710
is about 30% larger than the earth so

1107
00:49:22,070 --> 00:49:28,010
it's pretty small what's amazing is that

1108
00:49:24,710 --> 00:49:32,000
it takes 11 hours for this to orbit the

1109
00:49:28,010 --> 00:49:35,330
star half a day is one year on this

1110
00:49:32,000 --> 00:49:38,989
planet for context mercury the closest

1111
00:49:35,329 --> 00:49:41,029
planet to our Sun takes 88 days to go

1112

00:49:38,989 --> 00:49:44,719
around the Sun this thing takes 11 hours

1113
00:49:41,030 --> 00:49:47,420
to go around this star remarkably short

1114
00:49:44,719 --> 00:49:49,849
orbital period because it's so close

1115
00:49:47,420 --> 00:49:53,450
it's not a night place nice place to be

1116
00:49:49,849 --> 00:49:54,889
even in January the temperature on this

1117
00:49:53,449 --> 00:49:58,250
planet was something like a thousand

1118
00:49:54,889 --> 00:50:00,079
degrees Fahrenheit estimated not to

1119
00:49:58,250 --> 00:50:03,090
mention that it's being bombarded by all

1120
00:50:00,079 --> 00:50:05,559
kinds of ultraviolet rays and gamma ray

1121
00:50:03,090 --> 00:50:07,750
the atmosphere is probably been baked

1122
00:50:05,559 --> 00:50:09,549
off so there's no protection at all for

1123
00:50:07,750 --> 00:50:12,849
anybody you might be on the surface it's

1124
00:50:09,550 --> 00:50:16,150
a horrible place to be but in the

1125
00:50:12,849 --> 00:50:18,909
context of understanding how plants form

1126
00:50:16,150 --> 00:50:22,240

around stars it's vital because we want

1127

00:50:18,909 --> 00:50:24,009

to understand how is it that you got to

1128

00:50:22,239 --> 00:50:26,199

where you are it tells us a lot about

1129

00:50:24,010 --> 00:50:30,700

how plants form and how they change over

1130

00:50:26,199 --> 00:50:32,799

time the last exoplanet that was

1131

00:50:30,699 --> 00:50:36,789

discovered and was recently announced is

1132

00:50:32,800 --> 00:50:40,990

HD 21 40 79 and it's interesting because

1133

00:50:36,789 --> 00:50:43,529

once again it's sort of in between the

1134

00:50:40,989 --> 00:50:46,449

types of planets from the previous two

1135

00:50:43,530 --> 00:50:48,790

again it's very close it's about 52

1136

00:50:46,449 --> 00:50:51,129

light years away so all three are very

1137

00:50:48,789 --> 00:50:52,389

close to the Sun in terms of other stars

1138

00:50:51,130 --> 00:50:56,230

it's doing what we call the solar

1139

00:50:52,389 --> 00:50:58,809

neighborhood this star itself is sort of

1140

00:50:56,230 --> 00:51:01,780

in-between the previous time men's

1141
00:50:58,809 --> 00:51:04,239
planet a host star and and LHS is host

1142
00:51:01,780 --> 00:51:07,060
star it's about 75% as massive as the

1143
00:51:04,239 --> 00:51:09,759
song about 70% its size so this is what

1144
00:51:07,059 --> 00:51:11,799
we call an orange K dwarf star they're

1145
00:51:09,760 --> 00:51:14,380
very interesting in their own right the

1146
00:51:11,800 --> 00:51:17,170
planet is sort of we call it tiny

1147
00:51:14,380 --> 00:51:19,420
Neptune or a sub Neptune so it's an ice

1148
00:51:17,170 --> 00:51:22,389
giant we think but it's so much smaller

1149
00:51:19,420 --> 00:51:25,510
than Neptune it's about three times the

1150
00:51:22,389 --> 00:51:27,579
size of the earth about 23 25 times the

1151
00:51:25,510 --> 00:51:29,110
mass of the earth so it's probably some

1152
00:51:27,579 --> 00:51:31,029
sort of ice giant perhaps a little bit

1153
00:51:29,110 --> 00:51:34,570
smaller than what we have in our solar

1154
00:51:31,030 --> 00:51:36,340
system and it takes 35 days to over its

1155
00:51:34,570 --> 00:51:38,800
host are still within the orbit of

1156
00:51:36,340 --> 00:51:42,130
mercury right but compared to the other

1157
00:51:38,800 --> 00:51:43,660
two much further away the other

1158
00:51:42,130 --> 00:51:46,660
interesting thing about this system is

1159
00:51:43,659 --> 00:51:49,539
in the discovery paper there is evidence

1160
00:51:46,659 --> 00:51:53,230
of a second planet in this star system

1161
00:51:49,539 --> 00:51:56,050
this is actually very very similar to

1162
00:51:53,230 --> 00:51:59,670
the radius of the earth and if we can

1163
00:51:56,050 --> 00:52:03,640
measure its mass this might be the first

1164
00:51:59,670 --> 00:52:06,460
earth-sized an earth-mass planet

1165
00:52:03,639 --> 00:52:08,139
discovered by tennis not habitable

1166
00:52:06,460 --> 00:52:10,389
because the orbital period is only eight

1167
00:52:08,139 --> 00:52:12,339
days so it's getting baked just as much

1168
00:52:10,389 --> 00:52:15,309
as anything else but it shows we're able

1169

00:52:12,340 --> 00:52:16,900
to find these and perhaps perhaps be

1170
00:52:15,309 --> 00:52:19,509
able to characterize the atmosphere

1171
00:52:16,900 --> 00:52:22,210
years of some of these planets that are

1172
00:52:19,510 --> 00:52:24,520
similar to the earth in its size and its

1173
00:52:22,210 --> 00:52:26,800
mass very exciting so we should stay

1174
00:52:24,519 --> 00:52:28,659
tuned for more more information about

1175
00:52:26,800 --> 00:52:32,590
whether the second planet signal is real

1176
00:52:28,659 --> 00:52:34,899
or a false positive just a highlight

1177
00:52:32,590 --> 00:52:38,590
again the difference is tiny tiny

1178
00:52:34,900 --> 00:52:41,440
planets compared to huge neptune planets

1179
00:52:38,590 --> 00:52:45,670
no atmosphere and boiling ly hot around

1180
00:52:41,440 --> 00:52:48,490
a red mm dwarf sort of a tiny Neptune

1181
00:52:45,670 --> 00:52:50,500
orbiting an orange K dwarf now we have

1182
00:52:48,489 --> 00:52:53,049
PI manages this weird sort of super

1183
00:52:50,500 --> 00:52:54,940

earth class planet that we don't really

1184

00:52:53,050 --> 00:52:58,000

have examples of our own solar system

1185

00:52:54,940 --> 00:53:00,490

but orbiting star that's pretty similar

1186

00:52:58,000 --> 00:53:03,250

to the Sun so these first three by

1187

00:53:00,489 --> 00:53:05,769

themselves really show the diversity of

1188

00:53:03,250 --> 00:53:07,690

types of planets around different types

1189

00:53:05,769 --> 00:53:10,630

of stars that we're gonna find in tests

1190

00:53:07,690 --> 00:53:13,269

and there are hundreds of other

1191

00:53:10,630 --> 00:53:15,400

candidate planets that astronomers are

1192

00:53:13,269 --> 00:53:16,989

following up right now with telescopes

1193

00:53:15,400 --> 00:53:19,840

from around the world and this is just

1194

00:53:16,989 --> 00:53:21,879

from the first couple of months of the

1195

00:53:19,840 --> 00:53:23,620

two-year mission so stay tuned there'll

1196

00:53:21,880 --> 00:53:29,050

be a lot of new discoveries coming in

1197

00:53:23,619 --> 00:53:30,940

2019 and 2020 for sure just a highlight

1198
00:53:29,050 --> 00:53:33,370
this fact even further about how

1199
00:53:30,940 --> 00:53:36,639
important it is to discover nearby

1200
00:53:33,369 --> 00:53:39,119
planets here is the location of the Sun

1201
00:53:36,639 --> 00:53:41,319
and these little circles sort of show

1202
00:53:39,119 --> 00:53:43,659
distances away from us right so this

1203
00:53:41,320 --> 00:53:46,450
circle represents ten light years away

1204
00:53:43,659 --> 00:53:48,399
this circles 30 light years away and as

1205
00:53:46,449 --> 00:53:50,829
we go further and further out we get

1206
00:53:48,400 --> 00:53:53,889
more and more stars in our neighborhood

1207
00:53:50,829 --> 00:53:55,960
and so the location of the first three

1208
00:53:53,889 --> 00:53:56,889
planets you notice you may have noticed

1209
00:53:55,960 --> 00:53:58,929
I'll have roughly the same distance

1210
00:53:56,889 --> 00:54:00,730
they're all roughly the same distance

1211
00:53:58,929 --> 00:54:04,929
away from the Sun they're pretty close

1212
00:54:00,730 --> 00:54:07,059
by if I add some of the previously

1213
00:54:04,929 --> 00:54:09,819
discovered planets you can see that

1214
00:54:07,059 --> 00:54:12,639
these three that come out are already

1215
00:54:09,820 --> 00:54:14,980
sort of in the top ten or twenty closest

1216
00:54:12,639 --> 00:54:16,449
planets we know about to the Sun which

1217
00:54:14,980 --> 00:54:19,329
is already exciting there's going to be

1218
00:54:16,449 --> 00:54:22,689
a lot more coming in fact we can make

1219
00:54:19,329 --> 00:54:25,809
some predictions so this is assert as a

1220
00:54:22,690 --> 00:54:27,909
simulation where we know which stars

1221
00:54:25,809 --> 00:54:30,269
Tess is observing and we know how common

1222
00:54:27,909 --> 00:54:34,559
planets are and so we can predict

1223
00:54:30,269 --> 00:54:36,539
roughly how many stars near the earth

1224
00:54:34,559 --> 00:54:38,489
will be detect planets around you can see

1225
00:54:36,539 --> 00:54:40,559
Tess is really going to fill in there

1226

00:54:38,489 --> 00:54:42,929
really really close by known planets

1227
00:54:40,559 --> 00:54:45,210
that are discovered and as we zoom out

1228
00:54:42,929 --> 00:54:48,989
to further and further distances you can

1229
00:54:45,210 --> 00:54:51,360
see Tess is really gonna fill in all of

1230
00:54:48,989 --> 00:54:54,569
the known exoplanets that are as close

1231
00:54:51,360 --> 00:54:56,550
to the Sun as we can get in blue you

1232
00:54:54,570 --> 00:54:58,890
actually have the Kepler detection and

1233
00:54:56,550 --> 00:55:02,460
you see that while Kepler discovered

1234
00:54:58,889 --> 00:55:04,949
lots and lots of planets unfortunately a

1235
00:55:02,460 --> 00:55:06,780
lot of them are really far away and so

1236
00:55:04,949 --> 00:55:09,569
well we can detect them and measure some

1237
00:55:06,780 --> 00:55:11,700
basic properties but we really can't do

1238
00:55:09,570 --> 00:55:13,260
very well let's get follow-up data to

1239
00:55:11,699 --> 00:55:15,929
really characterize what they're like

1240
00:55:13,260 --> 00:55:19,140

try to measure atmospheric compositions

1241

00:55:15,929 --> 00:55:22,019

try to predict whether there's strong

1242

00:55:19,139 --> 00:55:25,230

winds on some of these gas giants things

1243

00:55:22,019 --> 00:55:27,119

like that so the tests discoveries which

1244

00:55:25,230 --> 00:55:30,809

should fill in this yellow space are

1245

00:55:27,119 --> 00:55:34,079

designed to do exactly that this is one

1246

00:55:30,809 --> 00:55:36,420

last way of showing that's this point so

1247

00:55:34,079 --> 00:55:38,819

on the up-and-down direction you have

1248

00:55:36,420 --> 00:55:42,659

the size of discovered planets relative

1249

00:55:38,820 --> 00:55:45,030

to the earth so this is one earth radius

1250

00:55:42,659 --> 00:55:46,679

this is a planet that would be twice the

1251

00:55:45,030 --> 00:55:50,310

size of Earth three times the size of

1252

00:55:46,679 --> 00:55:52,769

Earth etc and on the left and right

1253

00:55:50,309 --> 00:55:55,590

direction we have distance away from the

1254

00:55:52,769 --> 00:55:58,409

Sun so in black are some of these

1255
00:55:55,590 --> 00:56:03,358
previously discovered planets from the

1256
00:55:58,409 --> 00:56:06,629
ground primarily that have been you know

1257
00:56:03,358 --> 00:56:09,269
orbiting really really close stars to

1258
00:56:06,630 --> 00:56:11,760
the Sun and in blue we have the kepler

1259
00:56:09,269 --> 00:56:13,829
and k2 discoveries and one thing I hope

1260
00:56:11,760 --> 00:56:17,070
you'll all notice is that they're all on

1261
00:56:13,829 --> 00:56:20,699
the right and this plot a lot of them

1262
00:56:17,070 --> 00:56:23,670
are far away they're 300 500 maybe even

1263
00:56:20,699 --> 00:56:26,219
a few thousand light years away which

1264
00:56:23,670 --> 00:56:28,470
make it very hard to study them in a lot

1265
00:56:26,219 --> 00:56:31,230
of detail here's where those test

1266
00:56:28,469 --> 00:56:34,618
predictions come in Tess is gonna find

1267
00:56:31,230 --> 00:56:36,480
lots and lots of small planets one times

1268
00:56:34,619 --> 00:56:40,079
two times three times the size of the

1269
00:56:36,480 --> 00:56:42,599
earth orbiting only 30 or 50 or maybe a

1270
00:56:40,079 --> 00:56:44,039
few hundred light years away and these

1271
00:56:42,599 --> 00:56:46,019
are the ones we can

1272
00:56:44,039 --> 00:56:48,570
really follow up with telescopes like

1273
00:56:46,019 --> 00:56:49,650
Hubble and James Webb and from some of

1274
00:56:48,570 --> 00:56:54,180
the most powerful ground-based

1275
00:56:49,650 --> 00:56:56,460
telescopes around the world so I wanted

1276
00:56:54,179 --> 00:56:58,139
to leave you with a quick summary the

1277
00:56:56,460 --> 00:57:00,059
first public data release has happened

1278
00:56:58,139 --> 00:57:01,500
here in Baltimore if you're from

1279
00:57:00,059 --> 00:57:04,079
Baltimore you can be proud to know where

1280
00:57:01,500 --> 00:57:05,969
the helmet tests long-term the first

1281
00:57:04,079 --> 00:57:07,170
test exoplanets have been discovered and

1282
00:57:05,969 --> 00:57:09,089
published and I shared with you the

1283

00:57:07,170 --> 00:57:11,550
first three that have been published

1284
00:57:09,090 --> 00:57:13,650
there are hundreds of exoplanet

1285
00:57:11,550 --> 00:57:16,200
candidates actively being followed up by

1286
00:57:13,650 --> 00:57:18,269
astronomers around the world as we speak

1287
00:57:16,199 --> 00:57:20,639
so there'll be a lot more discoveries

1288
00:57:18,269 --> 00:57:23,730
coming in the next few months and even

1289
00:57:20,639 --> 00:57:26,099
the next two years the spacecraft isn't

1290
00:57:23,730 --> 00:57:28,099
is very healthy it's actually starting

1291
00:57:26,099 --> 00:57:30,420
at seventh sector just a week ago

1292
00:57:28,099 --> 00:57:32,579
observations are ongoing data are being

1293
00:57:30,420 --> 00:57:36,539
downloaded from the spacecraft to earth

1294
00:57:32,579 --> 00:57:37,739
every two weeks and the initial

1295
00:57:36,539 --> 00:57:39,300
discoveries in other areas of

1296
00:57:37,739 --> 00:57:41,909
astrophysics are happening now as well

1297
00:57:39,300 --> 00:57:43,769

you have asteroids and comets all kinds

1298

00:57:41,909 --> 00:57:47,159

of stellar astrophysics supernovae all

1299

00:57:43,769 --> 00:57:49,079

kinds of bonus science so what's really

1300

00:57:47,159 --> 00:57:52,559

interesting is that every single one of

1301

00:57:49,079 --> 00:57:56,909

these planets that we find with tests

1302

00:57:52,559 --> 00:57:59,969

are going to be new worlds around nearby

1303

00:57:56,909 --> 00:58:02,219

stars it has an exoplanet scientist we

1304

00:57:59,969 --> 00:58:04,649

are super excited to be able to work

1305

00:58:02,219 --> 00:58:05,579

hard every day to confirm as many of

1306

00:58:04,650 --> 00:58:09,539

these as possible

1307

00:58:05,579 --> 00:58:12,719

because after all we think it's you know

1308

00:58:09,539 --> 00:58:16,650

by far time for us to meet our neighbors

1309

00:58:12,719 --> 00:58:18,209

and that's what we're doing so thanks

1310

00:58:16,650 --> 00:58:20,070

for your attention and I'll take any

1311

00:58:18,210 --> 00:58:23,730

questions you have

1312
00:58:20,070 --> 00:58:34,380
[Applause]

1313
00:58:23,730 --> 00:58:36,809
oh yeah so I have a limited supply this

1314
00:58:34,380 --> 00:58:38,490
is all I could steal from the meeting of

1315
00:58:36,809 --> 00:58:40,170
test mission stickers but if you'd like

1316
00:58:38,489 --> 00:58:42,659
one after the question session feel free

1317
00:58:40,170 --> 00:58:45,570
to come up and grab one and if we run

1318
00:58:42,659 --> 00:59:00,839
out I may even try to pilfer some more

1319
00:58:45,570 --> 00:59:02,850
and give it to Frank let's start over

1320
00:59:00,840 --> 00:59:03,869
here how about you wait wait wait wait

1321
00:59:02,849 --> 00:59:13,710
for the microphone it's gonna come

1322
00:59:03,869 --> 00:59:16,108
around very simple question um what is

1323
00:59:13,710 --> 00:59:19,320
the diameter of that orbit of tests did

1324
00:59:16,108 --> 00:59:21,929
you say that's a good question and that

1325
00:59:19,320 --> 00:59:25,470
really tests my limit of the of the

1326
00:59:21,929 --> 00:59:28,980
orbit of the spacecraft I want to say it

1327
00:59:25,469 --> 00:59:31,739
doesn't go much further than the lunar

1328
00:59:28,980 --> 00:59:34,710
orbit but I'm afraid I can't answer with

1329
00:59:31,739 --> 00:59:37,019
any definitive question about it yeah

1330
00:59:34,710 --> 00:59:39,539
all right so but that prompts my comment

1331
00:59:37,019 --> 00:59:41,969
um there was a talk given just just

1332
00:59:39,539 --> 00:59:45,449
recently here about that orbit and I was

1333
00:59:41,969 --> 00:59:48,179
just flabbergasted how stable that word

1334
00:59:45,449 --> 00:59:50,489
I would mention that yeah just tell

1335
00:59:48,179 --> 00:59:54,299
these people are so it was like 20-30

1336
00:59:50,489 --> 00:59:57,149
years no no no ha ha ha so this is

1337
00:59:54,300 --> 00:59:58,859
actually sort of along my line to sort

1338
00:59:57,150 --> 01:00:01,380
of if you're if you're excited by test

1339
00:59:58,858 --> 01:00:04,019
set to advocate so the primary mission

1340

01:00:01,380 --> 01:00:07,769
will end in 2020 there is opportunity

1341
01:00:04,019 --> 01:00:10,079
for us to ask NASA to fund tests to do

1342
01:00:07,769 --> 01:00:12,329
another two years in another two years

1343
01:00:10,079 --> 01:00:14,759
in another two years as long as NASA is

1344
01:00:12,329 --> 01:00:16,710
willing to support the funds the orbit

1345
01:00:14,760 --> 01:00:17,970
of tests is actually balanced for

1346
01:00:16,710 --> 01:00:20,820
something called implied off MIT because

1347
01:00:17,969 --> 01:00:23,189
I lied off mechanism because SpaceX did

1348
01:00:20,820 --> 01:00:25,380
a bang on job of getting it to where it

1349
01:00:23,190 --> 01:00:27,900
wants to go without using much fuel and

1350
01:00:25,380 --> 01:00:32,390
the orbit is so stable the spacecraft

1351
01:00:27,900 --> 01:00:35,010
has enough fuel to last for 300 years

1352
01:00:32,389 --> 01:00:39,338
minimum

1353
01:00:35,010 --> 01:00:42,400
so suffice it to say it will not be fuel

1354
01:00:39,338 --> 01:00:44,230

that causes Tess to stop taking day you

1355

01:00:42,400 --> 01:00:46,480

will either have a hardware failure or

1356

01:00:44,230 --> 01:00:49,420

at some point NASA will make a decision

1357

01:00:46,480 --> 01:00:51,699

to retire the spacecraft and move on to

1358

01:00:49,420 --> 01:00:53,260

another project but there is every

1359

01:00:51,699 --> 01:00:55,719

indication that tests will be able to

1360

01:00:53,260 --> 01:00:58,869

extend not only up to James Webb Space

1361

01:00:55,719 --> 01:01:00,730

Telescope lunch but even past James Webb

1362

01:00:58,869 --> 01:01:02,950

Space Telescope launched finding planets

1363

01:01:00,730 --> 01:01:05,858

studying stellar astrophysics finding

1364

01:01:02,949 --> 01:01:10,808

comets and asteroids so that's an orbit

1365

01:01:05,858 --> 01:01:14,348

okay yeah hi so I have a two-part

1366

01:01:10,809 --> 01:01:17,048

question about the simulated preneur the

1367

01:01:14,349 --> 01:01:20,829

predicted locations of planets the first

1368

01:01:17,048 --> 01:01:23,139

part is how did those predictions map to

1369
01:01:20,829 --> 01:01:26,410
the graphic that you showed us as that

1370
01:01:23,139 --> 01:01:28,838
was 2-dimensional and I didn't quite get

1371
01:01:26,409 --> 01:01:31,629
like how that I guess it was before this

1372
01:01:28,838 --> 01:01:35,139
in the presentation yeah yes I believe

1373
01:01:31,630 --> 01:01:39,400
it was this oh and sorry the second part

1374
01:01:35,139 --> 01:01:43,778
is then how what is the second part is

1375
01:01:39,400 --> 01:01:47,559
the angle a significant part of the the

1376
01:01:43,778 --> 01:01:50,079
simulation or is that is it yeah I guess

1377
01:01:47,559 --> 01:01:52,269
like how did you choose what's how are

1378
01:01:50,079 --> 01:01:54,009
what spots chosen in the simulation yeah

1379
01:01:52,268 --> 01:01:56,469
that's a that's a those are two good

1380
01:01:54,009 --> 01:01:59,199
questions so the orange points here do

1381
01:01:56,469 --> 01:02:01,778
correspond to the orange points on this

1382
01:01:59,199 --> 01:02:03,759
two-dimensional plot and the simulations

1383
01:02:01,778 --> 01:02:06,130
are statistical right so they're not

1384
01:02:03,759 --> 01:02:08,798
necessarily guaranteeing that so-and-so

1385
01:02:06,130 --> 01:02:11,349
planet will have a star it's sort of a

1386
01:02:08,798 --> 01:02:13,690
random simulation where we aren't we

1387
01:02:11,349 --> 01:02:16,720
know which stars and what types of stars

1388
01:02:13,690 --> 01:02:18,818
are in our field of view and we have

1389
01:02:16,719 --> 01:02:20,828
some good numbers from Kepler and from

1390
01:02:18,818 --> 01:02:22,630
the ground of how often certain types of

1391
01:02:20,829 --> 01:02:25,329
planets are found around them so this is

1392
01:02:22,630 --> 01:02:27,460
one instance if you will of Tess's

1393
01:02:25,329 --> 01:02:29,349
predicted yield we could do a similar

1394
01:02:27,460 --> 01:02:31,539
calculation with a slightly different

1395
01:02:29,349 --> 01:02:33,039
random number and have the orange

1396
01:02:31,539 --> 01:02:35,470
circles themselves be around different

1397

01:02:33,039 --> 01:02:39,069
stars and different angles but the key

1398
01:02:35,469 --> 01:02:42,399
point is that the number and overall

1399
01:02:39,068 --> 01:02:43,900
distribution will be roughly similar so

1400
01:02:42,400 --> 01:02:46,410
we could run this a hundred times

1401
01:02:43,900 --> 01:02:48,170
but the point is you still have orange

1402
01:02:46,409 --> 01:02:50,719
points

1403
01:02:48,170 --> 01:02:53,000
Merilee all around here you'll have very

1404
01:02:50,719 --> 01:02:56,318
few out here you'll have very few way

1405
01:02:53,000 --> 01:02:59,239
over here and so it's just sort of a

1406
01:02:56,318 --> 01:03:00,650
testament of the yield and so don't

1407
01:02:59,239 --> 01:03:02,750
worry too much about with which

1408
01:03:00,650 --> 01:03:04,579
individual star has a predicted planet

1409
01:03:02,750 --> 01:03:07,760
around it it's the total number and the

1410
01:03:04,579 --> 01:03:10,010
overall distributions yeah yeah and in

1411
01:03:07,760 --> 01:03:12,500

fact although I don't have the data at

1412

01:03:10,010 --> 01:03:15,500

the meeting they over plotted on this

1413

01:03:12,500 --> 01:03:17,269

the initial candidates that are actually

1414

01:03:15,500 --> 01:03:18,980

detected around the actual stars those

1415

01:03:17,269 --> 01:03:21,048

few hundred I talked about and indeed

1416

01:03:18,980 --> 01:03:23,240

they do sort of overlap right in this

1417

01:03:21,048 --> 01:03:26,059

region so we're in great shape for that

1418

01:03:23,239 --> 01:03:27,828

yeah so there's a question online about

1419

01:03:26,059 --> 01:03:29,900

focusing on like the Gliese e catalog

1420

01:03:27,829 --> 01:03:31,609

goes out to 25 light-years and so it

1421

01:03:29,900 --> 01:03:34,670

sounds like we're gonna get maybe five

1422

01:03:31,608 --> 01:03:38,318

six half a dozen of them inside 30

1423

01:03:34,670 --> 01:03:38,318

light-years and those of course will be

1424

01:03:39,280 --> 01:03:44,510

yeah so the target selection was a

1425

01:03:42,318 --> 01:03:48,199

multi-year effort of which I played a

1426
01:03:44,510 --> 01:03:50,089
very small part in but indeed we had to

1427
01:03:48,199 --> 01:03:52,039
do a lot of work before the spacecraft

1428
01:03:50,088 --> 01:03:54,650
even launched to figure out which

1429
01:03:52,039 --> 01:03:57,529
targets we want to get the best most

1430
01:03:54,650 --> 01:03:59,630
sort of the fastest measurements on to

1431
01:03:57,530 --> 01:04:02,930
look for planets and so we indeed are

1432
01:03:59,630 --> 01:04:05,030
observing pretty much every M dwarf we

1433
01:04:02,929 --> 01:04:06,440
know about that's bright enough to get

1434
01:04:05,030 --> 01:04:07,880
the signal that we need to find plants

1435
01:04:06,440 --> 01:04:09,619
around because M dwarfs are so

1436
01:04:07,880 --> 01:04:12,048
interesting and then on top of that

1437
01:04:09,619 --> 01:04:14,838
we're also observing as many of the best

1438
01:04:12,048 --> 01:04:16,429
sort of solar like and those K dwarfs I

1439
01:04:14,838 --> 01:04:18,710
mentioned the orange dwarfs that are

1440
01:04:16,429 --> 01:04:20,088
close by and are well it's relatively

1441
01:04:18,710 --> 01:04:23,829
well behaved otherwise we're not

1442
01:04:20,088 --> 01:04:23,828
particularly no easy or have other bad

1443
01:04:24,099 --> 01:04:32,750
other questions is there a greater

1444
01:04:30,409 --> 01:04:35,989
likelihood that test will find shorter

1445
01:04:32,750 --> 01:04:38,510
period orbit planets rather than longer

1446
01:04:35,989 --> 01:04:40,098
period orbits yep of course it depends

1447
01:04:38,510 --> 01:04:43,549
on what you mean by short and long but

1448
01:04:40,099 --> 01:04:45,798
the the minimum baseline for a given

1449
01:04:43,548 --> 01:04:48,619
star in tests for the first two years at

1450
01:04:45,798 --> 01:04:51,530
least is about a month because it takes

1451
01:04:48,619 --> 01:04:53,599
one of those orange wedges now if you're

1452
01:04:51,530 --> 01:04:56,298
lucky and you happen to be a star that

1453
01:04:53,599 --> 01:04:58,970
lives in the holes you'll actually get

1454

01:04:56,298 --> 01:05:01,400
twelve months of coverage and so you can

1455
01:04:58,969 --> 01:05:02,029
find orbital periods out to several

1456
01:05:01,400 --> 01:05:04,910
months

1457
01:05:02,030 --> 01:05:07,160
but you are right tests is not really

1458
01:05:04,909 --> 01:05:08,690
designed to measure the question

1459
01:05:07,159 --> 01:05:11,899
Kepler's out to do which is to ask how

1460
01:05:08,690 --> 01:05:14,389
many one year earth-sized planets are

1461
01:05:11,900 --> 01:05:16,250
there Tess's job is to find lots and

1462
01:05:14,389 --> 01:05:18,739
lots of earth sized planets and it will

1463
01:05:16,250 --> 01:05:20,840
be very close so we can actually probe

1464
01:05:18,739 --> 01:05:22,879
the atmospheres of them with James Webb

1465
01:05:20,840 --> 01:05:26,480
and it turns out the best candidates for

1466
01:05:22,880 --> 01:05:30,110
that are planets orbiting bright nearby

1467
01:05:26,480 --> 01:05:34,010
stars as close to the star as they can

1468
01:05:30,110 --> 01:05:36,050

get so you can get lots of samples the

1469

01:05:34,010 --> 01:05:39,680

questions we had a question from online

1470

01:05:36,050 --> 01:05:41,180

the continuous viewing zones sometimes

1471

01:05:39,679 --> 01:05:47,839

those are pointed at the north and south

1472

01:05:41,179 --> 01:05:50,949

galactic polls how are they okay so that

1473

01:05:47,840 --> 01:05:53,420

was the question online was where the

1474

01:05:50,949 --> 01:05:55,579

yeah sorry I didn't I didn't know if I

1475

01:05:53,420 --> 01:05:58,490

wanted to go into ecliptic verses and

1476

01:05:55,579 --> 01:06:00,469

polling but essentially the we got some

1477

01:05:58,489 --> 01:06:01,309

gigs online oh sure no that's awesome

1478

01:06:00,469 --> 01:06:03,799

that that's great

1479

01:06:01,309 --> 01:06:06,500

so yeah I wanna I want to try to get to

1480

01:06:03,800 --> 01:06:10,070

the movie that shows it but if not they

1481

01:06:06,500 --> 01:06:12,260

can go back the the test in the first

1482

01:06:10,070 --> 01:06:14,420

two years is avoiding what we call the

1483
01:06:12,260 --> 01:06:17,270
ecliptic plane which is where the

1484
01:06:14,420 --> 01:06:19,519
majority of our planets around the Sun

1485
01:06:17,269 --> 01:06:21,500
and I'll be asteroids and comets though

1486
01:06:19,519 --> 01:06:23,539
not all of them are sort of located

1487
01:06:21,500 --> 01:06:25,699
which actually avoiding that for the

1488
01:06:23,539 --> 01:06:28,400
first two years but there's a potential

1489
01:06:25,699 --> 01:06:29,599
to go and get those in the next two

1490
01:06:28,400 --> 01:06:31,730
years and that's something we're

1491
01:06:29,599 --> 01:06:33,259
thinking about very hard if NASA funds

1492
01:06:31,730 --> 01:06:35,329
us for two more years of observation yes

1493
01:06:33,260 --> 01:06:38,770
it is the ecliptic poles where the

1494
01:06:35,329 --> 01:06:38,769
Seavey's are good

1495
01:06:39,289 --> 01:06:45,139
[Laughter]

1496
01:06:42,050 --> 01:06:45,139
[Applause]

1497
01:06:57,320 --> 01:07:02,860
I'm just interested in how this data can

1498
01:06:59,929 --> 01:07:06,669
feed into changing the Drake Equation

1499
01:07:02,860 --> 01:07:06,670
that's a great question

1500
01:07:10,570 --> 01:07:16,130
we always say test is not a statistical

1501
01:07:13,670 --> 01:07:18,500
mission Kepler's

1502
01:07:16,130 --> 01:07:20,510
science objective was to try and do a

1503
01:07:18,500 --> 01:07:24,739
complete survey to sort of answer

1504
01:07:20,510 --> 01:07:28,220
questions like how many stars of type X

1505
01:07:24,739 --> 01:07:30,199
have planets of type Y that was its

1506
01:07:28,219 --> 01:07:32,059
primary objective the targets and the

1507
01:07:30,199 --> 01:07:33,799
whole mission design were designed to

1508
01:07:32,059 --> 01:07:36,619
answer that question

1509
01:07:33,800 --> 01:07:38,750
Tesla's question is different Tess is

1510
01:07:36,619 --> 01:07:40,849
not worried about completeness and

1511

01:07:38,750 --> 01:07:43,369
although people will do statistics on

1512
01:07:40,849 --> 01:07:45,710
these things it's not really even

1513
01:07:43,369 --> 01:07:47,329
sensitive to a lot of the habitable

1514
01:07:45,710 --> 01:07:48,889
zones with the possible exception of

1515
01:07:47,329 --> 01:07:51,650
those M dwarfs because the how those are

1516
01:07:48,889 --> 01:07:54,400
so much closer instead Tess is really

1517
01:07:51,650 --> 01:07:56,990
finding as many of our nearby

1518
01:07:54,400 --> 01:07:59,930
short-period planets of all kinds of

1519
01:07:56,989 --> 01:08:02,359
sizes for two reasons one to understand

1520
01:07:59,929 --> 01:08:03,619
which of our solar neighborhood friends

1521
01:08:02,360 --> 01:08:05,450
our solar neighborhood stars have

1522
01:08:03,619 --> 01:08:07,400
planets around them and they may have

1523
01:08:05,449 --> 01:08:10,159
plants further away if we do follow-up

1524
01:08:07,400 --> 01:08:12,260
and two to enable things like James Webb

1525
01:08:10,159 --> 01:08:14,119

and Hubble and the most powerful

1526

01:08:12,260 --> 01:08:15,560
ground-based telescopes to basically

1527

01:08:14,119 --> 01:08:18,199
detect the compositions of their

1528

01:08:15,559 --> 01:08:19,609
atmospheres which is arguably one step

1529

01:08:18,199 --> 01:08:21,199
of the Drake Equation if you want to

1530

01:08:19,609 --> 01:08:22,579
call it it but it's not really sort of

1531

01:08:21,199 --> 01:08:24,619
measuring a to earth if you've heard it

1532

01:08:22,579 --> 01:08:26,300
before that was really kept visual yeah

1533

01:08:24,619 --> 01:08:30,229
if that would have addresses your

1534

01:08:26,300 --> 01:08:34,070
question I'm happy to talk more as well

1535

01:08:30,229 --> 01:08:39,709
if there's time we're all actors ah yes

1536

01:08:34,069 --> 01:08:41,329
so yeah so this will actually sort of we

1537

01:08:39,710 --> 01:08:42,920
expect to find comparable number

1538

01:08:41,329 --> 01:08:44,269
compared to Kepler the difference of

1539

01:08:42,920 --> 01:08:47,239
course is these stars are much closer to

1540
01:08:44,270 --> 01:08:50,440
us so it will give us a good census

1541
01:08:47,239 --> 01:08:54,559
about planet frequency around

1542
01:08:50,439 --> 01:09:01,879
neighborhood stars we have a question

1543
01:08:54,560 --> 01:09:05,090
here so I was once told that if you were

1544
01:09:01,880 --> 01:09:07,699
looking at stars - what would happen if

1545
01:09:05,090 --> 01:09:11,329
you had an ocean I was told basically

1546
01:09:07,699 --> 01:09:13,579
oceans were where photons went to die is

1547
01:09:11,329 --> 01:09:16,039
that still true would there if you

1548
01:09:13,579 --> 01:09:18,590
happen to find the star that our planet

1549
01:09:16,039 --> 01:09:20,479
that had an ocean on it you're still not

1550
01:09:18,590 --> 01:09:23,539
gonna be able to see it or or the

1551
01:09:20,479 --> 01:09:26,239
atmospheric composition questions more

1552
01:09:23,539 --> 01:09:26,659
well like actual ocean water ocean oh

1553
01:09:26,239 --> 01:09:29,028
yeah

1554
01:09:26,659 --> 01:09:32,599
so for detecting the planet

1555
01:09:29,029 --> 01:09:34,039
it's pretty insensitive because the way

1556
01:09:32,599 --> 01:09:35,359
we're detecting into planets is we're

1557
01:09:34,038 --> 01:09:38,208
just asking is there something in the

1558
01:09:35,359 --> 01:09:41,298
way and whether there's a pure water

1559
01:09:38,208 --> 01:09:43,038
world or rock or iron or gas doesn't

1560
01:09:41,298 --> 01:09:44,838
matter it turns out is gonna block the

1561
01:09:43,038 --> 01:09:46,399
light and we're gonna see a decrease in

1562
01:09:44,838 --> 01:09:48,618
the brightness of the star either way

1563
01:09:46,399 --> 01:09:51,198
the challenge comes with the atmospheric

1564
01:09:48,618 --> 01:09:53,509
composition there's a couple of factors

1565
01:09:51,198 --> 01:09:55,189
that sort of dictate how well we can

1566
01:09:53,509 --> 01:09:57,439
really measure the atmospheric

1567
01:09:55,189 --> 01:09:59,448
composition and even size of these

1568

01:09:57,439 --> 01:10:01,879
planets and one of them is how thick is

1569
01:09:59,448 --> 01:10:03,738
the atmosphere as you might imagine the

1570
01:10:01,880 --> 01:10:05,569
thicker the atmosphere the more

1571
01:10:03,738 --> 01:10:07,038
atmosphere the light has to travel

1572
01:10:05,569 --> 01:10:09,078
through to get to us and so we have an

1573
01:10:07,038 --> 01:10:11,509
easier way of measuring some of the

1574
01:10:09,078 --> 01:10:13,248
details about those properties for pure

1575
01:10:11,510 --> 01:10:14,570
water worlds it can be sometimes a

1576
01:10:13,248 --> 01:10:16,130
challenge because a lot of light might

1577
01:10:14,569 --> 01:10:18,319
bounce off of the atmosphere before it

1578
01:10:16,130 --> 01:10:19,969
gets to us so yeah that's one of the

1579
01:10:18,319 --> 01:10:22,158
reasons why we want to find lots of them

1580
01:10:19,969 --> 01:10:24,590
so that when James Webb is operating in

1581
01:10:22,158 --> 01:10:26,388
a couple of years we can have it start

1582
01:10:24,590 --> 01:10:28,190

off with the best candidates instead of

1583

01:10:26,389 --> 01:10:30,078

sort of spending a lot of time on some

1584

01:10:28,189 --> 01:10:31,609

of these water worlds or other things

1585

01:10:30,078 --> 01:10:35,029

that might not have as good a chance of

1586

01:10:31,609 --> 01:10:38,149

us detecting atmosphere hmm okay so we

1587

01:10:35,029 --> 01:10:40,069

have a question from online how sure are

1588

01:10:38,149 --> 01:10:42,679

you that these light curve dips are

1589

01:10:40,069 --> 01:10:46,069

planets could there be other phenomenon

1590

01:10:42,679 --> 01:10:48,529

that mimic this and how do you that's a

1591

01:10:46,069 --> 01:10:50,328

fantastic question it's actually the

1592

01:10:48,529 --> 01:10:53,408

subject and careers of several

1593

01:10:50,328 --> 01:10:55,849

astronomers myself included actually

1594

01:10:53,408 --> 01:10:57,348

I've been a co-author on papers that

1595

01:10:55,849 --> 01:10:59,769

have disproved planets and ones that

1596

01:10:57,349 --> 01:11:04,038

have proved planets it's actually a

1597
01:10:59,769 --> 01:11:06,650
multi telescope and multi technique

1598
01:11:04,038 --> 01:11:08,478
method but one of so we can do a lot

1599
01:11:06,649 --> 01:11:10,308
from just the shape of the light curves

1600
01:11:08,479 --> 01:11:12,380
themselves we've learned so much from

1601
01:11:10,309 --> 01:11:14,239
Kepler and k2 and other ground-based

1602
01:11:12,380 --> 01:11:16,368
systems you can actually do a pretty

1603
01:11:14,238 --> 01:11:18,138
good job of weeding out false positives

1604
01:11:16,368 --> 01:11:21,170
and there's a variety of those some of

1605
01:11:18,139 --> 01:11:23,868
them include just artifacts or not even

1606
01:11:21,170 --> 01:11:25,550
real a big one or eclipsing binaries

1607
01:11:23,868 --> 01:11:27,558
actually I'm interested in

1608
01:11:25,550 --> 01:11:30,650
scientifically but all the exoplanet

1609
01:11:27,559 --> 01:11:31,820
people say they're junk I want to do

1610
01:11:30,649 --> 01:11:33,708
cool stellar stuff with equal sign

1611
01:11:31,819 --> 01:11:35,538
buyers but the problem is they can

1612
01:11:33,708 --> 01:11:37,368
sometimes look like planets when they're

1613
01:11:35,538 --> 01:11:39,529
not really so there's a couple of ways

1614
01:11:37,368 --> 01:11:42,139
to avoid that one of the best ways to

1615
01:11:39,529 --> 01:11:44,539
really know if a transiting object

1616
01:11:42,140 --> 01:11:46,100
a planet is to look for what we call the

1617
01:11:44,539 --> 01:11:47,750
Doppler effect with the radial velocity

1618
01:11:46,100 --> 01:11:49,850
method and you may have heard about this

1619
01:11:47,750 --> 01:11:52,189
before but it's a different technique it

1620
01:11:49,850 --> 01:11:54,289
requires telescopes on the ground and

1621
01:11:52,189 --> 01:11:56,899
the way that works is once we see a

1622
01:11:54,289 --> 01:11:58,430
signal with a dip we then have the

1623
01:11:56,899 --> 01:12:01,849
hypothesis that this is caused by a

1624
01:11:58,430 --> 01:12:03,230
planet if it's a planet what happens is

1625

01:12:01,850 --> 01:12:07,820
the planets orbiting around the star

1626
01:12:03,229 --> 01:12:10,339
I'll illustrate right because it's being

1627
01:12:07,819 --> 01:12:11,840
tugged on by gravity right gravitational

1628
01:12:10,340 --> 01:12:13,730
pull the star on the planet is having

1629
01:12:11,840 --> 01:12:16,369
this thing go around but Newton's law

1630
01:12:13,729 --> 01:12:19,129
tells us there's an equal but smaller

1631
01:12:16,369 --> 01:12:22,010
effect of the planet on the Sun so if

1632
01:12:19,130 --> 01:12:25,190
you have a very very precise instrument

1633
01:12:22,010 --> 01:12:27,320
you can actually look for myself as the

1634
01:12:25,189 --> 01:12:29,599
Sun now being pulled toward the planet a

1635
01:12:27,319 --> 01:12:32,479
little bit vary a little bit but

1636
01:12:29,600 --> 01:12:34,370
nonetheless measurable as the planet

1637
01:12:32,479 --> 01:12:35,839
goes around it and so if the planets in

1638
01:12:34,369 --> 01:12:37,460
front of me I get pulled a little bit

1639
01:12:35,840 --> 01:12:39,199

toward it now it orbits over here now

1640

01:12:37,460 --> 01:12:40,850

I'm pulled a little bit over here now

1641

01:12:39,199 --> 01:12:42,739

it's behind me and pulled a little bit

1642

01:12:40,850 --> 01:12:45,620

right and so we end up having this

1643

01:12:42,739 --> 01:12:49,119

wobble of these stars you can actually

1644

01:12:45,619 --> 01:12:51,470

detect that believe it or not with

1645

01:12:49,119 --> 01:12:54,229

instruments on the ground the effect

1646

01:12:51,470 --> 01:13:00,140

sometimes the effect we're looking at is

1647

01:12:54,229 --> 01:13:01,909

slower than me walking that's the size

1648

01:13:00,140 --> 01:13:03,470

of the signal we measure with some of

1649

01:13:01,909 --> 01:13:05,689

these instruments but we're able to do

1650

01:13:03,470 --> 01:13:07,550

that with a lot of experience and with

1651

01:13:05,689 --> 01:13:09,409

very big powerful instrument from the

1652

01:13:07,550 --> 01:13:11,570

ground so that's the best way we have of

1653

01:13:09,409 --> 01:13:13,010

detecting it and indeed a few of the

1654
01:13:11,569 --> 01:13:17,229
ones I mentioned have been confirmed by

1655
01:13:13,010 --> 01:13:19,699
that method okay other questions here

1656
01:13:17,229 --> 01:13:22,129
one in the back just to give you some

1657
01:13:19,699 --> 01:13:28,909
exercise grant thank you for running

1658
01:13:22,130 --> 01:13:30,440
with the mycube so I was kind of

1659
01:13:28,909 --> 01:13:32,000
interested in how you said that it

1660
01:13:30,439 --> 01:13:34,219
sounded like a lot of these or most of

1661
01:13:32,000 --> 01:13:35,869
them can be looked at you said they're

1662
01:13:34,220 --> 01:13:38,840
gonna follow up with telescopes from

1663
01:13:35,869 --> 01:13:41,479
Earth yep so are these things that could

1664
01:13:38,840 --> 01:13:43,220
have been seen any way without tests so

1665
01:13:41,479 --> 01:13:45,439
what's test doing is test just helping

1666
01:13:43,220 --> 01:13:47,510
them find them quicker or that's like

1667
01:13:45,439 --> 01:13:50,389
that's a great question there's a couple

1668
01:13:47,510 --> 01:13:52,190
of parts some of these are not able to

1669
01:13:50,390 --> 01:13:53,690
be found with our current instruments

1670
01:13:52,189 --> 01:13:55,819
because some of the things like the

1671
01:13:53,689 --> 01:13:58,368
wobble I mentioned that they induce

1672
01:13:55,819 --> 01:14:01,519
is just too small we can't even see them

1673
01:13:58,368 --> 01:14:04,009
so the other thing it does is the field

1674
01:14:01,520 --> 01:14:05,150
of view most of the instruments I

1675
01:14:04,010 --> 01:14:07,760
mentioned especially the ones that

1676
01:14:05,149 --> 01:14:10,759
measure wobble have to look at one star

1677
01:14:07,760 --> 01:14:14,119
at a time it has to monitor it for

1678
01:14:10,760 --> 01:14:15,530
usually several days and get dozens of

1679
01:14:14,118 --> 01:14:17,380
measurements before it can really show

1680
01:14:15,529 --> 01:14:21,828
that it's a wobble that's happening

1681
01:14:17,380 --> 01:14:24,770
there's 200,000 stars just in the high

1682

01:14:21,828 --> 01:14:26,658
priority list so two hundred thousand

1683
01:14:24,770 --> 01:14:28,280
one at a time you only have a certain

1684
01:14:26,658 --> 01:14:29,799
number of nights per year because the

1685
01:14:28,279 --> 01:14:33,828
telescope's being used for other things

1686
01:14:29,800 --> 01:14:36,170
it becomes impossible to do the size and

1687
01:14:33,828 --> 01:14:38,509
scope of the search from ground-based

1688
01:14:36,170 --> 01:14:40,520
using those methods so you're right your

1689
01:14:38,510 --> 01:14:43,610
your your hype your idea was exactly

1690
01:14:40,520 --> 01:14:45,260
right Tess is a large part of test is

1691
01:14:43,609 --> 01:14:47,658
being able to detect a lot of these

1692
01:14:45,260 --> 01:14:50,510
small planets using the dip technique

1693
01:14:47,658 --> 01:14:54,049
the transit technique with a huge net

1694
01:14:50,510 --> 01:14:55,969
and then we can take the expensive part

1695
01:14:54,050 --> 01:14:57,889
which is going to these huge cells on

1696
01:14:55,969 --> 01:14:59,929

the ground and gain these expensive

1697

01:14:57,889 --> 01:15:02,359

measurements that that cost a lot in

1698

01:14:59,929 --> 01:15:04,489

terms of number of nights and all this

1699

01:15:02,359 --> 01:15:06,198

other stuff to then confirm them once we

1700

01:15:04,488 --> 01:15:07,218

know there's a signal there we don't

1701

01:15:06,198 --> 01:15:08,750

want to have to look at a hundred

1702

01:15:07,219 --> 01:15:11,149

thousand stars I don't doing anything

1703

01:15:08,750 --> 01:15:13,488

that's not a good use of our talisman no

1704

01:15:11,149 --> 01:15:16,129

great question though thank you okay

1705

01:15:13,488 --> 01:15:17,799

time for one more question you've had a

1706

01:15:16,130 --> 01:15:20,118

question that says there's anybody else

1707

01:15:17,800 --> 01:15:21,650

all right come on down here we had

1708

01:15:20,118 --> 01:15:28,759

though this journalist got another

1709

01:15:21,649 --> 01:15:31,009

question well finished off there I'm

1710

01:15:28,760 --> 01:15:34,340

interested in in the effect of the

1711
01:15:31,010 --> 01:15:37,039
orbital period of the planets that were

1712
01:15:34,340 --> 01:15:40,130
detecting I'm as a thought experiment

1713
01:15:37,039 --> 01:15:43,429
I'm thinking if another solar system

1714
01:15:40,130 --> 01:15:46,760
someplace out there was looking at us if

1715
01:15:43,429 --> 01:15:50,060
our periods one year if you didn't

1716
01:15:46,760 --> 01:15:54,429
happen to be looking at earth when we

1717
01:15:50,060 --> 01:15:56,840
occulted the Sun or transited the Sun

1718
01:15:54,429 --> 01:15:59,859
you'd miss it if you are looking for

1719
01:15:56,840 --> 01:16:02,869
Jupiter it's once every 12 - bucks right

1720
01:15:59,859 --> 01:16:05,899
and so how do you how do you allow for

1721
01:16:02,868 --> 01:16:08,059
that what what adjustments do you make

1722
01:16:05,899 --> 01:16:10,699
for that well that's a great question

1723
01:16:08,060 --> 01:16:13,430
giving a lifetime of the current funding

1724
01:16:10,699 --> 01:16:15,380
how long of a period can you see these

1725
01:16:13,430 --> 01:16:17,720
planets so that's a great question and

1726
01:16:15,380 --> 01:16:20,420
the way we get around it is twofold one

1727
01:16:17,720 --> 01:16:22,100
we go to space in space there's no pesky

1728
01:16:20,420 --> 01:16:24,529
a thing called the day/night cycle on

1729
01:16:22,100 --> 01:16:26,840
the ground when it's daytime you can

1730
01:16:24,529 --> 01:16:30,380
observe because it sums up space you can

1731
01:16:26,840 --> 01:16:31,940
observe all day every day and just stare

1732
01:16:30,380 --> 01:16:33,560
at these things and get lots and lots of

1733
01:16:31,939 --> 01:16:35,839
measurements to cuz you don't know when

1734
01:16:33,560 --> 01:16:36,140
it's gonna happen right so a we look at

1735
01:16:35,840 --> 01:16:38,300
them

1736
01:16:36,140 --> 01:16:41,869
all the time during the time we're

1737
01:16:38,300 --> 01:16:43,880
taking gate data - we do it very quickly

1738
01:16:41,869 --> 01:16:45,380
so we're constantly measuring measured

1739

01:16:43,880 --> 01:16:46,460
measurement so almost like OCD right

1740
01:16:45,380 --> 01:16:49,579
measure measure measure measure measure

1741
01:16:46,460 --> 01:16:52,819
measure measure measure and then the the

1742
01:16:49,579 --> 01:16:56,510
third point was about the solar system

1743
01:16:52,819 --> 01:16:59,479
so again Kepler lasted four years and so

1744
01:16:56,510 --> 01:17:02,420
it was able to learn the prime mission

1745
01:16:59,479 --> 01:17:05,599
right it was able to see a signal at

1746
01:17:02,420 --> 01:17:07,130
least one during a one year orbit most

1747
01:17:05,600 --> 01:17:07,610
of tests will not be sensitive to things

1748
01:17:07,130 --> 01:17:09,619
like that

1749
01:17:07,609 --> 01:17:12,049
so we won't be able to see things that

1750
01:17:09,619 --> 01:17:13,220
have one year periods during the prime

1751
01:17:12,050 --> 01:17:16,520
to your mission

1752
01:17:13,220 --> 01:17:19,760
but if NASA decides to fund tests for

1753
01:17:16,520 --> 01:17:22,460

two for six more years now we have

1754

01:17:19,760 --> 01:17:26,150

enough observations that we will be able

1755

01:17:22,460 --> 01:17:27,980

to see single dips caused by something

1756

01:17:26,149 --> 01:17:30,019

that might be very very long period and

1757

01:17:27,979 --> 01:17:33,739

because we have so many stars or such a

1758

01:17:30,020 --> 01:17:35,270

huge part of the sky even if we miss 99%

1759

01:17:33,739 --> 01:17:35,719

of the Jupiter's what or something like

1760

01:17:35,270 --> 01:17:38,120

that

1761

01:17:35,720 --> 01:17:39,770

we need to find one and then follow it

1762

01:17:38,119 --> 01:17:41,689

up and have some patience

1763

01:17:39,770 --> 01:17:44,630

we'll be able to find things potentially

1764

01:17:41,689 --> 01:17:46,489

like Jupiter's at 5 au that take 25

1765

01:17:44,630 --> 01:17:48,529

years to orbit you look at a whole bunch

1766

01:17:46,489 --> 01:17:51,380

of stars you have the one at the right

1767

01:17:48,529 --> 01:17:53,539

time you might be able to get it yeah

1768
01:17:51,380 --> 01:17:55,760
and that's a great perspective on that's

1769
01:17:53,539 --> 01:17:57,739
because you realize that we've only been

1770
01:17:55,760 --> 01:18:01,670
discovering extrasolar planets since

1771
01:17:57,739 --> 01:18:03,590
1990s so we got 20 years Saturn takes

1772
01:18:01,670 --> 01:18:05,449
over 30 years to orbit the Sun we could

1773
01:18:03,590 --> 01:18:07,000
never have found a Saturn in a Saturn

1774
01:18:05,449 --> 01:18:11,479
size orbit with this technique with this

1775
01:18:07,000 --> 01:18:14,529
type of technique so you know exoplanets

1776
01:18:11,479 --> 01:18:17,269
are only gonna get more interesting

1777
01:18:14,529 --> 01:18:20,300
absolutely wonderful presentation on us

1778
01:18:17,270 --> 01:18:20,679
and we can't wait for more stuff you're

1779
01:18:20,300 --> 01:18:22,119
gonna come

1780
01:18:20,679 --> 01:18:25,350
next year tops be here next year I'll

1781
01:18:22,119 --> 01:18:25,349
have a lot more plans talk about

1782

01:18:26,590 --> 01:18:34,650

[Applause]