

1
00:00:00,000 --> 00:00:04,528
good evening ladies and gentlemen and

2
00:00:01,260 --> 00:00:07,108
welcome to the Space Telescope public

3
00:00:04,528 --> 00:00:08,759
lecture series I am dr. Frank summers of

4
00:00:07,108 --> 00:00:10,859
the office of public outreach and it is

5
00:00:08,759 --> 00:00:13,649
my pleasure and joy to welcome you here

6
00:00:10,859 --> 00:00:16,259
each and every month and when you come

7
00:00:13,650 --> 00:00:18,539
in there are lithographs tonight's

8
00:00:16,260 --> 00:00:20,490
lithograph chosen by our speaker because

9
00:00:18,539 --> 00:00:23,580
she will mention it in her talk is the

10
00:00:20,489 --> 00:00:25,890
extreme deep field you want to know what

11
00:00:23,579 --> 00:00:29,368
that means turn over we get about 300

12
00:00:25,890 --> 00:00:32,070
words describing this Hubble observation

13
00:00:29,368 --> 00:00:35,939
that was released like 2011 2012

14
00:00:32,070 --> 00:00:38,100
timeframe and all of the thousands of

15
00:00:35,939 --> 00:00:40,949
galaxies that you are seeing in the

16
00:00:38,100 --> 00:00:43,770
extreme deep field our speaker tonight

17
00:00:40,950 --> 00:00:45,780
is Kelsey Glaser from Towson University

18
00:00:43,770 --> 00:00:50,430
and she'll be speaking on Olbers paradox

19
00:00:45,780 --> 00:00:54,448
and gravitational light deflection next

20
00:00:50,429 --> 00:00:57,390
month we have a special date okay we

21
00:00:54,448 --> 00:00:59,608
usually skip the day after New Year's it

22
00:00:57,390 --> 00:01:02,340
would have been January 2nd and people

23
00:00:59,609 --> 00:01:04,170
are tend to tend to be otherwise engaged

24
00:01:02,340 --> 00:01:05,939
at that time so we usually skip that and

25
00:01:04,170 --> 00:01:08,100
then we're going to put it on January

26
00:01:05,938 --> 00:01:10,919
9th but the American Astronomical

27
00:01:08,099 --> 00:01:14,099
Society meeting is in Washington DC this

28
00:01:10,920 --> 00:01:16,228
year so lots of people from this

29

00:01:14,099 --> 00:01:18,750
building will be down in DC it's very

30
00:01:16,228 --> 00:01:20,908
hard to get a speaker for January 9th so

31
00:01:18,750 --> 00:01:23,519
at the speakers request I moved it to

32
00:01:20,909 --> 00:01:25,890
January 16th okay so not the first

33
00:01:23,519 --> 00:01:28,769
Tuesday not the second Tuesday but the

34
00:01:25,890 --> 00:01:30,989
third Tuesday next month is one of the

35
00:01:28,769 --> 00:01:32,969
few times I've ever done that okay but

36
00:01:30,989 --> 00:01:35,938
it's worth coming to see because it will

37
00:01:32,969 --> 00:01:39,509
be web in three acts the telescope the

38
00:01:35,938 --> 00:01:41,758
science the legacy and it's such a big

39
00:01:39,509 --> 00:01:45,299
topic we have three not one not two but

40
00:01:41,759 --> 00:01:48,049
three speakers for you Nicole Lewis

41
00:01:45,299 --> 00:01:51,509
Bonnie Meinke and Klaus pontoppidan

42
00:01:48,049 --> 00:01:54,750
we'll be giving you the lowdown on the

43
00:01:51,509 --> 00:01:58,859

next great Observatory the James Webb

44

00:01:54,750 --> 00:02:00,718

Space Telescope in February we will have

45

00:01:58,859 --> 00:02:05,069

Hannah Wickford and she'll be talking on

46

00:02:00,718 --> 00:02:07,438

the wildest weather in the universe and

47

00:02:05,069 --> 00:02:09,868

that will be a talk on the weather on

48

00:02:07,438 --> 00:02:12,479

extrasolar planets not planets in our

49

00:02:09,868 --> 00:02:13,590

solar system the planets outside our

50

00:02:12,479 --> 00:02:16,199

solar system

51

00:02:13,590 --> 00:02:18,870

for information on this and other talks

52

00:02:16,199 --> 00:02:20,929

we go to our web page go to your

53

00:02:18,870 --> 00:02:23,819

favorite search engine and put in Hubble

54

00:02:20,930 --> 00:02:26,700

Space Telescope public talks you'll find

55

00:02:23,818 --> 00:02:28,589

this webpage where we have a link the

56

00:02:26,699 --> 00:02:31,229

the descriptions of the upcoming

57

00:02:28,590 --> 00:02:34,650

lectures we have a link to watching it

58
00:02:31,229 --> 00:02:38,399
on YouTube and our webcasting site we

59
00:02:34,650 --> 00:02:40,980
have past lectures back to 2005 and you

60
00:02:38,400 --> 00:02:43,590
can subscribe to our email list for

61
00:02:40,979 --> 00:02:45,988
announcements we've actually gotten like

62
00:02:43,590 --> 00:02:50,039
almost 600 people on our announcements

63
00:02:45,989 --> 00:02:50,879
list it's it's kind of nice we have if

64
00:02:50,039 --> 00:02:53,639
you would like to sign up for the

65
00:02:50,879 --> 00:02:56,519
announcements I this seems duplicitous

66
00:02:53,639 --> 00:02:59,009
because I do play duplicate because you

67
00:02:56,519 --> 00:03:01,650
know I just said it but anyways sign up

68
00:02:59,009 --> 00:03:03,359
at the websites easiest or if you don't

69
00:03:01,650 --> 00:03:05,430
like doing that you can just provide

70
00:03:03,360 --> 00:03:08,549
your email address to me and I will make

71
00:03:05,430 --> 00:03:09,930
sure you get on it if you have comments

72
00:03:08,549 --> 00:03:12,689
or questions you can send it to this

73
00:03:09,930 --> 00:03:16,829
email address public lecture at stsci

74
00:03:12,689 --> 00:03:19,318
dot edu if you like social media we are

75
00:03:16,829 --> 00:03:22,409
available on Facebook and Twitter and

76
00:03:19,318 --> 00:03:24,388
YouTube and Instagram and myself I do

77
00:03:22,409 --> 00:03:27,449
Facebook Google and Twitter every now

78
00:03:24,389 --> 00:03:31,650
and then and sometimes write blog posts

79
00:03:27,449 --> 00:03:33,179
on hubble site I spend too much my time

80
00:03:31,650 --> 00:03:36,420
working that I don't spend enough time

81
00:03:33,180 --> 00:03:39,810
social media oh well yeah there's only

82
00:03:36,419 --> 00:03:42,899
so much time in life right observatory

83
00:03:39,810 --> 00:03:44,509
the weather is not permitting now how

84
00:03:42,900 --> 00:03:47,189
many people were here last month and

85
00:03:44,509 --> 00:03:50,009
remember that the Maryland spacecraft

86

00:03:47,189 --> 00:03:53,250
servitor II closed for repairs they got

87
00:03:50,009 --> 00:03:56,969
the repairs done okay so it is back in

88
00:03:53,250 --> 00:04:00,090
business okay so even though we're not

89
00:03:56,969 --> 00:04:03,959
able to do it tonight it is available if

90
00:04:00,090 --> 00:04:05,609
you go to MD dot space grant o RG and

91
00:04:03,959 --> 00:04:08,699
click on the observatory they do have

92
00:04:05,609 --> 00:04:11,280
open houses on Fridays and see this

93
00:04:08,699 --> 00:04:12,899
Observatory status box over there that

94
00:04:11,280 --> 00:04:14,909
is where you will find out if you check

95
00:04:12,900 --> 00:04:16,470
on Friday afternoon Friday early Friday

96
00:04:14,909 --> 00:04:20,219
evening whether or not there will be

97
00:04:16,470 --> 00:04:21,900
open for observing that night okay so

98
00:04:20,220 --> 00:04:25,260
come support the Maryland Space Grant

99
00:04:21,899 --> 00:04:27,469
observatory and now our news from the

100
00:04:25,259 --> 00:04:32,370

universe for December 2

101

00:04:27,470 --> 00:04:37,500

2017 our first story tonight echoes of a

102

00:04:32,370 --> 00:04:39,720

dying star now we have had a very famous

103

00:04:37,500 --> 00:04:43,310

press release of over a bunch of years

104

00:04:39,720 --> 00:04:45,930

and involved the star v838 monocerotis

105

00:04:43,310 --> 00:04:50,339

okay or VA three eight month or short

106

00:04:45,930 --> 00:04:51,900

and this star witness in March of 2003

107

00:04:50,339 --> 00:04:54,329

this is a picture from the US Naval

108

00:04:51,899 --> 00:04:56,459

Observatory of a star going Nova and

109

00:04:54,329 --> 00:04:57,719

that basically means it brightened okay

110

00:04:56,459 --> 00:05:00,329

it had an explosion on the surface

111

00:04:57,720 --> 00:05:02,730

basically and it brightened okay the

112

00:05:00,329 --> 00:05:06,389

star did not explode but it just had a

113

00:05:02,730 --> 00:05:09,450

very event for the Nova now this became

114

00:05:06,389 --> 00:05:12,689

very famous in Hubble lore because the

115
00:05:09,449 --> 00:05:14,819
light from that explosion spread out

116
00:05:12,689 --> 00:05:19,829
across space and we watched it for

117
00:05:14,819 --> 00:05:21,659
several years so in May of 2003 here you

118
00:05:19,829 --> 00:05:24,180
can see the star in the center here has

119
00:05:21,660 --> 00:05:26,490
gone back to its normal state but the

120
00:05:24,180 --> 00:05:29,100
light is actually going through the dust

121
00:05:26,490 --> 00:05:32,129
clouds around it and illuminating those

122
00:05:29,100 --> 00:05:34,910
dust clouds and over the years as we

123
00:05:32,129 --> 00:05:39,418
watched it that that light expanded

124
00:05:34,910 --> 00:05:49,740
farther and farther into space so v838

125
00:05:39,418 --> 00:05:52,049
monocerotis the Nova went off at one

126
00:05:49,740 --> 00:05:54,449
point but because space is so big it

127
00:05:52,050 --> 00:05:56,100
takes years for that light to propagate

128
00:05:54,449 --> 00:05:59,250
out through the dust cloud around it and

129
00:05:56,100 --> 00:06:00,200
it illuminated different layers of that

130
00:05:59,250 --> 00:06:04,050
dust cloud

131
00:06:00,199 --> 00:06:08,129
now Nova happened in our galaxy we can

132
00:06:04,050 --> 00:06:11,490
observe them but supernovae are even

133
00:06:08,129 --> 00:06:15,889
bigger explosions and this for example

134
00:06:11,490 --> 00:06:18,990
is supernova 1987a where a star in here

135
00:06:15,889 --> 00:06:21,509
brightened up to be incredibly bright

136
00:06:18,990 --> 00:06:24,360
just brightened and basically becomes

137
00:06:21,509 --> 00:06:27,899
the brightest thing in a galaxy a very

138
00:06:24,360 --> 00:06:31,500
very short time we can see these across

139
00:06:27,899 --> 00:06:33,959
intergalactic distances so the light

140
00:06:31,500 --> 00:06:37,680
echo from a supernova should be

141
00:06:33,959 --> 00:06:40,789
observable and with Hubble we did

142
00:06:37,680 --> 00:06:43,100
observe it in the galaxy m82

143

00:06:40,790 --> 00:06:44,960
and you can see this cross here in the

144
00:06:43,100 --> 00:06:48,050
center okay that indicates where the

145
00:06:44,959 --> 00:06:50,959
supernova went off alright and the

146
00:06:48,050 --> 00:06:54,770
supernova went off and we started to see

147
00:06:50,959 --> 00:06:57,829
the light echo propagating around that

148
00:06:54,769 --> 00:07:00,109
supernova so from the distance of mm an

149
00:06:57,829 --> 00:07:02,870
82 we're able to see the supernova and

150
00:07:00,110 --> 00:07:06,290
then go back in and reprocess images

151
00:07:02,870 --> 00:07:10,129
taken by Hubble of m82 later to be able

152
00:07:06,290 --> 00:07:13,460
to pull out light echo from it alright

153
00:07:10,129 --> 00:07:23,689
so here is a video let me start it for

154
00:07:13,459 --> 00:07:26,599
you alright so this video is going to

155
00:07:23,689 --> 00:07:27,589
zoom into m82 that shows you the Big

156
00:07:26,600 --> 00:07:32,390
Dipper which is part of the

157
00:07:27,589 --> 00:07:37,179

constellation Ursa Major and just above

158

00:07:32,389 --> 00:07:48,110

are some Ager we'll pull into the galaxy

159

00:07:37,180 --> 00:07:50,660

Messier 82 and this is the Hubble image

160

00:07:48,110 --> 00:07:52,879

of M 82 and all that red is the H alpha

161

00:07:50,660 --> 00:07:54,560

emission from you know the starbursts

162

00:07:52,879 --> 00:07:56,120

and the center but we're not worried

163

00:07:54,560 --> 00:07:58,670

about that starburst in the center we're

164

00:07:56,120 --> 00:08:02,120

worried about one particular star that

165

00:07:58,670 --> 00:08:04,759

went supernova way down deep inside this

166

00:08:02,120 --> 00:08:09,949

galaxy yes see how far we have to zoom

167

00:08:04,759 --> 00:08:12,500

in in order to see this all right okay

168

00:08:09,949 --> 00:08:17,300

and here is a time-lapse of it sort of

169

00:08:12,500 --> 00:08:20,990

an animation of the explosion and we can

170

00:08:17,300 --> 00:08:24,620

process it to pull out the light echo so

171

00:08:20,990 --> 00:08:27,500

although that star has died it's light

172
00:08:24,620 --> 00:08:30,129
lives on echoing through the gas clouds

173
00:08:27,500 --> 00:08:35,289
around it for years afterwards

174
00:08:30,129 --> 00:08:40,960
that's kind of cool our second story

175
00:08:35,289 --> 00:08:44,049
rendezvous with drama well we had a

176
00:08:40,960 --> 00:08:47,240
interesting observation occur in October

177
00:08:44,049 --> 00:08:48,889
on October 19th I know this says October

178
00:08:47,240 --> 00:08:52,610
25th but that's when this graphic was

179
00:08:48,889 --> 00:08:54,649
was made on October 19th the pan-starrs

180
00:08:52,610 --> 00:08:56,778
one telescope

181
00:08:54,649 --> 00:09:00,049
observe what it thought was a comment

182
00:08:56,778 --> 00:09:03,139
and it gave it the provisional

183
00:09:00,049 --> 00:09:05,719
designation C 2017 you won

184
00:09:03,139 --> 00:09:07,519
well after just a little bit of study

185
00:09:05,720 --> 00:09:10,249
they could tell well there wasn't any

186
00:09:07,519 --> 00:09:12,799
coma around it so it can't be a comet

187
00:09:10,249 --> 00:09:16,970
must be an asteroid then it was given

188
00:09:12,799 --> 00:09:19,128
this designation a 2017 you want then

189
00:09:16,970 --> 00:09:21,499
after following it for a couple week or

190
00:09:19,129 --> 00:09:24,819
two they're able to determine an orbit

191
00:09:21,499 --> 00:09:29,269
for it and the orbit of this is

192
00:09:24,818 --> 00:09:33,378
hyperbolic which means it's not bound to

193
00:09:29,269 --> 00:09:35,629
the Sun okay it's on such a speedy orbit

194
00:09:33,379 --> 00:09:37,428
that it's going to escape the solar

195
00:09:35,629 --> 00:09:39,409
system it's coming through you can see

196
00:09:37,428 --> 00:09:41,028
it came through closer than the orbit of

197
00:09:39,409 --> 00:09:45,129
mercury and it's headed out it was

198
00:09:41,028 --> 00:09:52,009
actually discovered on its way out so

199
00:09:45,129 --> 00:09:54,589
this is a hyperbolic orbit which the

200

00:09:52,009 --> 00:09:56,600
simplest explanation for it is that it's

201
00:09:54,589 --> 00:10:01,129
not of this solar system that is

202
00:09:56,600 --> 00:10:03,499
actually interstellar in origin this has

203
00:10:01,129 --> 00:10:06,709
been touted as the first interstellar

204
00:10:03,499 --> 00:10:09,558
visitor to be observed now when we

205
00:10:06,708 --> 00:10:10,998
predict how many things from other solar

206
00:10:09,558 --> 00:10:13,308
systems should be passing through our

207
00:10:10,999 --> 00:10:15,699
solar system we say that there should be

208
00:10:13,308 --> 00:10:18,438
about tens to hundreds of these a year

209
00:10:15,698 --> 00:10:20,448
right but we've never seen one that we

210
00:10:18,438 --> 00:10:22,370
can say oh here is the out here is the

211
00:10:20,448 --> 00:10:24,740
observation that says yes this should be

212
00:10:22,370 --> 00:10:26,808
intercept it should be interstellar this

213
00:10:24,740 --> 00:10:29,688
is the first one okay the first

214
00:10:26,808 --> 00:10:33,039

interstellar visitor as people have been

215

00:10:29,688 --> 00:10:36,049
been want to call it so of course

216

00:10:33,039 --> 00:10:38,539
everybody who had a telescope was going

217

00:10:36,049 --> 00:10:41,178
out and looking at it okay and they did

218

00:10:38,539 --> 00:10:44,629
so with the very large telescope and

219

00:10:41,178 --> 00:10:47,990
they got this observation of it and you

220

00:10:44,629 --> 00:10:51,019
pick it out no so let's give you the

221

00:10:47,990 --> 00:10:54,860
arrow all right right there

222

00:10:51,019 --> 00:10:56,298
okay that is an observation and people

223

00:10:54,860 --> 00:10:58,220
were measuring it with various

224

00:10:56,298 --> 00:11:00,379
telescopes around the world and

225

00:10:58,220 --> 00:11:02,269
basically trying to get all the

226

00:11:00,379 --> 00:11:04,579
characteristics of it and one of the

227

00:11:02,269 --> 00:11:07,278
most intriguing characteristics of it is

228

00:11:04,578 --> 00:11:08,089
that its brightness change so this is

229

00:11:07,278 --> 00:11:10,639

the magnitude

230

00:11:08,090 --> 00:11:13,220

the brightness and you can see that it's

231

00:11:10,639 --> 00:11:17,389

going up and down and up and down by a

232

00:11:13,220 --> 00:11:22,910

large amount okay a very large variation

233

00:11:17,389 --> 00:11:24,409

in the brightness and so the one paper

234

00:11:22,909 --> 00:11:25,909

which got a lot of press from the

235

00:11:24,409 --> 00:11:28,029

European Southern Observatory because

236

00:11:25,909 --> 00:11:30,259

they put out a press release about it

237

00:11:28,029 --> 00:11:33,500

determined that it was about it was

238

00:11:30,259 --> 00:11:36,860

small about 400 meters and had a very

239

00:11:33,500 --> 00:11:39,500

long elongated aspect ratio to explain

240

00:11:36,860 --> 00:11:44,360

this light curve they deduced that it

241

00:11:39,500 --> 00:11:46,519

was an aspect ratio of 10 to 1 about 400

242

00:11:44,360 --> 00:11:49,940

meters long and only about 1/10 that

243
00:11:46,519 --> 00:11:52,100
width when they did that they put out an

244
00:11:49,940 --> 00:11:53,360
artist's illustration of it so this is

245
00:11:52,100 --> 00:11:56,450
what you may have seen floating around

246
00:11:53,360 --> 00:11:58,190
the internet this image of here is the

247
00:11:56,450 --> 00:12:00,879
picture of our interstellar our first

248
00:11:58,190 --> 00:12:05,110
inner cell or visitor and has this

249
00:12:00,879 --> 00:12:06,799
unbelievably long thin profile all right

250
00:12:05,110 --> 00:12:09,860
that's crazy

251
00:12:06,799 --> 00:12:12,679
that's just plain weird we don't get

252
00:12:09,860 --> 00:12:14,870
things with a 10 to 1 profile we've

253
00:12:12,679 --> 00:12:17,479
never seen two antennae one aspect ratio

254
00:12:14,870 --> 00:12:18,679
in our solar system this is just sort of

255
00:12:17,480 --> 00:12:21,200
mind-blowing ok

256
00:12:18,679 --> 00:12:23,089
and of course everyone said hey you know

257

00:12:21,200 --> 00:12:26,570
what this looks like this looks like a

258
00:12:23,090 --> 00:12:28,070
spaceship ok and it matches what the

259
00:12:26,570 --> 00:12:31,280
reason why I call this rendezvous with

260
00:12:28,070 --> 00:12:33,680
drama is because it matches the opening

261
00:12:31,279 --> 00:12:35,839
of arthur c clarke spoke rendezvous with

262
00:12:33,679 --> 00:12:38,000
Rama where there an alien spaceship

263
00:12:35,840 --> 00:12:40,220
flies through our solar system etc and

264
00:12:38,000 --> 00:12:42,080
so we were all excited about oh my gosh

265
00:12:40,220 --> 00:12:48,790
it's got all these crazy characteristics

266
00:12:42,080 --> 00:12:51,230
it must be aliens yes it's not aliens ok

267
00:12:48,789 --> 00:12:53,750
the internet loves this they love to

268
00:12:51,230 --> 00:12:56,659
jump the gun and they definitely jump

269
00:12:53,750 --> 00:12:57,919
the gun here so I thought I would just

270
00:12:56,659 --> 00:13:03,709
give you a little bit of a summary of

271
00:12:57,919 --> 00:13:08,089

what we do know about Oh mwah mwah

272

00:13:03,710 --> 00:13:12,259

okay that is a I believe it's a Hawaiian

273

00:13:08,090 --> 00:13:15,290

name of something about a visitor I

274

00:13:12,259 --> 00:13:16,939

can't remember what it means but I just

275

00:13:15,289 --> 00:13:18,860

try to remember Oh mwah

276

00:13:16,940 --> 00:13:20,810

okay trying to get that pronunciation

277

00:13:18,860 --> 00:13:21,889

was difficult first of all the orbit is

278

00:13:20,809 --> 00:13:24,378

consistent with an

279

00:13:21,889 --> 00:13:26,889

interstellar origin do we know that it

280

00:13:24,379 --> 00:13:29,749

truly is interstellar in origin have

281

00:13:26,889 --> 00:13:31,159

none we can't prove that it's

282

00:13:29,749 --> 00:13:34,220

interstellar in origin but the orbit is

283

00:13:31,159 --> 00:13:36,708

consistent okay you can't argue about

284

00:13:34,220 --> 00:13:39,678

lacor 'but you know says that you know

285

00:13:36,708 --> 00:13:41,628

it could have definitely a plausible

286
00:13:39,678 --> 00:13:45,708
origin is from interstellar space okay

287
00:13:41,629 --> 00:13:47,418
it rotates every set 37.3 hours so it's

288
00:13:45,708 --> 00:13:50,418
got event very quick it can't be too

289
00:13:47,418 --> 00:13:52,039
large okay it's got a relatively quick

290
00:13:50,418 --> 00:13:53,869
rotation and there are these large

291
00:13:52,039 --> 00:13:55,969
brightness variations okay

292
00:13:53,869 --> 00:13:57,439
those are the three things I in looking

293
00:13:55,970 --> 00:14:01,910
at the literature that we can say for

294
00:13:57,438 --> 00:14:06,139
sure now what's more is what we don't

295
00:14:01,909 --> 00:14:07,909
know about Oh mwah mwah it's sighs the

296
00:14:06,139 --> 00:14:10,068
estimate that was published in the ESO

297
00:14:07,909 --> 00:14:13,188
press release was about 400 meters long

298
00:14:10,068 --> 00:14:14,269
okay but that was just an estimate and

299
00:14:13,188 --> 00:14:17,088
there are other groups that are getting

300
00:14:14,269 --> 00:14:19,428
other sizes it's but very well resolved

301
00:14:17,089 --> 00:14:21,589
so it's very hard to estimate the size

302
00:14:19,428 --> 00:14:24,019
you actually have to assume other

303
00:14:21,589 --> 00:14:26,679
parameters about the object in order to

304
00:14:24,019 --> 00:14:29,298
estimate that size the axis ratio

305
00:14:26,678 --> 00:14:31,909
although the highly publicized one was

306
00:14:29,298 --> 00:14:33,438
this 10 to one asked axis ratio there

307
00:14:31,909 --> 00:14:36,168
are other papers that are down to a

308
00:14:33,438 --> 00:14:38,448
three to one aspect ratio okay so the

309
00:14:36,168 --> 00:14:40,879
researchers don't agree on what the

310
00:14:38,448 --> 00:14:44,269
access ratio is the color of the object

311
00:14:40,879 --> 00:14:46,100
or and most importantly its albedo its

312
00:14:44,269 --> 00:14:49,100
brightness how much less sunlight it

313
00:14:46,100 --> 00:14:50,569
reflects back and the variations that

314

00:14:49,100 --> 00:14:52,759
could be on the surface we don't know

315
00:14:50,568 --> 00:14:55,248
about that a lot of that brightness

316
00:14:52,759 --> 00:14:58,068
change could be explained by albedo

317
00:14:55,249 --> 00:15:00,079
variations for example we have the moon

318
00:14:58,068 --> 00:15:02,208
in the solar system i habitus which is

319
00:15:00,078 --> 00:15:04,938
really dark on one side and really

320
00:15:02,208 --> 00:15:06,469
bright on another and that alone can

321
00:15:04,938 --> 00:15:09,019
produce very strong brightness

322
00:15:06,470 --> 00:15:11,629
variations as if you were watching

323
00:15:09,019 --> 00:15:12,918
lapetus rotate you would get very long

324
00:15:11,629 --> 00:15:14,749
brightness strong about your

325
00:15:12,918 --> 00:15:17,119
segregations furthermore the

326
00:15:14,749 --> 00:15:19,909
measurements of the color was between

327
00:15:17,119 --> 00:15:20,778
two different groups are inconsistent

328
00:15:19,909 --> 00:15:22,698

with each other

329

00:15:20,778 --> 00:15:24,409
this one haired there in certainties

330

00:15:22,698 --> 00:15:26,298
that here this one's in certainties here

331

00:15:24,409 --> 00:15:29,538
and they say they disagree at the three

332

00:15:26,298 --> 00:15:31,278
sigma level so we just we don't know the

333

00:15:29,538 --> 00:15:33,470
color we certainly don't know its

334

00:15:31,278 --> 00:15:34,899
composition yet although if it's going

335

00:15:33,470 --> 00:15:37,809
to rotate in this path it

336

00:15:34,899 --> 00:15:40,509
this type of speed it should be rocky or

337

00:15:37,808 --> 00:15:42,338
metallic or something should be hard and

338

00:15:40,509 --> 00:15:45,669
the most important thing we don't know

339

00:15:42,339 --> 00:15:47,980
is the group characteristics this is a

340

00:15:45,669 --> 00:15:50,498
group of one if this is the first

341

00:15:47,980 --> 00:15:52,600
interstellar object to come through the

342

00:15:50,499 --> 00:15:54,999
solar system that we have observed we

343
00:15:52,600 --> 00:15:58,360
don't know what we should expect for

344
00:15:54,999 --> 00:16:01,089
these so part of the interpretation of

345
00:15:58,360 --> 00:16:03,759
observations is sort of knowing what

346
00:16:01,089 --> 00:16:06,689
type of object you're looking at so

347
00:16:03,759 --> 00:16:12,028
we're going to need more observations

348
00:16:06,688 --> 00:16:14,498
now that's the cool thing the pan-starrs

349
00:16:12,028 --> 00:16:16,688
project was able to trigger this and

350
00:16:14,499 --> 00:16:19,119
I'll let everyone know about it and

351
00:16:16,688 --> 00:16:21,938
allow to observe it we had the large

352
00:16:19,119 --> 00:16:24,428
synoptic survey telescope LSST that will

353
00:16:21,938 --> 00:16:26,740
be online next decade which will be a

354
00:16:24,428 --> 00:16:29,409
boon for this field because it will be

355
00:16:26,740 --> 00:16:34,058
taking pictures of the whole sky every

356
00:16:29,409 --> 00:16:38,219
night so this type of observation will

357
00:16:34,058 --> 00:16:40,600
be really prevalent in the next decade I

358
00:16:38,220 --> 00:16:42,220
not gonna say that I have answers for

359
00:16:40,600 --> 00:16:43,509
you tonight I'm not gonna say I have

360
00:16:42,220 --> 00:16:45,730
answers for you tomorrow

361
00:16:43,509 --> 00:16:48,730
but in the net counting decades we will

362
00:16:45,730 --> 00:16:51,459
have lots of observations we expect to

363
00:16:48,730 --> 00:16:54,159
have these kind of observations now of

364
00:16:51,458 --> 00:16:55,539
course we're the home of Hubble here so

365
00:16:54,159 --> 00:16:59,198
half of you in the audience are going

366
00:16:55,539 --> 00:17:03,938
okay so what did Hubble see well Hubble

367
00:16:59,198 --> 00:17:08,379
has observed this object and that's all

368
00:17:03,938 --> 00:17:12,338
I'm allowed to say we have not gotten

369
00:17:08,380 --> 00:17:14,620
any results that we are that the hope

370
00:17:12,338 --> 00:17:17,558
that we were going to take out for press

371

00:17:14,619 --> 00:17:20,109
so unfortunately I have to leave you

372
00:17:17,558 --> 00:17:22,389
with a final slide that says to be

373
00:17:20,109 --> 00:17:23,979
continued okay all right there will be

374
00:17:22,390 --> 00:17:25,659
more about this object people are

375
00:17:23,980 --> 00:17:27,568
studying it's going it's leaving the

376
00:17:25,659 --> 00:17:31,570
solar system at a relatively rapid rate

377
00:17:27,568 --> 00:17:33,428
so people are studying it in detail in

378
00:17:31,569 --> 00:17:34,450
the next couple months all of the

379
00:17:33,429 --> 00:17:36,880
observations that we're ever going to

380
00:17:34,450 --> 00:17:37,899
get of this object will be done and

381
00:17:36,880 --> 00:17:39,970
we'll see where that where they lead

382
00:17:37,898 --> 00:17:42,089
okay all right

383
00:17:39,970 --> 00:17:45,490
so that's our news from the universe and

384
00:17:42,089 --> 00:17:49,079
now we go to our featured speaker

385
00:17:45,490 --> 00:17:53,829

tonight and let me get to

386

00:17:49,079 --> 00:17:55,689

her lips you're gonna have to log in

387

00:17:53,829 --> 00:17:57,759

your machine went up all right so our

388

00:17:55,690 --> 00:18:01,240

featured speaker tonight is Kelsey

389

00:17:57,759 --> 00:18:04,359

glazier from Towson University and she

390

00:18:01,240 --> 00:18:07,630

is for the my hosting period the very

391

00:18:04,359 --> 00:18:16,959

first undergraduate we've ever had speak

392

00:18:07,630 --> 00:18:19,660

at the public lecture series okay she is

393

00:18:16,960 --> 00:18:22,120

on the James urn over the earnest II

394

00:18:19,660 --> 00:18:24,190

wouldn't scholarship at Towson

395

00:18:22,119 --> 00:18:25,709

University for this year and over the

396

00:18:24,190 --> 00:18:28,539

past summer she was doing research

397

00:18:25,710 --> 00:18:30,100

supported by the Maryland space grant

398

00:18:28,539 --> 00:18:31,450

observatory the group across the street

399

00:18:30,099 --> 00:18:33,669

that runs the observer ends the

400
00:18:31,450 --> 00:18:38,110
telescope she was supported by them

401
00:18:33,670 --> 00:18:40,750
working on Olbers paradox and the light

402
00:18:38,109 --> 00:18:43,289
deflection during the 2017 solar eclipse

403
00:18:40,750 --> 00:18:45,429
and let me try this again

404
00:18:43,289 --> 00:18:54,609
there we go number one now it should

405
00:18:45,429 --> 00:18:56,769
connect you there we go okay and her

406
00:18:54,609 --> 00:18:59,349
professor who's she's working with has

407
00:18:56,769 --> 00:19:01,808
already put on her webpage that she's

408
00:18:59,349 --> 00:19:03,609
giving a public outreach lecture at the

409
00:19:01,808 --> 00:19:09,279
Hubble Space Science Telescope Institute

410
00:19:03,609 --> 00:19:10,990
he's got to get that right so it's

411
00:19:09,279 --> 00:19:11,920
already up there about it all right so

412
00:19:10,990 --> 00:19:14,880
ladies and gentlemen

413
00:19:11,920 --> 00:19:14,880
Kelsey Glazer

414
00:19:18,109 --> 00:19:26,509
oh um as dr. Sommer said my name's

415
00:19:25,429 --> 00:19:29,110
Kelsey Glaser

416
00:19:26,509 --> 00:19:31,730
I'm undergraduate at Towson University

417
00:19:29,109 --> 00:19:34,399
my major is in physics with a

418
00:19:31,730 --> 00:19:36,319
concentration in astrophysics and again

419
00:19:34,400 --> 00:19:38,420
this summer I was allowed the

420
00:19:36,319 --> 00:19:41,240
opportunity to specifically dive into

421
00:19:38,420 --> 00:19:43,220
these titude subjects and you'll hear

422
00:19:41,240 --> 00:19:44,990
about my research as well but we'll also

423
00:19:43,220 --> 00:19:48,319
cover in this talk some of the theory

424
00:19:44,990 --> 00:19:50,000
behind it as well so just to get you

425
00:19:48,319 --> 00:19:52,159
familiar with some of the people who

426
00:19:50,000 --> 00:19:54,769
were actually working with me on this

427
00:19:52,160 --> 00:19:56,870
you'll see myself and dr. James over

428

00:19:54,769 --> 00:20:00,650
doing my mentor in front of the Towson

429
00:19:56,869 --> 00:20:03,229
University 16 inch telescope for any of

430
00:20:00,650 --> 00:20:06,110
you telescope enthusiasts it's actually

431
00:20:03,230 --> 00:20:09,019
a Richie 14 reflector with an equatorial

432
00:20:06,109 --> 00:20:12,199
mount and in the far image you'll see

433
00:20:09,019 --> 00:20:15,558
myself and dr. Alexander stars atop the

434
00:20:12,200 --> 00:20:17,298
16 inch but you'll also see mr. Chris

435
00:20:15,558 --> 00:20:19,160
misko it's in his telescope that we

436
00:20:17,298 --> 00:20:20,869
actually were able to take down with us

437
00:20:19,160 --> 00:20:24,380
to South Carolina for when we actually

438
00:20:20,869 --> 00:20:26,539
went to view the solar eclipse and you

439
00:20:24,380 --> 00:20:28,970
also see two young ladies Kari

440
00:20:26,539 --> 00:20:30,889
McClelland and Charlotte Edwards these

441
00:20:28,970 --> 00:20:33,230
two ladies were high school interns who

442
00:20:30,890 --> 00:20:36,140

actually came along for the ride so it

443

00:20:33,230 --> 00:20:39,769

was a quite a nice quite a nice group I

444

00:20:36,140 --> 00:20:43,179

would say um so jumping into overs

445

00:20:39,769 --> 00:20:45,740

paradox why is the night sky dark right

446

00:20:43,179 --> 00:20:48,860

we all agreed that the universe is

447

00:20:45,740 --> 00:20:51,740

static and infinite and that light is

448

00:20:48,859 --> 00:20:54,439

evenly distributed through it so

449

00:20:51,740 --> 00:20:56,839

technically by that definition no matter

450

00:20:54,440 --> 00:20:59,058

where I look in the sky I should always

451

00:20:56,839 --> 00:21:02,539

see some sort of light a star or a

452

00:20:59,058 --> 00:21:05,119

galaxy but I don't write the night sky

453

00:21:02,539 --> 00:21:08,720

is dark it's actually more dark than it

454

00:21:05,119 --> 00:21:12,139

is light that's why it's nice and you

455

00:21:08,720 --> 00:21:14,150

know why is that if you're having a hard

456

00:21:12,140 --> 00:21:17,000

time understanding what this is like

457
00:21:14,150 --> 00:21:18,798
imagine yourself in a forest and you're

458
00:21:17,000 --> 00:21:20,839
standing in the middle of it and no

459
00:21:18,798 --> 00:21:23,690
matter where you look your eye would

460
00:21:20,839 --> 00:21:25,359
always hit a tree the same thing applies

461
00:21:23,690 --> 00:21:28,220
no matter where we look in the sky

462
00:21:25,359 --> 00:21:30,709
technically we should always be seeing a

463
00:21:28,220 --> 00:21:33,769
quick galaxy or a star

464
00:21:30,710 --> 00:21:35,899
and it turns out when we take our most

465
00:21:33,769 --> 00:21:38,389
powerful telescope pointed out one of

466
00:21:35,898 --> 00:21:41,359
the darkest parts of our night sky for

467
00:21:38,390 --> 00:21:44,778
ten whole days we still come up with

468
00:21:41,359 --> 00:21:47,240
darkness in between these galaxies why

469
00:21:44,778 --> 00:21:49,369
though and just a quick background on

470
00:21:47,240 --> 00:21:52,308
the this image it's called the Hubble

471
00:21:49,369 --> 00:21:55,459
Deep Field and they actually went back

472
00:21:52,308 --> 00:21:59,990
the Hubble Deep Field is inside Ursa

473
00:21:55,460 --> 00:22:02,120
Major and later on and I believe 2004

474
00:21:59,990 --> 00:22:03,589
they went back and took some more images

475
00:22:02,119 --> 00:22:06,168
of another part of sky and they called

476
00:22:03,589 --> 00:22:06,918
it the Hubble Ultra Deep Field inside of

477
00:22:06,169 --> 00:22:10,759
Fornax

478
00:22:06,919 --> 00:22:12,919
and they took one in infrared as well

479
00:22:10,759 --> 00:22:14,000
and then compiled it into the picture

480
00:22:12,919 --> 00:22:16,309
you're holding in your hands right now

481
00:22:14,000 --> 00:22:22,429
the extreme deep field

482
00:22:16,308 --> 00:22:23,928
dun-dun-dun and it's actually as a quick

483
00:22:22,429 --> 00:22:29,090
side note not to run off on a tangent

484
00:22:23,929 --> 00:22:32,600
but inside the extreme deep field they

485

00:22:29,089 --> 00:22:35,148
apparently spotted a galaxy that's about

486
00:22:32,599 --> 00:22:37,490
thirteen point two billion light-years

487
00:22:35,148 --> 00:22:40,009
away now this is a significant find

488
00:22:37,490 --> 00:22:42,440
because that means this galaxy is lying

489
00:22:40,009 --> 00:22:45,950
at the very edges of our observable

490
00:22:42,440 --> 00:22:46,909
universe and it's age is significant

491
00:22:45,950 --> 00:22:48,788
right

492
00:22:46,909 --> 00:22:51,020
the universe has only existed for about

493
00:22:48,788 --> 00:22:53,658
fourteen billion years and this thing is

494
00:22:51,019 --> 00:22:56,450
almost the age of our universe think

495
00:22:53,659 --> 00:22:58,340
about let's say you had a baby you went

496
00:22:56,450 --> 00:22:59,860
to bed and then then wake up the next

497
00:22:58,339 --> 00:23:02,209
morning and the baby is now an adult

498
00:22:59,859 --> 00:23:05,240
that's kind of like what astronomers saw

499
00:23:02,210 --> 00:23:07,909

right this the the significance behind

500

00:23:05,240 --> 00:23:12,380

this is that you know galaxies take time

501

00:23:07,909 --> 00:23:14,510

to form and this one is showing that it

502

00:23:12,380 --> 00:23:16,309

formed rather quickly so either you know

503

00:23:14,509 --> 00:23:18,710

there's something very special about

504

00:23:16,308 --> 00:23:21,558

that baby or there's something we're not

505

00:23:18,710 --> 00:23:24,409

understanding about the way you know

506

00:23:21,558 --> 00:23:26,690

humans develop and grow so there so the

507

00:23:24,409 --> 00:23:30,169

existence of this galaxy that's thirteen

508

00:23:26,690 --> 00:23:32,600

point two billion light years away makes

509

00:23:30,169 --> 00:23:34,970

us wonder about you know is this just a

510

00:23:32,599 --> 00:23:36,439

special galaxy is this an anomaly or you

511

00:23:34,970 --> 00:23:37,909

know is this a mistake or you know is

512

00:23:36,440 --> 00:23:39,889

there some crucial piece of evidence

513

00:23:37,909 --> 00:23:43,890

we're not understanding it about galaxy

514
00:23:39,888 --> 00:23:47,308
formation it's actually pretty neat

515
00:23:43,890 --> 00:23:49,170
it's a pretty neat subject so back to

516
00:23:47,308 --> 00:23:51,750
what I was discussing before you know

517
00:23:49,170 --> 00:23:55,380
the dark night sky was pondered by many

518
00:23:51,750 --> 00:23:56,759
philosophers astronomers physicists and

519
00:23:55,380 --> 00:23:59,429
I'm going to talk about a few of their

520
00:23:56,759 --> 00:24:01,319
theories they proposed and the title

521
00:23:59,429 --> 00:24:03,600
already gives it away many incomplete

522
00:24:01,319 --> 00:24:05,759
answers you'll see some and we're gonna

523
00:24:03,599 --> 00:24:09,269
go over the ones that are really cool

524
00:24:05,759 --> 00:24:12,359
but not exactly the right ones

525
00:24:09,269 --> 00:24:14,639
we'll start with Kepler he believed in

526
00:24:12,359 --> 00:24:17,189
an island universe right there's he

527
00:24:14,640 --> 00:24:19,169
believed there's the Sun there's us and

528
00:24:17,190 --> 00:24:22,230
there's these glowing things in the sky

529
00:24:19,169 --> 00:24:25,860
around the Sun and that's it and he and

530
00:24:22,230 --> 00:24:28,259
the thing is right in his universe he

531
00:24:25,859 --> 00:24:30,750
has a finite amount of stars and only

532
00:24:28,259 --> 00:24:32,849
like a finite amount of space they can

533
00:24:30,750 --> 00:24:34,650
exist however that's not the universe we

534
00:24:32,849 --> 00:24:36,329
live in we live in an infinite universe

535
00:24:34,650 --> 00:24:39,870
and the light is evenly distributed

536
00:24:36,329 --> 00:24:41,939
through it so Kepler is kind of outdated

537
00:24:39,869 --> 00:24:45,869
and he got the boot is there he got the

538
00:24:41,940 --> 00:24:48,269
boot going further we have people like

539
00:24:45,869 --> 00:24:50,519
dishes or and overs himself who thought

540
00:24:48,269 --> 00:24:52,710
you know maybe what's happening is that

541
00:24:50,519 --> 00:24:54,690
this light is just getting blocked by

542

00:24:52,710 --> 00:24:57,808
stuff like intergalactic medium like

543
00:24:54,690 --> 00:24:59,880
dust right but it's important to note

544
00:24:57,808 --> 00:25:03,480
that this does happen this is happening

545
00:24:59,880 --> 00:25:06,690
in in the universe but it can't solely

546
00:25:03,480 --> 00:25:09,808
be the only answer to the paradox for

547
00:25:06,690 --> 00:25:11,759
for two reasons one if there was one

548
00:25:09,808 --> 00:25:13,829
there can't be that much dust in the

549
00:25:11,759 --> 00:25:17,099
universe there can and even if there was

550
00:25:13,829 --> 00:25:18,298
two if there was that dust concealing

551
00:25:17,099 --> 00:25:21,659
all that light would start to heat up

552
00:25:18,298 --> 00:25:25,650
and it then would radiate so we would

553
00:25:21,660 --> 00:25:28,380
see that light as well so it's important

554
00:25:25,650 --> 00:25:30,480
to remember absorption is happening but

555
00:25:28,380 --> 00:25:32,070
isn't it does not account for the entire

556
00:25:30,480 --> 00:25:34,308

reason why we see darkness in the night

557

00:25:32,069 --> 00:25:34,308

sky

558

00:25:35,240 --> 00:25:42,690

Immanuel Kant is a philosopher in 1755

559

00:25:40,829 --> 00:25:45,048

he came out with the idea of the fractal

560

00:25:42,690 --> 00:25:48,600

universe this is a really cool theory

561

00:25:45,048 --> 00:25:50,639

it's simply put there that if you take

562

00:25:48,599 --> 00:25:52,019

the same pattern in this case a cross

563

00:25:50,640 --> 00:25:54,600

but you can choose any pattern you like

564

00:25:52,019 --> 00:25:57,109

and if you just repeat it over and over

565

00:25:54,599 --> 00:25:59,959

and over making a scale large enlargen

566

00:25:57,109 --> 00:26:03,469

as it is in the image right here you can

567

00:25:59,960 --> 00:26:07,640

see where certain lines of sight you

568

00:26:03,470 --> 00:26:10,460

would get darkness however Kant's a

569

00:26:07,640 --> 00:26:12,830

proposal theory only works for

570

00:26:10,460 --> 00:26:15,110

small-scale and universes right if we

571
00:26:12,829 --> 00:26:19,099
were to apply you know this fractal this

572
00:26:15,109 --> 00:26:20,839
pattern to infinity weird end up at the

573
00:26:19,099 --> 00:26:22,459
same problem we started at we would

574
00:26:20,839 --> 00:26:24,740
technically then have to see light

575
00:26:22,460 --> 00:26:27,100
everywhere we looked which is not the

576
00:26:24,740 --> 00:26:31,849
case therefore a fractal universe is out

577
00:26:27,099 --> 00:26:34,399
so Zoeller came next he thought you know

578
00:26:31,849 --> 00:26:37,579
space was positively curved making this

579
00:26:34,400 --> 00:26:39,919
sphere which would cause the universe to

580
00:26:37,579 --> 00:26:41,808
be unbounded and infinite but it would

581
00:26:39,919 --> 00:26:44,960
make all the light inside of it finite

582
00:26:41,808 --> 00:26:46,849
and going off this model here what it

583
00:26:44,960 --> 00:26:49,910
would mean is that like I would see a

584
00:26:46,849 --> 00:26:52,849
star over here coming towards me but it

585
00:26:49,910 --> 00:26:54,110
would also travel all the way around the

586
00:26:52,849 --> 00:26:55,699
sphere and I could see it at the

587
00:26:54,109 --> 00:26:57,500
opposite direction it would be light

588
00:26:55,700 --> 00:27:01,819
from the same star but just at the

589
00:26:57,500 --> 00:27:03,349
opposite direction and you know if we

590
00:27:01,819 --> 00:27:04,849
only have a finite amount of stars doing

591
00:27:03,349 --> 00:27:07,009
this there's gotta be lines of sight

592
00:27:04,849 --> 00:27:09,259
that we don't see anything

593
00:27:07,009 --> 00:27:11,599
however this this theory falls through

594
00:27:09,259 --> 00:27:13,849
because of gravitational lensing which

595
00:27:11,599 --> 00:27:17,589
is a topic we'll talk about later but

596
00:27:13,849 --> 00:27:19,939
basically not to spoil anything but the

597
00:27:17,589 --> 00:27:22,629
what would happen is you know these

598
00:27:19,940 --> 00:27:25,789
these photons traveling through space

599

00:27:22,630 --> 00:27:28,040
would pass by massive objects these

600
00:27:25,789 --> 00:27:30,529
massive objects due to the warping it

601
00:27:28,039 --> 00:27:32,599
does to space-time would cause it to

602
00:27:30,529 --> 00:27:35,178
deflect it would be focus that light and

603
00:27:32,599 --> 00:27:36,859
therefore instead of meeting up back

604
00:27:35,179 --> 00:27:39,290
where it started

605
00:27:36,859 --> 00:27:43,129
it would go off right in every direction

606
00:27:39,289 --> 00:27:46,339
and then by that nature we would then

607
00:27:43,130 --> 00:27:49,250
see light in every direction and then we

608
00:27:46,339 --> 00:27:51,769
end up back at the problem so curved

609
00:27:49,250 --> 00:27:54,380
space goodbye

610
00:27:51,769 --> 00:27:56,509
the last incomplete answer I'm going to

611
00:27:54,380 --> 00:28:01,400
talk about is cosmic expansion and

612
00:27:56,509 --> 00:28:02,900
cosmic expansion like absorption is part

613
00:28:01,400 --> 00:28:05,960

is partly what's happening in the

614

00:28:02,900 --> 00:28:08,269
universe but again it can't solely stand

615

00:28:05,960 --> 00:28:09,110
on its own as being the only solution to

616

00:28:08,269 --> 00:28:10,529
the paradox

617

00:28:09,109 --> 00:28:12,089
so what cosmic

618

00:28:10,529 --> 00:28:15,539
expansion is saying and it was proposed

619

00:28:12,089 --> 00:28:18,000
by steady state theorists that um the

620

00:28:15,539 --> 00:28:19,740
universe is expanding as a steady-state

621

00:28:18,000 --> 00:28:22,289
uniformly everything inside of it is U

622

00:28:19,740 --> 00:28:24,960
is expanding together right and

623

00:28:22,289 --> 00:28:27,240
therefore it's by an expanding universe

624

00:28:24,960 --> 00:28:30,600
it's doing two things to my photon it's

625

00:28:27,240 --> 00:28:32,880
in its elongated its wavelengths and

626

00:28:30,599 --> 00:28:35,309
it's also increasing the distance and

627

00:28:32,880 --> 00:28:37,530
needs to travel for us to for it to

628
00:28:35,309 --> 00:28:40,200
reach us right so it makes sense that

629
00:28:37,529 --> 00:28:42,180
you know the more expansion the less

630
00:28:40,200 --> 00:28:44,730
brightness I'm going to see because that

631
00:28:42,180 --> 00:28:47,250
means more distance and these photons

632
00:28:44,730 --> 00:28:49,349
have to travel to get to me but in order

633
00:28:47,250 --> 00:28:50,970
for study state there's cosmic expansion

634
00:28:49,349 --> 00:28:53,069
to work that would mean that the

635
00:28:50,970 --> 00:28:56,789
universe would have to expand uniformly

636
00:28:53,069 --> 00:28:58,980
and once the once cosmic microwave

637
00:28:56,789 --> 00:29:01,379
background came around a lot of people

638
00:28:58,980 --> 00:29:03,390
ended up abandoning this idea because

639
00:29:01,380 --> 00:29:07,770
what the Cosmic Microwave Background did

640
00:29:03,390 --> 00:29:11,190
was it showed a lot of inflation models

641
00:29:07,769 --> 00:29:13,650
came out as an outcome of finding the

642
00:29:11,190 --> 00:29:15,090
Cosmic Microwave Background and for

643
00:29:13,650 --> 00:29:17,910
those of you who aren't familiar with

644
00:29:15,089 --> 00:29:21,119
inflation it is what we believe to be a

645
00:29:17,910 --> 00:29:24,410
point in time right um after the Big

646
00:29:21,119 --> 00:29:27,659
Bang where the universe actually

647
00:29:24,410 --> 00:29:31,290
expanded faster than possibly the speed

648
00:29:27,660 --> 00:29:32,790
of light now if you're like wait nothing

649
00:29:31,289 --> 00:29:34,369
can move faster than the speed of light

650
00:29:32,789 --> 00:29:40,470
you don't know what you're talking about

651
00:29:34,369 --> 00:29:42,059
true no I'm kidding everybody but you

652
00:29:40,470 --> 00:29:44,160
know everything inside the universe is

653
00:29:42,059 --> 00:29:48,299
bound to this law that nothing can

654
00:29:44,160 --> 00:29:51,290
exceed the speed of light but the

655
00:29:48,299 --> 00:29:54,569
universe itself isn't bound to this law

656

00:29:51,289 --> 00:29:56,099
therefore there's no technically rule

657
00:29:54,569 --> 00:29:58,589
say there's no technical there's

658
00:29:56,099 --> 00:30:00,809
technically no rule saying that the

659
00:29:58,589 --> 00:30:02,730
universe can't expand faster than speed

660
00:30:00,809 --> 00:30:07,230
of life so when CMB came around and gave

661
00:30:02,730 --> 00:30:09,779
race two models of inflation cosmic

662
00:30:07,230 --> 00:30:13,700
expansion being the sole reason why you

663
00:30:09,779 --> 00:30:15,809
know the night sky is dark got the boot

664
00:30:13,700 --> 00:30:17,460
and of course there's many other

665
00:30:15,809 --> 00:30:19,619
theories these are just listing a few

666
00:30:17,460 --> 00:30:20,850
cool ones that intrigued me this one

667
00:30:19,619 --> 00:30:22,859
tired light I really wish I could talk

668
00:30:20,849 --> 00:30:23,699
about it's literally the idea that light

669
00:30:22,859 --> 00:30:31,408
just gets

670
00:30:23,700 --> 00:30:33,028

hired on its way to us you know yeah but

671

00:30:31,409 --> 00:30:35,970

there's a lot more out there and if

672

00:30:33,028 --> 00:30:38,369

you're interested you know there's a ton

673

00:30:35,970 --> 00:30:40,230

more of theories of why the night sky is

674

00:30:38,369 --> 00:30:42,750

dark but to fast forward a little bit

675

00:30:40,230 --> 00:30:45,528

we're gonna actually look at the guy who

676

00:30:42,750 --> 00:30:51,210

figured it out

677

00:30:45,528 --> 00:30:53,659

recognized him can you believe it a poet

678

00:30:51,210 --> 00:30:57,538

beat it beat us to the answer

679

00:30:53,659 --> 00:30:59,899

ding now there is some controversy over

680

00:30:57,538 --> 00:31:04,648

who actually came up with the solution

681

00:30:59,898 --> 00:31:07,739

in Edgar Allen Poe Edgar Allen Poe's

682

00:31:04,648 --> 00:31:09,418

poem Eureka a prose poem Eureka he

683

00:31:07,740 --> 00:31:12,778

actually touched the subject here as you

684

00:31:09,419 --> 00:31:18,080

can see of why exactly the night sky is

685
00:31:12,778 --> 00:31:20,579
dark but later 10 years later in 1850 58

686
00:31:18,079 --> 00:31:22,379
Johann mad ler came out with an actual

687
00:31:20,579 --> 00:31:24,359
paper saying this is why the night skies

688
00:31:22,380 --> 00:31:27,360
are right so there's some discrepancy on

689
00:31:24,359 --> 00:31:29,579
who they believe you know was potent at

690
00:31:27,359 --> 00:31:31,859
it or was he really you know saying

691
00:31:29,579 --> 00:31:34,970
something he's a poet do we want to

692
00:31:31,859 --> 00:31:37,079
trust a poet / a scientist you know it's

693
00:31:34,970 --> 00:31:38,250
it's not a here no there so I'll leave

694
00:31:37,079 --> 00:31:40,168
it to you to decide who you think

695
00:31:38,250 --> 00:31:42,179
thought of it first but I do want to

696
00:31:40,169 --> 00:31:43,889
read you this section of his poem

697
00:31:42,179 --> 00:31:46,649
because it's it's a quite a profound

698
00:31:43,888 --> 00:31:49,048
statement he says where the succession

699
00:31:46,648 --> 00:31:51,629
of stars endless then the background of

700
00:31:49,048 --> 00:31:53,908
the sky would present us an uniform

701
00:31:51,630 --> 00:31:56,730
luminosity like that displayed by the

702
00:31:53,909 --> 00:31:59,399
galaxy since there could be absolutely

703
00:31:56,730 --> 00:32:02,220
no point in all that background at which

704
00:31:59,398 --> 00:32:04,018
would not exist a star the only mode

705
00:32:02,220 --> 00:32:06,210
therefore in which under such a state of

706
00:32:04,019 --> 00:32:08,669
affairs we could comprehend the voids

707
00:32:06,210 --> 00:32:11,700
which our telescopes find in innumerable

708
00:32:08,669 --> 00:32:13,980
directions would be by supposing the

709
00:32:11,700 --> 00:32:16,470
distance of the invisible background so

710
00:32:13,980 --> 00:32:19,950
immense that no ray from it has yet been

711
00:32:16,470 --> 00:32:23,220
able to reach us at all that this may be

712
00:32:19,950 --> 00:32:25,080
so you shall venture to deny I maintain

713

00:32:23,220 --> 00:32:27,889
simply that we have not even the shadow

714
00:32:25,079 --> 00:32:31,379
of a reason for believing that it is so

715
00:32:27,888 --> 00:32:33,058
so I actually highlighted you know all

716
00:32:31,380 --> 00:32:35,100
the theatrics but I actually highlighted

717
00:32:33,058 --> 00:32:36,950
the most important part and if you're

718
00:32:35,099 --> 00:32:38,449
still having trouble like

719
00:32:36,950 --> 00:32:41,420
kind of digging it out because poets

720
00:32:38,450 --> 00:32:44,779
like to be all you know ambiguous about

721
00:32:41,420 --> 00:32:48,529
stuff he's basically proposing that you

722
00:32:44,779 --> 00:32:49,910
know light has a finite speed and it's

723
00:32:48,529 --> 00:32:52,940
only been allowed a certain amount of

724
00:32:49,910 --> 00:32:54,679
time to travel right and if a distance

725
00:32:52,940 --> 00:32:56,570
it has to travel is larger than its

726
00:32:54,679 --> 00:32:59,179
speed times the amount of time it's

727
00:32:56,569 --> 00:33:01,308

allowed to travel what the problem is is

728

00:32:59,179 --> 00:33:03,019

the lights just not reaching us and that

729

00:33:01,308 --> 00:33:05,629

turned out to be the solution to the

730

00:33:03,019 --> 00:33:07,460

paradox right that there's some time the

731

00:33:05,630 --> 00:33:09,410

the darkness and I sky is due to the

732

00:33:07,460 --> 00:33:13,669

fact that we just haven't received light

733

00:33:09,410 --> 00:33:15,440

from there yet and if you want to think

734

00:33:13,669 --> 00:33:19,580

about this a little bit further and

735

00:33:15,440 --> 00:33:22,669

imagine the universe as this glowing

736

00:33:19,579 --> 00:33:25,189

sphere with a luminosity density and a

737

00:33:22,669 --> 00:33:27,380

radius that's equal to the speed of

738

00:33:25,190 --> 00:33:29,419

light C times T not the amount of time

739

00:33:27,380 --> 00:33:32,390

it's been allowed to travel here we say

740

00:33:29,419 --> 00:33:35,690

it is T not is the age of the universe

741

00:33:32,390 --> 00:33:38,090

about 14 billion years old we can relate

742
00:33:35,690 --> 00:33:41,450
the luminosity and the distance it's

743
00:33:38,089 --> 00:33:44,899
gone to intensity the intensity of this

744
00:33:41,450 --> 00:33:46,580
very far distant light called as we call

745
00:33:44,900 --> 00:33:48,650
extra galactic background light light

746
00:33:46,579 --> 00:33:52,879
from very foreign distant distant

747
00:33:48,650 --> 00:33:56,210
sources and to touch upon the EBL real

748
00:33:52,880 --> 00:33:57,770
quickly when we first discovered it we

749
00:33:56,210 --> 00:33:59,419
discovered it from a quasar that I

750
00:33:57,769 --> 00:34:01,250
believe was about seven point six

751
00:33:59,419 --> 00:34:02,960
billion light years away so this thing's

752
00:34:01,250 --> 00:34:05,240
about more than half the age of the

753
00:34:02,960 --> 00:34:08,449
universe and when we detected it in

754
00:34:05,240 --> 00:34:10,969
space of course we detected it as what

755
00:34:08,449 --> 00:34:13,269
we call a gamma-ray photon gamma-ray

756
00:34:10,969 --> 00:34:15,739
photons are very highly energetic

757
00:34:13,269 --> 00:34:18,980
photons they have very short wavelengths

758
00:34:15,739 --> 00:34:22,759
and this raised a lot of eyebrows right

759
00:34:18,980 --> 00:34:24,378
this thing travelled of like more than

760
00:34:22,760 --> 00:34:26,960
half the age of the universe to reach us

761
00:34:24,378 --> 00:34:29,949
and even with cosmic expansion affecting

762
00:34:26,960 --> 00:34:32,470
the photon in elongating its wavelength

763
00:34:29,949 --> 00:34:34,608
we're still reading it in as a gamma ray

764
00:34:32,469 --> 00:34:36,908
you know it would make sense you know if

765
00:34:34,608 --> 00:34:39,199
I drove my car from here to California

766
00:34:36,909 --> 00:34:41,300
I'd have a better chance of getting into

767
00:34:39,199 --> 00:34:42,949
a car accident then if I were to just

768
00:34:41,300 --> 00:34:44,869
drive it from here down the street and

769
00:34:42,949 --> 00:34:46,939
back of course that depends on how good

770

00:34:44,869 --> 00:34:49,300
of a driver I am but that's another

771
00:34:46,940 --> 00:34:49,300
topic

772
00:34:49,358 --> 00:34:55,690
but the same thing applies something

773
00:34:52,159 --> 00:34:59,390
traveling this great amount of distance

774
00:34:55,690 --> 00:35:01,220
really made us see just how empty space

775
00:34:59,389 --> 00:35:03,949
is right it's not hitting anything it's

776
00:35:01,219 --> 00:35:05,838
not getting caught in any dust or any

777
00:35:03,949 --> 00:35:10,129
other particle floating out in space

778
00:35:05,838 --> 00:35:12,920
though it actually hints at how just how

779
00:35:10,130 --> 00:35:14,960
empty space really is and it's quite a

780
00:35:12,920 --> 00:35:19,039
wonderful thing to contemplate for a

781
00:35:14,960 --> 00:35:22,490
second so moving on to how this worked

782
00:35:19,039 --> 00:35:23,599
in with my summer research was we wanted

783
00:35:22,489 --> 00:35:25,250
to go out and see if we could measure

784
00:35:23,599 --> 00:35:27,140

this intensity from the extra galactic

785

00:35:25,250 --> 00:35:28,909

background light because by doing that

786

00:35:27,139 --> 00:35:30,768

we can then make inferences about the

787

00:35:28,909 --> 00:35:32,449

age of the universe because this has

788

00:35:30,768 --> 00:35:34,308

travelled such a large distance it's

789

00:35:32,449 --> 00:35:36,139

holding information about how long it's

790

00:35:34,309 --> 00:35:39,559

traveled that T not I would like to know

791

00:35:36,139 --> 00:35:40,308

and so what you see here is that nice

792

00:35:39,559 --> 00:35:43,579

pink bluey

793

00:35:40,309 --> 00:35:45,769

picture that is a image we took from the

794

00:35:43,579 --> 00:35:47,720

Towson University 16 inch telescope and

795

00:35:45,768 --> 00:35:50,508

underneath it is another ground-based

796

00:35:47,719 --> 00:35:54,469

image of where the Hubble Deep Field is

797

00:35:50,509 --> 00:35:56,420

inside the Big Dipper and we're actually

798

00:35:54,469 --> 00:35:59,568

aiming for the Hubble Deep Field and as

799
00:35:56,420 --> 00:36:01,099
you can see we just we just missed it by

800
00:35:59,568 --> 00:36:03,619
a little bit they always say when you're

801
00:36:01,099 --> 00:36:05,240
planning when you're planning telescope

802
00:36:03,619 --> 00:36:05,539
time you pick three days you lose one to

803
00:36:05,239 --> 00:36:07,489
weather

804
00:36:05,539 --> 00:36:09,680
one to technical difficulties and by the

805
00:36:07,489 --> 00:36:12,139
third hopefully you get something so

806
00:36:09,679 --> 00:36:15,139
this falls under technical difficulties

807
00:36:12,139 --> 00:36:17,298
but luckily we planned ahead and we had

808
00:36:15,139 --> 00:36:19,608
multiple days but it was still a good

809
00:36:17,298 --> 00:36:22,099
practice to use this to do data

810
00:36:19,608 --> 00:36:23,298
calibration image reduction all these

811
00:36:22,099 --> 00:36:27,410
things you don't think about until

812
00:36:23,298 --> 00:36:29,719
you're in doing the project but it was

813
00:36:27,409 --> 00:36:31,368
also taken near new moon so we wanted to

814
00:36:29,719 --> 00:36:33,409
reduce the amount of light in our image

815
00:36:31,369 --> 00:36:35,000
because what we were looking at was

816
00:36:33,409 --> 00:36:37,129
something very far in distance so we

817
00:36:35,000 --> 00:36:38,929
didn't want light from close objects

818
00:36:37,130 --> 00:36:40,940
getting in the way and if you're curious

819
00:36:38,929 --> 00:36:43,068
it was taken in the our band filter what

820
00:36:40,940 --> 00:36:44,929
that is is exactly as it sounds it's a

821
00:36:43,068 --> 00:36:47,150
filter that you strap on to your

822
00:36:44,929 --> 00:36:49,460
telescope and you tell it hey I know you

823
00:36:47,150 --> 00:36:51,889
can read in multiple wavelengths but I

824
00:36:49,460 --> 00:36:54,079
only want you to look in this set of

825
00:36:51,889 --> 00:36:57,588
wavelengths this range that way you

826
00:36:54,079 --> 00:36:59,450
don't that way you don't get light from

827

00:36:57,588 --> 00:37:02,440
other wavelengths that you don't care

828
00:36:59,449 --> 00:37:06,889
about basically right so

829
00:37:02,440 --> 00:37:08,900
going into what we actually saw so we

830
00:37:06,889 --> 00:37:10,548
estimated assuming that the age of the

831
00:37:08,900 --> 00:37:12,170
universe was about fourteen billion

832
00:37:10,548 --> 00:37:14,119
years old we estimated that the

833
00:37:12,170 --> 00:37:15,829
intensity of this extra galactic

834
00:37:14,119 --> 00:37:17,180
background light should be about three

835
00:37:15,829 --> 00:37:19,849
nano watts per meter squared per

836
00:37:17,179 --> 00:37:21,230
steradian and that its luminosity should

837
00:37:19,849 --> 00:37:24,650
be about three times 10 to the negative

838
00:37:21,230 --> 00:37:26,269
33 watts per meter cubed and what we

839
00:37:24,650 --> 00:37:28,460
actually saw was what you get from

840
00:37:26,269 --> 00:37:31,940
telescopes did you get counts per pixel

841
00:37:28,460 --> 00:37:34,789

which then you have to go and convert

842

00:37:31,940 --> 00:37:36,710

into the unit's you want and so we

843

00:37:34,789 --> 00:37:38,900

converted it into ten thousand plus or

844

00:37:36,710 --> 00:37:40,760

minus five thousand nano watts per meter

845

00:37:38,900 --> 00:37:44,440

squared priests are radiant now if you

846

00:37:40,760 --> 00:37:46,849

like hey you thought you would see three

847

00:37:44,440 --> 00:37:50,298

but she's getting ten thousand who is

848

00:37:46,849 --> 00:37:50,690

this shake what's she doing and you're

849

00:37:50,298 --> 00:37:52,579

right

850

00:37:50,690 --> 00:37:56,119

ten thousand is a big number compared to

851

00:37:52,579 --> 00:37:59,240

three right so what what the heck

852

00:37:56,119 --> 00:38:01,579

happened and I'll tell you what happened

853

00:37:59,239 --> 00:38:05,058

being a ground-based telescope you're

854

00:38:01,579 --> 00:38:06,859

fighting a lot of light pollution inside

855

00:38:05,059 --> 00:38:09,019

Earth's atmosphere before you even get

856
00:38:06,858 --> 00:38:11,778
outside of it right so what we had to do

857
00:38:09,019 --> 00:38:14,000
we had to sit down and quantify you know

858
00:38:11,778 --> 00:38:17,719
the amounts of light pollution adding to

859
00:38:14,000 --> 00:38:21,199
our image from each different source of

860
00:38:17,719 --> 00:38:23,750
light and after we subtracted through

861
00:38:21,199 --> 00:38:25,818
subtracted out all those extra sources

862
00:38:23,750 --> 00:38:28,010
of light we actually ended up with a

863
00:38:25,818 --> 00:38:29,568
really nice number of a hundred nano

864
00:38:28,010 --> 00:38:31,760
watts per meter square per steradian and

865
00:38:29,568 --> 00:38:34,548
this is much closer to our estimated

866
00:38:31,760 --> 00:38:38,059
amount so it was quite a success and if

867
00:38:34,548 --> 00:38:40,250
you're wondering what that little map of

868
00:38:38,059 --> 00:38:42,170
Maryland is over there that is an image

869
00:38:40,250 --> 00:38:44,358
called the bortles scale

870
00:38:42,170 --> 00:38:47,599
now the bordel scale tries to quantify

871
00:38:44,358 --> 00:38:50,088
the amount of light pollution where you

872
00:38:47,599 --> 00:38:53,000
are geographically and it scales from

873
00:38:50,088 --> 00:38:55,338
one to nine about one to nine and one is

874
00:38:53,000 --> 00:38:58,579
represented as black about nine is

875
00:38:55,338 --> 00:39:00,769
represented at what as white white being

876
00:38:58,579 --> 00:39:03,589
the worst black being the best and if

877
00:39:00,769 --> 00:39:05,900
any of you have no idea what Towson or

878
00:39:03,588 --> 00:39:08,380
Baltimore is that's okay just look at

879
00:39:05,900 --> 00:39:08,380
the white spot

880
00:39:09,829 --> 00:39:15,860
yeah it's it would make sense though

881
00:39:13,940 --> 00:39:18,139
that you know in one of the most highly

882
00:39:15,860 --> 00:39:20,390
like polluted areas in Maryland our data

883
00:39:18,139 --> 00:39:24,769
would be off because there's so much

884

00:39:20,389 --> 00:39:26,929
light pollution right so in the end of

885
00:39:24,769 --> 00:39:29,690
this project out over abouts we

886
00:39:26,929 --> 00:39:31,460
collected about 70,000 photons over a

887
00:39:29,690 --> 00:39:34,429
thirty minute exposure the amount of

888
00:39:31,460 --> 00:39:36,320
time we left our telescope open and we

889
00:39:34,429 --> 00:39:39,230
can say approximately about twenty of

890
00:39:36,320 --> 00:39:42,950
them actually belonged to the EBL so it

891
00:39:39,230 --> 00:39:45,230
was quite quite a fun project learned a

892
00:39:42,949 --> 00:39:49,909
lot about why why we want to launch

893
00:39:45,230 --> 00:39:54,740
things up into space right ground base

894
00:39:49,909 --> 00:39:56,480
is is ground-based but it's it's really

895
00:39:54,739 --> 00:39:59,539
it was really a great learning

896
00:39:56,480 --> 00:40:01,940
experience and opportunity the other

897
00:39:59,539 --> 00:40:03,980
half of my summer was spent actually

898
00:40:01,940 --> 00:40:06,889

looking for light deflection during the

899

00:40:03,980 --> 00:40:08,990

2017 solar eclipse and in these images

900

00:40:06,889 --> 00:40:10,460

you'll see Chris misko hits with his

901

00:40:08,989 --> 00:40:12,169

telescope down and so all these were

902

00:40:10,460 --> 00:40:15,829

taken in South Carolina but you'll see

903

00:40:12,170 --> 00:40:17,420

him setting up the telescope the middle

904

00:40:15,829 --> 00:40:18,889

one is actually one we took with his

905

00:40:17,420 --> 00:40:20,450

telescope and you'll see you know the

906

00:40:18,889 --> 00:40:23,359

Eclipse in the middle in it transiting

907

00:40:20,449 --> 00:40:26,329

on either end and on the far one you'll

908

00:40:23,360 --> 00:40:28,519

see me under a nice cool tent with some

909

00:40:26,329 --> 00:40:31,579

ice water and a laptop in front of me I

910

00:40:28,519 --> 00:40:36,170

chose the right job for the end of

911

00:40:31,579 --> 00:40:39,049

August at 2:00 p.m. that is his personal

912

00:40:36,170 --> 00:40:40,789

telescope I know right I am very

913
00:40:39,050 --> 00:40:46,970
surprised he let me as close to it as he

914
00:40:40,789 --> 00:40:48,500
did it's just a telescope yep he would

915
00:40:46,969 --> 00:40:52,489
have think he would have thought but

916
00:40:48,500 --> 00:40:54,619
yeah yeah so I spent my so I we it was a

917
00:40:52,489 --> 00:40:57,799
very stressful time you know we only had

918
00:40:54,619 --> 00:40:59,750
two minutes to take these images that we

919
00:40:57,800 --> 00:41:00,950
needed and you know everything had to be

920
00:40:59,750 --> 00:41:02,960
perfect everything had to be right

921
00:41:00,949 --> 00:41:04,309
clouds were coming in threatening and I

922
00:41:02,960 --> 00:41:11,630
got really anxious I was like you better

923
00:41:04,309 --> 00:41:13,549
met her move and and yeah and so from

924
00:41:11,630 --> 00:41:15,500
inside the tent I what I was doing was

925
00:41:13,550 --> 00:41:17,900
we were setting out we were calibrating

926
00:41:15,500 --> 00:41:20,570
the telescope I was basically saying

927
00:41:17,900 --> 00:41:21,480
move it a little left no the other left

928
00:41:20,570 --> 00:41:25,740
you

929
00:41:21,480 --> 00:41:27,449
so so in case you didn't get to see the

930
00:41:25,739 --> 00:41:30,598
Eclipse along the line of totality I do

931
00:41:27,449 --> 00:41:34,019
have a video for you taken by CNN that

932
00:41:30,599 --> 00:41:37,230
map that shows the solar eclipse as it's

933
00:41:34,019 --> 00:41:39,030
going through North America right so it

934
00:41:37,230 --> 00:41:40,980
starts up in Washington and ends up in

935
00:41:39,030 --> 00:41:51,900
South Carolina so it's a really cool

936
00:41:40,980 --> 00:42:06,480
video so here you guys go it had sound

937
00:41:51,900 --> 00:42:09,230
but it use your imagination right well I

938
00:42:06,480 --> 00:42:09,230
feel bad for them

939
00:42:57,518 --> 00:43:02,808
so it was a little video it's actually

940
00:43:00,409 --> 00:43:06,048
funny cuz I'm I went down to Lexington

941

00:43:02,809 --> 00:43:07,579
South Carolina and I was going down of

942
00:43:06,048 --> 00:43:09,768
course to do some imaging and research

943
00:43:07,579 --> 00:43:11,599
and afterwards I was gonna meet up with

944
00:43:09,768 --> 00:43:13,968
some friends down at Myrtle Beach who

945
00:43:11,599 --> 00:43:16,400
drove two hours inward you know to view

946
00:43:13,969 --> 00:43:17,329
the solar eclipse and everything went

947
00:43:16,400 --> 00:43:19,639
wrong you know they couldn't get into

948
00:43:17,329 --> 00:43:21,349
the parks cuz you know it was backed up

949
00:43:19,639 --> 00:43:26,298
since like 2:00 a.m. the night before

950
00:43:21,349 --> 00:43:27,920
and they actually met a guy there who

951
00:43:26,298 --> 00:43:29,208
like brought him to this special spot

952
00:43:27,920 --> 00:43:31,150
where he was like building cabins or

953
00:43:29,208 --> 00:43:33,108
something it was kind of sketchy but

954
00:43:31,150 --> 00:43:35,269
regardless to say they had clear skies

955
00:43:33,108 --> 00:43:37,598

and some of my friends had some small

956

00:43:35,268 --> 00:43:40,879

telescopes where they could view it and

957

00:43:37,599 --> 00:43:45,048

as soon as transit started it clouds

958

00:43:40,880 --> 00:43:47,380

came in and rained on them so one of our

959

00:43:45,048 --> 00:43:50,268

friends in the group chat decided to

960

00:43:47,380 --> 00:43:54,349

change the image of the group chat from

961

00:43:50,268 --> 00:43:57,558

a solar eclipse to clouded cloudy cloudy

962

00:43:54,349 --> 00:44:01,999

to a cloudy sky it did not go over well

963

00:43:57,559 --> 00:44:05,119

let's just say hey but you know eclipse

964

00:44:01,998 --> 00:44:06,738

is as beautiful as they are what what I

965

00:44:05,119 --> 00:44:09,439

was down there for was what was

966

00:44:06,739 --> 00:44:11,749

happening behind the scenes right so

967

00:44:09,438 --> 00:44:13,458

what what is happening behind the scenes

968

00:44:11,748 --> 00:44:15,828

well something called gravitational

969

00:44:13,458 --> 00:44:18,618

light deflection right we in general

970
00:44:15,829 --> 00:44:20,329
relativity we believe that gravity is

971
00:44:18,619 --> 00:44:22,608
equal to the warping of space-time so

972
00:44:20,329 --> 00:44:24,769
what's keeping me on this floor is not

973
00:44:22,608 --> 00:44:27,739
some force gravity it's the fact that

974
00:44:24,768 --> 00:44:29,629
the earth is massive and it's it's

975
00:44:27,739 --> 00:44:32,119
dipping into the fabric of space-time

976
00:44:29,630 --> 00:44:33,679
causing this little war and this inward

977
00:44:32,119 --> 00:44:36,199
warp is what's holding me down so

978
00:44:33,679 --> 00:44:39,679
gravity is equal to how much warping is

979
00:44:36,199 --> 00:44:42,260
done to space-time and what happens to

980
00:44:39,679 --> 00:44:44,809
light when this happens is

981
00:44:42,260 --> 00:44:47,060
light actually wants to travel on a

982
00:44:44,809 --> 00:44:49,009
straight path but when it gets close

983
00:44:47,059 --> 00:44:51,440
enough to these massive objects and the

984
00:44:49,010 --> 00:44:54,230
warping that has it's done to the fabric

985
00:44:51,440 --> 00:44:58,039
of space-time it's gonna cause the light

986
00:44:54,230 --> 00:45:02,119
to bend and my eyes you can trick him

987
00:44:58,039 --> 00:45:04,909
very easily my eyes on you can trick our

988
00:45:02,119 --> 00:45:07,100
eyes only see in straight lines so if I

989
00:45:04,909 --> 00:45:09,379
have light coming in from over here and

990
00:45:07,099 --> 00:45:12,769
it's curving and it's coming to me like

991
00:45:09,380 --> 00:45:16,190
this I don't I don't see that oh though

992
00:45:12,769 --> 00:45:18,199
it's like being bent around the Sun no I

993
00:45:16,190 --> 00:45:20,300
think the star that the lights coming

994
00:45:18,199 --> 00:45:21,679
from the Stars located over here right

995
00:45:20,300 --> 00:45:22,940
if the light's coming here I think the

996
00:45:21,679 --> 00:45:27,108
star is actually over here because I can

997
00:45:22,940 --> 00:45:29,300
only see in straight lines right and so

998

00:45:27,108 --> 00:45:31,309
what I actually ends up happening is a

999
00:45:29,300 --> 00:45:34,369
star's position that we we know is over

1000
00:45:31,309 --> 00:45:37,340
here now looks like it's over here right

1001
00:45:34,369 --> 00:45:40,730
this deflection is causing an outward

1002
00:45:37,340 --> 00:45:43,100
shift in a star's position so if I were

1003
00:45:40,730 --> 00:45:46,519
to take the Sun out of this image and

1004
00:45:43,099 --> 00:45:48,799
have flat space I would recognize that

1005
00:45:46,519 --> 00:45:50,780
the star I was looking at was over here

1006
00:45:48,800 --> 00:45:53,060
but the fact that the sun's in there and

1007
00:45:50,780 --> 00:45:55,670
is warping space-time and the light is

1008
00:45:53,059 --> 00:45:56,029
being bent by it my eyes don't see the

1009
00:45:55,670 --> 00:45:57,670
difference

1010
00:45:56,030 --> 00:46:02,630
he thinks the Stars over here for sure

1011
00:45:57,670 --> 00:46:04,099
but it's not and this is what we wanted

1012
00:46:02,630 --> 00:46:06,230

to go out to see if we could see this in

1013

00:46:04,099 --> 00:46:08,539
the 2017 solar eclipse all right so

1014

00:46:06,230 --> 00:46:11,329
first we needed an equation this is a

1015

00:46:08,539 --> 00:46:15,139
fancy schmancy equation that basically

1016

00:46:11,329 --> 00:46:16,549
produces deflection of my light right

1017

00:46:15,139 --> 00:46:19,069
and this is done through a program

1018

00:46:16,550 --> 00:46:21,289
called Stellarium it is a planetary

1019

00:46:19,070 --> 00:46:22,760
program and it's you know it's made by

1020

00:46:21,289 --> 00:46:26,179
astronomers when there's a button to

1021

00:46:22,760 --> 00:46:29,210
take out the atmosphere so you can see

1022

00:46:26,179 --> 00:46:31,519
everything very nicely and what we

1023

00:46:29,210 --> 00:46:34,099
needed was two stars close enough to the

1024

00:46:31,519 --> 00:46:35,659
Sun that they would undergo this

1025

00:46:34,099 --> 00:46:39,529
deflection of light and it just so

1026

00:46:35,659 --> 00:46:41,118
happens there were two stars that would

1027
00:46:39,530 --> 00:46:46,970
be perfect candidates to undergo this

1028
00:46:41,119 --> 00:46:49,400
light deflection so it's also noteworthy

1029
00:46:46,969 --> 00:46:52,339
to mention that these two stars are both

1030
00:46:49,400 --> 00:46:54,200
what we call 7th magnitude stars which

1031
00:46:52,340 --> 00:46:55,559
means they're very very dim so in

1032
00:46:54,199 --> 00:46:57,929
astronomy

1033
00:46:55,559 --> 00:46:59,309
have this ridiculous scale that says the

1034
00:46:57,929 --> 00:47:01,259
brighter the star is the lower the

1035
00:46:59,309 --> 00:47:03,059
number magnitude it is so if I have like

1036
00:47:01,259 --> 00:47:05,039
a two magnitude star that means it's

1037
00:47:03,059 --> 00:47:07,019
very bright compared to a seventh or a

1038
00:47:05,039 --> 00:47:08,549
10th magnitude star which is very faint

1039
00:47:07,018 --> 00:47:10,649
I didn't make the rules

1040
00:47:08,548 --> 00:47:12,179
I just follow them maybe one of you guys

1041
00:47:10,650 --> 00:47:16,048
can come up with a better way of scaling

1042
00:47:12,179 --> 00:47:18,268
our stars but it's it's what we normally

1043
00:47:16,048 --> 00:47:21,809
use so that's what it means by 7th

1044
00:47:18,268 --> 00:47:23,728
magnitude since they both lie on the

1045
00:47:21,809 --> 00:47:25,890
opposite side of the Sun we must be

1046
00:47:23,728 --> 00:47:29,218
measured we estimated a total angular

1047
00:47:25,889 --> 00:47:31,920
separation of about 0.2 for arc seconds

1048
00:47:29,219 --> 00:47:38,880
which is potentially measurable with

1049
00:47:31,920 --> 00:47:41,729
with our equipment so this is not what

1050
00:47:38,880 --> 00:47:44,849
we this is what we saw but what you see

1051
00:47:41,728 --> 00:47:47,278
here is actually um our telescope

1052
00:47:44,849 --> 00:47:48,930
decided you know I'm not gonna work for

1053
00:47:47,278 --> 00:47:51,778
the most important part of your project

1054
00:47:48,929 --> 00:47:52,348
I'm just gonna conk out and not do what

1055

00:47:51,778 --> 00:48:00,449
I'm told

1056
00:47:52,349 --> 00:48:02,039
so yeah images look cool but they didn't

1057
00:48:00,449 --> 00:48:04,798
have what we needed in them which was

1058
00:48:02,039 --> 00:48:07,109
the Stars to measure to see if this

1059
00:48:04,798 --> 00:48:09,719
deflection actually happened occurred

1060
00:48:07,108 --> 00:48:11,038
but this is an image and I got

1061
00:48:09,719 --> 00:48:13,559
permission to use this image in my

1062
00:48:11,039 --> 00:48:17,489
project from Miss lob drum from Euler

1063
00:48:13,559 --> 00:48:19,589
he's a he comes from the Czech Republic

1064
00:48:17,489 --> 00:48:22,409
and he photographs his photographs

1065
00:48:19,588 --> 00:48:26,159
eclipses and if you just you know Google

1066
00:48:22,409 --> 00:48:28,139
2017 solar eclipse miss la France Mila

1067
00:48:26,159 --> 00:48:30,389
he has tons of eclipses and not just

1068
00:48:28,139 --> 00:48:31,978
from 2017 and if you have a chance it's

1069
00:48:30,389 --> 00:48:34,199

really worth just pulling up on your

1070

00:48:31,978 --> 00:48:35,909
computer because I don't know if you

1071

00:48:34,199 --> 00:48:37,829
probably can't see but there's a ton of

1072

00:48:35,909 --> 00:48:39,838
stars and this and you can probably see

1073

00:48:37,829 --> 00:48:41,849
you can even see some of the cratering

1074

00:48:39,838 --> 00:48:44,429
in the moon from the light being

1075

00:48:41,849 --> 00:48:47,729
reflected off earth back to it so it's

1076

00:48:44,429 --> 00:48:50,039
quite a beautiful image and it works

1077

00:48:47,728 --> 00:48:51,718
perfectly for us because it has

1078

00:48:50,039 --> 00:48:54,839
everything we need in it right first

1079

00:48:51,719 --> 00:48:57,208
step one we got to identify our target

1080

00:48:54,838 --> 00:49:00,748
stars that we found in stellarium which

1081

00:48:57,208 --> 00:49:02,969
with his image their star a GM leo and

1082

00:49:00,748 --> 00:49:04,618
star b HD eight six eight nine eight

1083

00:49:02,969 --> 00:49:07,920
what a phone number

1084
00:49:04,619 --> 00:49:09,019
stars tend to have we have a lot of

1085
00:49:07,920 --> 00:49:11,298
catalogs we

1086
00:49:09,018 --> 00:49:15,438
give a lot of names to the same thing so

1087
00:49:11,298 --> 00:49:16,728
if you're wondering hey you know it says

1088
00:49:15,438 --> 00:49:18,558
it's this star it's just probably

1089
00:49:16,728 --> 00:49:20,648
because that star is being named through

1090
00:49:18,559 --> 00:49:23,959
another catalog but it's the same start

1091
00:49:20,648 --> 00:49:25,489
the next step is that in order to

1092
00:49:23,958 --> 00:49:26,598
transform the image into our a deck

1093
00:49:25,489 --> 00:49:28,938
which is right Ascension and declination

1094
00:49:26,599 --> 00:49:31,548
it's basically how we locate things in

1095
00:49:28,938 --> 00:49:33,558
the sky we need to use some reference

1096
00:49:31,548 --> 00:49:35,208
stars stars far enough away from this

1097
00:49:33,559 --> 00:49:37,009
eclipse that their positions aren't

1098
00:49:35,208 --> 00:49:40,548
going to be altered and they're gonna be

1099
00:49:37,009 --> 00:49:42,380
fine everything's gonna be great so the

1100
00:49:40,548 --> 00:49:44,329
more spread-out they are the better my

1101
00:49:42,380 --> 00:49:46,309
solution turned out to be so we picked

1102
00:49:44,329 --> 00:49:50,089
some very far stars there's that star

1103
00:49:46,309 --> 00:49:53,298
that star C D and E again with their

1104
00:49:50,088 --> 00:49:56,328
lovely phone numbers identifying them so

1105
00:49:53,298 --> 00:49:57,858
step three all we got to do now is find

1106
00:49:56,329 --> 00:49:59,719
the ings angular separation between a

1107
00:49:57,858 --> 00:50:02,208
and B and care pair it to what I

1108
00:49:59,719 --> 00:50:06,039
predicted right easy peasy lemon squeezy

1109
00:50:02,208 --> 00:50:09,068
I was so wrong

1110
00:50:06,039 --> 00:50:10,999
so what mate this was probably I

1111
00:50:09,068 --> 00:50:12,619
wouldn't say the most stressful cuz the

1112

00:50:10,998 --> 00:50:15,098
most stressful is always setting up the

1113
00:50:12,619 --> 00:50:17,239
telescope making sure it works but um

1114
00:50:15,099 --> 00:50:21,588
this was definitely one of the more

1115
00:50:17,239 --> 00:50:24,588
gruesome parts of the the research was

1116
00:50:21,588 --> 00:50:28,099
that this image had to be transformed

1117
00:50:24,588 --> 00:50:29,648
from XY coordinates pixel by pixel into

1118
00:50:28,099 --> 00:50:34,759
our a right Ascension and declination

1119
00:50:29,648 --> 00:50:37,009
locations and and it a lot of things had

1120
00:50:34,759 --> 00:50:39,019
to happen to it so what you see here are

1121
00:50:37,009 --> 00:50:41,778
some transformation equations that we

1122
00:50:39,018 --> 00:50:44,978
needed that we made to account for the

1123
00:50:41,778 --> 00:50:47,958
fact that one my origin needs to change

1124
00:50:44,978 --> 00:50:51,129
to beta is my scaling factor the factor

1125
00:50:47,958 --> 00:50:55,158
that I'm going to multiply in to turn my

1126
00:50:51,130 --> 00:50:56,898

my number that I get out into degrees

1127

00:50:55,159 --> 00:51:00,229

argument its arc seconds that sort of

1128

00:50:56,898 --> 00:51:02,208

thing and the Phi is represented by the

1129

00:51:00,228 --> 00:51:03,798

angle I had a rotated by so the reason

1130

00:51:02,208 --> 00:51:06,489

I'm doing this in the first place is

1131

00:51:03,798 --> 00:51:10,059

because if I kept the picture horizontal

1132

00:51:06,489 --> 00:51:13,369

Michael acting north would not match up

1133

00:51:10,059 --> 00:51:16,099

with a cataloged galactic North which

1134

00:51:13,369 --> 00:51:17,449

would mean yeah I could produce some

1135

00:51:16,099 --> 00:51:18,949

numbers but I couldn't compare to

1136

00:51:17,449 --> 00:51:21,168

anything I would have to make up my own

1137

00:51:18,949 --> 00:51:22,789

things I'd have to do all this stuff so

1138

00:51:21,168 --> 00:51:23,119

I have to manipulate my photos so that

1139

00:51:22,789 --> 00:51:24,470

it

1140

00:51:23,119 --> 00:51:27,349

lines up with the general standard of

1141
00:51:24,469 --> 00:51:29,089
galactic north being up and that that

1142
00:51:27,349 --> 00:51:30,860
now my reference star is I can identify

1143
00:51:29,090 --> 00:51:33,590
them through the catalog and use those

1144
00:51:30,860 --> 00:51:36,829
locations so everything's good fine and

1145
00:51:33,590 --> 00:51:38,150
dandy right so do this this gives me

1146
00:51:36,829 --> 00:51:40,549
four unknowns that I don't know about

1147
00:51:38,150 --> 00:51:43,190
right this Alpha Delta this new origin

1148
00:51:40,550 --> 00:51:45,050
of my image the beta the scaling factor

1149
00:51:43,190 --> 00:51:47,030
I'm going to need to multiply in and Phi

1150
00:51:45,050 --> 00:51:49,580
the angle I'm gonna have to rotate my

1151
00:51:47,030 --> 00:51:53,810
picture by but not all hope is lost

1152
00:51:49,579 --> 00:51:57,139
because I have reference stars yay and I

1153
00:51:53,809 --> 00:51:59,269
can get all of these unknowns by

1154
00:51:57,139 --> 00:52:01,519
applying them to the reference stars the

1155
00:51:59,269 --> 00:52:04,219
stars that have not been changed by

1156
00:52:01,519 --> 00:52:07,219
gravitational lensing so once I find

1157
00:52:04,219 --> 00:52:08,989
them for the for the reference stars I

1158
00:52:07,219 --> 00:52:12,579
can go back to my target stars the two

1159
00:52:08,989 --> 00:52:16,899
stars I believe are going going through

1160
00:52:12,579 --> 00:52:21,500
gravitational lensing and move change

1161
00:52:16,900 --> 00:52:26,630
transform their coordinates so this

1162
00:52:21,500 --> 00:52:29,599
involve some spherical trig yeah three

1163
00:52:26,630 --> 00:52:31,280
Oracle trig good stuff all you need to

1164
00:52:29,599 --> 00:52:33,170
know is that you know the basic

1165
00:52:31,280 --> 00:52:35,030
trigonometry you you're taught in high

1166
00:52:33,170 --> 00:52:35,930
school or middle school I don't know

1167
00:52:35,030 --> 00:52:37,160
they teach them like when they're

1168
00:52:35,929 --> 00:52:41,539
practically elementary schools these

1169

00:52:37,159 --> 00:52:44,869
days I don't know but all you need to

1170
00:52:41,539 --> 00:52:46,969
know is that you know when we do regular

1171
00:52:44,869 --> 00:52:48,889
trigonometry with right angles and

1172
00:52:46,969 --> 00:52:50,779
hypotenuse right we're normally doing

1173
00:52:48,889 --> 00:52:53,299
that on a flat surface on like a 2d

1174
00:52:50,780 --> 00:52:54,920
image of a triangle as such well

1175
00:52:53,300 --> 00:52:58,850
spherical tree game about because you

1176
00:52:54,920 --> 00:53:01,789
know we we don't live in a flat universe

1177
00:52:58,849 --> 00:53:03,529
we can't use flat equations on something

1178
00:53:01,789 --> 00:53:05,989
that's three-dimensional so this takes

1179
00:53:03,530 --> 00:53:08,960
into the idea that we're applying

1180
00:53:05,989 --> 00:53:10,639
trigonometry but to stuff that is curved

1181
00:53:08,960 --> 00:53:14,929
that's not flat that's in three

1182
00:53:10,639 --> 00:53:19,099
dimensions right so I result in the

1183
00:53:14,929 --> 00:53:22,250

deflected light came up to be 22900 five

1184

00:53:19,099 --> 00:53:25,699

days 57 plus or minus 29 arc seconds and

1185

00:53:22,250 --> 00:53:29,389

deflected and then the actual separation

1186

00:53:25,699 --> 00:53:31,159

the undeflected light being about 2953

1187

00:53:29,389 --> 00:53:32,960

arc seconds and what I want to do is I

1188

00:53:31,159 --> 00:53:35,069

want to take the difference of this to

1189

00:53:32,960 --> 00:53:38,010

match it to the difference of the

1190

00:53:35,070 --> 00:53:40,789

separation I produced in my prediction

1191

00:53:38,010 --> 00:53:43,830

to see if their clothes are compatible

1192

00:53:40,789 --> 00:53:45,690

after doing the math I get four arc

1193

00:53:43,829 --> 00:53:48,389

seconds which is consistent with general

1194

00:53:45,690 --> 00:53:51,570

relativity and is very close to my

1195

00:53:48,389 --> 00:53:53,759

predicted difference in deflection which

1196

00:53:51,570 --> 00:53:57,390

was two point four seconds so this was

1197

00:53:53,760 --> 00:53:59,760

very much a success you might be saying

1198
00:53:57,389 --> 00:54:02,909
hey Herrera bar is pretty high there you

1199
00:53:59,760 --> 00:54:04,980
know just like the last one but what

1200
00:54:02,909 --> 00:54:07,710
actually ended up happening was my

1201
00:54:04,980 --> 00:54:09,920
mentor and I were not fluent in like

1202
00:54:07,710 --> 00:54:12,329
coding languages such as Python or

1203
00:54:09,920 --> 00:54:15,180
manipulation through ds9 and this image

1204
00:54:12,329 --> 00:54:17,130
was not given to us as like a fits in

1205
00:54:15,179 --> 00:54:19,889
astronomy there's these file it's just

1206
00:54:17,130 --> 00:54:21,329
like another type of image file you get

1207
00:54:19,889 --> 00:54:24,869
you get something sent to you by like

1208
00:54:21,329 --> 00:54:26,969
JPEG or PDF well in astronomy we have

1209
00:54:24,869 --> 00:54:28,980
this thing called Fitz and normally why

1210
00:54:26,969 --> 00:54:30,509
we do it through Fitz is because there's

1211
00:54:28,980 --> 00:54:32,940
a lot of information about like where

1212
00:54:30,510 --> 00:54:35,130
the what telescope took this image you

1213
00:54:32,940 --> 00:54:38,970
know where it was taken all sorts of

1214
00:54:35,130 --> 00:54:41,130
things like that but that make the data

1215
00:54:38,969 --> 00:54:44,939
calculator his life so much easier but

1216
00:54:41,130 --> 00:54:46,320
this image was like a JPEG so I so

1217
00:54:44,940 --> 00:54:49,380
everything had to be done manually

1218
00:54:46,320 --> 00:54:51,000
including the calculation so this we my

1219
00:54:49,380 --> 00:54:53,820
mentor and I actually sat down and did

1220
00:54:51,000 --> 00:54:54,989
this calculation so and we yes we were

1221
00:54:53,820 --> 00:54:57,180
rushing because we were very eager to

1222
00:54:54,989 --> 00:55:00,000
see if we saw some deflection in light

1223
00:54:57,179 --> 00:55:01,169
which we did if we go back and do it a

1224
00:55:00,000 --> 00:55:03,320
little more careful I'm sure we can get

1225
00:55:01,170 --> 00:55:06,269
that error about their error bar down

1226

00:55:03,320 --> 00:55:08,550
but it's important to note that we are

1227
00:55:06,269 --> 00:55:09,989
detecting an angle deflection deflection

1228
00:55:08,550 --> 00:55:12,390
in light I should say and that that's

1229
00:55:09,989 --> 00:55:14,250
consistent with general relativity so

1230
00:55:12,389 --> 00:55:16,980
it's quite a spectacular thing and I'm

1231
00:55:14,250 --> 00:55:20,489
told I was just told this earlier today

1232
00:55:16,980 --> 00:55:23,369
that the next 30 years worth of eclipses

1233
00:55:20,489 --> 00:55:26,039
there are no stars close enough to the

1234
00:55:23,369 --> 00:55:28,889
eclipses where you'll be able to do this

1235
00:55:26,039 --> 00:55:34,539
sort of thing to it so we struck why the

1236
00:55:28,889 --> 00:55:42,369
iron was hot and voila so

1237
00:55:34,539 --> 00:55:43,960
thank you just some just some

1238
00:55:42,369 --> 00:55:46,389
last-minute acknowledgments I'd like to

1239
00:55:43,960 --> 00:55:48,820
thank my mentor dr. James overdoing for

1240
00:55:46,389 --> 00:55:50,519

you know getting me involved and this

1241

00:55:48,820 --> 00:55:52,809
was an experience of a lifetime

1242

00:55:50,519 --> 00:55:53,920
Alexander stores dr. Alexander stories

1243

00:55:52,809 --> 00:55:56,469
he helped to Christmas Kuwait's

1244

00:55:53,920 --> 00:55:58,360
telescope a he was so nice he let us

1245

00:55:56,469 --> 00:55:59,739
borrow his equipment and again the

1246

00:55:58,360 --> 00:56:01,120
Maryland Space Grant consortium the

1247

00:55:59,739 --> 00:56:03,759
people right across the street for

1248

00:56:01,119 --> 00:56:06,159
funding this whole thing because this

1249

00:56:03,760 --> 00:56:07,720
whole thing was I was funded and I could

1250

00:56:06,159 --> 00:56:09,879
do it which is great because I don't

1251

00:56:07,719 --> 00:56:11,469
like not being paid for things cuz it's

1252

00:56:09,880 --> 00:56:14,110
hard to live these days and not get paid

1253

00:56:11,469 --> 00:56:15,879
for things and they really they really

1254

00:56:14,110 --> 00:56:18,789
made this whole thing whole shabang

1255
00:56:15,880 --> 00:56:21,309
possible and just one quick last minute

1256
00:56:18,789 --> 00:56:24,009
thing before I take some questions this

1257
00:56:21,309 --> 00:56:26,889
image is also I have permission to use

1258
00:56:24,010 --> 00:56:29,940
it this image was taken by a French

1259
00:56:26,889 --> 00:56:32,650
astronomer his name is John moet and I

1260
00:56:29,940 --> 00:56:35,440
have a bunch of these and these luckily

1261
00:56:32,650 --> 00:56:38,800
are in fits file so it won't be such a

1262
00:56:35,440 --> 00:56:42,220
nightmare going through and I am tasked

1263
00:56:38,800 --> 00:56:43,630
with a senior year capstone going in and

1264
00:56:42,219 --> 00:56:45,579
doing the same sort of treatment and see

1265
00:56:43,630 --> 00:56:47,559
if I can find some light deflection in

1266
00:56:45,579 --> 00:56:50,889
there so this is one of his beautiful

1267
00:56:47,559 --> 00:56:52,329
images of the Eclipse and that's what

1268
00:56:50,889 --> 00:56:55,150
I'll be spending part of my senior year

1269
00:56:52,329 --> 00:56:56,860
doing so thank you very much and all

1270
00:56:55,150 --> 00:56:59,309
except I'll take questions now if any of

1271
00:56:56,860 --> 00:56:59,309
your having

1272
00:57:02,710 --> 00:57:12,230
[Applause]

1273
00:57:05,829 --> 00:57:14,090
yeah of course okay so I'm gonna repeat

1274
00:57:12,230 --> 00:57:16,670
the questions for the webcast okay how

1275
00:57:14,090 --> 00:57:18,620
did you start in astronomy it's funny

1276
00:57:16,670 --> 00:57:24,349
you asked I was supposed to be a music

1277
00:57:18,619 --> 00:57:26,210
education major yeah it's quite a it's

1278
00:57:24,349 --> 00:57:28,670
quite a funny story um I spent my first

1279
00:57:26,210 --> 00:57:30,470
year in college you know doing what any

1280
00:57:28,670 --> 00:57:32,659
young Shore College student does take a

1281
00:57:30,469 --> 00:57:36,079
bunch of classes I was very much into

1282
00:57:32,659 --> 00:57:37,190
music and I was preparing to be a music

1283

00:57:36,079 --> 00:57:40,279
ed major so I was learning other

1284
00:57:37,190 --> 00:57:42,440
instruments practicing on my own and I

1285
00:57:40,280 --> 00:57:44,570
just you know Towson forces you to take

1286
00:57:42,440 --> 00:57:46,700
these other classes that aren't related

1287
00:57:44,570 --> 00:57:49,700
to anything else so you become

1288
00:57:46,699 --> 00:57:53,989
well-rounded and well-rounded individual

1289
00:57:49,699 --> 00:57:56,980
so so I wandered up into a general

1290
00:57:53,989 --> 00:58:00,889
astronomy class and I wasn't allowed to

1291
00:57:56,980 --> 00:58:02,929
sign up until the end of registration

1292
00:58:00,889 --> 00:58:05,719
because I was a freshman so the only

1293
00:58:02,929 --> 00:58:09,949
teman are left open was physics and

1294
00:58:05,719 --> 00:58:11,809
metaphysics taught by my mentor and gosh

1295
00:58:09,949 --> 00:58:14,509
boy did I thought I think this was going

1296
00:58:11,809 --> 00:58:15,920
to be awful and it turns out that taking

1297
00:58:14,510 --> 00:58:18,470

those two two classes concurrently

1298

00:58:15,920 --> 00:58:21,559

really made me like oh my gosh this

1299

00:58:18,469 --> 00:58:23,629

stuff is so cool you know and I was I

1300

00:58:21,559 --> 00:58:26,480

was a little nervous because you know

1301

00:58:23,630 --> 00:58:29,780

like I said I was so ready to be a music

1302

00:58:26,480 --> 00:58:31,940

major but um I had a lot of help and

1303

00:58:29,780 --> 00:58:34,190

confidence boosters from from people all

1304

00:58:31,940 --> 00:58:35,240

around me my family my mom she pushed me

1305

00:58:34,190 --> 00:58:39,320

she was like else we just pick something

1306

00:58:35,239 --> 00:58:43,250

I need you to pick something so I okay

1307

00:58:39,320 --> 00:58:46,670

so much yeah that led me to astronomy um

1308

00:58:43,250 --> 00:58:48,230

and I'm quite happy I'm keeping with it

1309

00:58:46,670 --> 00:58:49,639

because if you weren't pretty like all

1310

00:58:48,230 --> 00:58:51,019

the Astronomy cool things happening in

1311

00:58:49,639 --> 00:58:53,299

space I don't know if I'd continue with

1312
00:58:51,019 --> 00:58:56,599
it because that's just cuz of my own

1313
00:58:53,300 --> 00:58:58,700
personal interests but it's it's it is

1314
00:58:56,599 --> 00:59:01,309
in my opinion in science in general if I

1315
00:58:58,699 --> 00:59:03,409
should quit what do you play music well

1316
00:59:01,309 --> 00:59:06,829
I was I've played piano since I was four

1317
00:59:03,409 --> 00:59:09,079
and I started flute when I was in middle

1318
00:59:06,829 --> 00:59:11,179
school but by high school like around my

1319
00:59:09,079 --> 00:59:13,429
junior year I just started skipping

1320
00:59:11,179 --> 00:59:14,629
hopping from instrument to instrument to

1321
00:59:13,429 --> 00:59:17,328
whatever instrumentation the bay

1322
00:59:14,630 --> 00:59:20,298
needed for the band so I ended up on

1323
00:59:17,329 --> 00:59:22,278
tenor sax I ended up on alto sax um my

1324
00:59:20,298 --> 00:59:23,900
sister played the clarinet so I try to

1325
00:59:22,278 --> 00:59:26,389
honk a few notes my best friend was an

1326
00:59:23,900 --> 00:59:31,068
oboe player so double reed instruments

1327
00:59:26,389 --> 00:59:35,298
are the devil are you into music of the

1328
00:59:31,068 --> 00:59:41,778
spheres I'm not gonna repeat that

1329
00:59:35,298 --> 00:59:44,298
question other questions I would get a

1330
00:59:41,778 --> 00:59:48,650
couple questions from I Peter you have a

1331
00:59:44,298 --> 00:59:51,380
real question your description of

1332
00:59:48,650 --> 00:59:54,798
gravity being a distortion of space-time

1333
00:59:51,380 --> 00:59:58,000
and not a force of such I'm thinking of

1334
00:59:54,798 --> 01:00:00,798
the quest for the grand unified theory

1335
00:59:58,000 --> 01:00:05,170
still hanging out there but does this

1336
01:00:00,798 --> 01:00:13,548
kind of destroy that effort thinking of

1337
01:00:05,170 --> 01:00:15,230
gravity being something apart from okay

1338
01:00:13,548 --> 01:00:17,838
so I get a repeat the question is to

1339
01:00:15,230 --> 01:00:19,338
make sure people in line here so your

1340

01:00:17,838 --> 01:00:21,170
description subscribe gravity of course

1341
01:00:19,338 --> 01:00:24,409
in general ativity is a distortion of

1342
01:00:21,170 --> 01:00:26,568
space-time but yet there is this quest

1343
01:00:24,409 --> 01:00:29,598
for a grand unified theory and how does

1344
01:00:26,568 --> 01:00:31,068
this guy with all the other forces we

1345
01:00:29,599 --> 01:00:34,160
actually had a question about quantum

1346
01:00:31,068 --> 01:00:35,960
gravity online as well so when you were

1347
01:00:34,159 --> 01:00:38,509
discussing this people started thinking

1348
01:00:35,960 --> 01:00:43,338
you know can congrat the question online

1349
01:00:38,509 --> 01:00:50,088
was can it has gravity been it's nine

1350
01:00:43,338 --> 01:00:52,038
o'clock has been confirmed even worked

1351
01:00:50,088 --> 01:00:54,380
with the quantum mechanics I don't

1352
01:00:52,039 --> 01:00:59,150
believe there's been a bridge between

1353
01:00:54,380 --> 01:01:01,910
the two I'm not quite familiar but as to

1354
01:00:59,150 --> 01:01:04,460

whether there is a link between quantum

1355

01:01:01,909 --> 01:01:07,788

mechanics and gravity yet quantum

1356

01:01:04,460 --> 01:01:09,139

gravity has not been solved yet you

1357

01:01:07,789 --> 01:01:12,009

would have heard about it and there will

1358

01:01:09,139 --> 01:01:12,009

be Nobel prizes

1359

01:01:15,699 --> 01:01:20,689

okay so let me explain what's happening

1360

01:01:18,230 --> 01:01:23,869

here when they redid the auditorium

1361

01:01:20,690 --> 01:01:25,970

there was an automatic shutdown that's

1362

01:01:23,869 --> 01:01:28,819

supposed to be scheduled for 10:30 every

1363

01:01:25,969 --> 01:01:30,739

night summaries in the second second

1364

01:01:28,820 --> 01:01:32,530

time it's gone off at nine o'clock while

1365

01:01:30,739 --> 01:01:34,879

we're doing the public lecture series so

1366

01:01:32,530 --> 01:01:35,480

I'm gonna ignore it I'm gonna pretend it

1367

01:01:34,880 --> 01:01:45,079

didn't happen

1368

01:01:35,480 --> 01:01:47,990

okay I don't believe there is something

1369
01:01:45,079 --> 01:01:50,119
yet discovered linking the two so I'm

1370
01:01:47,989 --> 01:01:50,659
not too familiar so I can't speak on its

1371
01:01:50,119 --> 01:01:52,250
behalf

1372
01:01:50,659 --> 01:01:54,739
okay all the way in the back what's

1373
01:01:52,250 --> 01:01:59,570
faster gravity or light which is faster

1374
01:01:54,739 --> 01:02:05,589
gravity or light well that's quite a

1375
01:01:59,570 --> 01:02:09,820
great question actually um because well

1376
01:02:05,590 --> 01:02:12,950
light moves at a pretty fast pace like I

1377
01:02:09,820 --> 01:02:15,019
would say light is faster even though we

1378
01:02:12,949 --> 01:02:16,429
have evidence of where gravity is

1379
01:02:15,019 --> 01:02:18,650
overcoming light such as black holes

1380
01:02:16,429 --> 01:02:22,849
where we can't see inside them because

1381
01:02:18,650 --> 01:02:24,230
it's so dense that light is falling in

1382
01:02:22,849 --> 01:02:26,059
faster than the speed of light therefore

1383
01:02:24,230 --> 01:02:28,369
we can't see it but I would still say

1384
01:02:26,059 --> 01:02:31,519
overall light is faster I would have to

1385
01:02:28,369 --> 01:02:34,009
correct you on that thank you with the

1386
01:02:31,519 --> 01:02:36,469
gravitational right so yeah we talked

1387
01:02:34,010 --> 01:02:38,300
about last week about the last month and

1388
01:02:36,469 --> 01:02:40,519
the month before that gravitational wave

1389
01:02:38,300 --> 01:02:43,280
astronomy that we've detected

1390
01:02:40,519 --> 01:02:44,989
gravitational waves the time delay

1391
01:02:43,280 --> 01:02:49,820
between detection in Hanford Washington

1392
01:02:44,989 --> 01:02:52,489
and in Louisiana was correspond to a

1393
01:02:49,820 --> 01:02:54,590
time delay of the speed of light so this

1394
01:02:52,489 --> 01:02:57,229
is one of the very first measures that

1395
01:02:54,590 --> 01:03:01,370
gravity waves travel at the same speed

1396
01:02:57,230 --> 01:03:04,730
of speed as light does okay we only have

1397

01:03:01,369 --> 01:03:08,359
a few measures right so but right now it

1398
01:03:04,730 --> 01:03:10,820
appears that the bias that we have that

1399
01:03:08,360 --> 01:03:14,980
gravity waves travel at gravity travels

1400
01:03:10,820 --> 01:03:14,980
at the speed of light is being confirmed

1401
01:03:15,010 --> 01:03:18,320
so it's alright you're an undergraduate

1402
01:03:17,030 --> 01:03:20,200
you know your response to us don't know

1403
01:03:18,320 --> 01:03:22,150
everything

1404
01:03:20,199 --> 01:03:23,409
it's when you it's when you it's when

1405
01:03:22,150 --> 01:03:31,900
you get a job that you have to pretend

1406
01:03:23,409 --> 01:03:44,230
you know everything okay I have a

1407
01:03:31,900 --> 01:03:46,150
question their English people I think

1408
01:03:44,230 --> 01:03:47,380
for like like proved it through their

1409
01:03:46,150 --> 01:03:50,798
like it was an eclipse I think in the

1410
01:03:47,380 --> 01:03:54,630
nineteen yeah so he's referring to the

1411
01:03:50,798 --> 01:03:54,630

nineteen nineteen total solar eclipse

1412

01:04:00,480 --> 01:04:04,358
how did they measure this light

1413

01:04:02,349 --> 01:04:07,630
deflection in 1919 when they didn't have

1414

01:04:04,358 --> 01:04:11,449
computers something called photographic

1415

01:04:07,630 --> 01:04:15,360
plates which photographs what are those

1416

01:04:11,449 --> 01:04:15,359
[Laughter]

1417

01:04:19,289 --> 01:04:25,599
they would use photographic plates to

1418

01:04:22,030 --> 01:04:28,960
take images of the Eclipse back in

1419

01:04:25,599 --> 01:04:30,338
nineteen and 19 1919 and actually I

1420

01:04:28,960 --> 01:04:31,929
believe they would have to sit down and

1421

01:04:30,338 --> 01:04:35,619
do the math that we had to do as well

1422

01:04:31,929 --> 01:04:40,868
right with the spherical trigonal that

1423

01:04:35,619 --> 01:04:43,750
but different we used something on but

1424

01:04:40,869 --> 01:04:45,548
mmm the image we used was on something

1425

01:04:43,750 --> 01:04:48,548
called a CCD chip a charged a couple

1426
01:04:45,548 --> 01:04:50,019
device and it's kind of it's a better

1427
01:04:48,548 --> 01:04:52,539
version of a photographic plate more

1428
01:04:50,019 --> 01:04:53,889
portable works better but that's what

1429
01:04:52,539 --> 01:04:57,068
they would use at night that's what I

1430
01:04:53,889 --> 01:04:59,409
believe they used all right so here's a

1431
01:04:57,068 --> 01:05:01,690
question from online you showed them the

1432
01:04:59,409 --> 01:05:03,909
observable universe right that you're

1433
01:05:01,690 --> 01:05:06,250
looking out you see an edge to the

1434
01:05:03,909 --> 01:05:09,838
universe so why is every point in the

1435
01:05:06,250 --> 01:05:09,838
middle of the observable universe

1436
01:05:12,269 --> 01:05:17,219
but they why were we at the exact center

1437
01:05:15,570 --> 01:05:19,170
of that universe that was just a

1438
01:05:17,219 --> 01:05:21,719
simplistic model

1439
01:05:19,170 --> 01:05:24,210
there's nothing supposedly saying that

1440
01:05:21,719 --> 01:05:26,629
we are located at located at the center

1441
01:05:24,210 --> 01:05:29,369
of the universe I just used that shape

1442
01:05:26,630 --> 01:05:33,180
for simplicity sake when I went ahead

1443
01:05:29,369 --> 01:05:34,469
and did my own project but we there's no

1444
01:05:33,179 --> 01:05:36,029
evidence saying that we are at the

1445
01:05:34,469 --> 01:05:38,309
center of the universe we're not going

1446
01:05:36,030 --> 01:05:41,760
back to the targa jizz of a heliocentric

1447
01:05:38,309 --> 01:05:52,590
and a geocentric universe so in the back

1448
01:05:41,760 --> 01:05:55,920
there and dark energy and then it

1449
01:05:52,590 --> 01:05:59,539
covered almost the entire universe so in

1450
01:05:55,920 --> 01:06:05,789
your lecture you mentioned emptiness

1451
01:05:59,539 --> 01:06:08,009
nothing do both all right so does the

1452
01:06:05,789 --> 01:06:10,500
idea there be that dark matter and dark

1453
01:06:08,010 --> 01:06:13,110
energy comprised most of the universe

1454

01:06:10,500 --> 01:06:14,909
conflict with the idea that over the

1455
01:06:13,110 --> 01:06:21,000
presented during Olbers paradox that a

1456
01:06:14,909 --> 01:06:24,839
lot of the universe is empty mess with

1457
01:06:21,000 --> 01:06:28,289
the paradox or the solution the solution

1458
01:06:24,840 --> 01:06:30,630
to the paradox is just that the light

1459
01:06:28,289 --> 01:06:31,199
has yet to reach us and that's why it's

1460
01:06:30,630 --> 01:06:33,900
dark

1461
01:06:31,199 --> 01:06:36,480
not that there's dark energy or dark

1462
01:06:33,900 --> 01:06:38,639
matter you know that's what we're seeing

1463
01:06:36,480 --> 01:06:41,369
in this guy right because we can't see

1464
01:06:38,639 --> 01:06:43,710
dark energy or dark matter right if

1465
01:06:41,369 --> 01:06:49,679
that's why it's called dark it's given

1466
01:06:43,710 --> 01:06:51,329
that mysterious name um it doesn't I

1467
01:06:49,679 --> 01:06:54,509
don't believe it does yeah

1468
01:06:51,329 --> 01:06:55,799

it doesn't really interact with it the

1469

01:06:54,510 --> 01:06:58,020

light comes through one way or another

1470

01:06:55,800 --> 01:07:00,360

and it doesn't really get affected by

1471

01:06:58,019 --> 01:07:02,880

those things right matter of fact if the

1472

01:07:00,360 --> 01:07:05,039

dark matter or the dark energy changed

1473

01:07:02,880 --> 01:07:06,750

the light in a significant way it's a

1474

01:07:05,039 --> 01:07:08,509

way of detecting it and that's how of

1475

01:07:06,750 --> 01:07:11,389

course we do detect dark matter by its

1476

01:07:08,510 --> 01:07:15,500

gravitational influence on on things

1477

01:07:11,389 --> 01:07:15,500

such all right down front here

1478

01:07:21,010 --> 01:07:28,150

can you relate the Milkyway size /

1479

01:07:24,130 --> 01:07:32,849

position within the universe the Milky

1480

01:07:28,150 --> 01:07:36,450

Way is 12 kiloparsecs across the

1481

01:07:32,849 --> 01:07:36,449

universe is

1482

01:07:44,119 --> 01:07:47,529

[Laughter]

1483
01:07:52,920 --> 01:07:58,630
well the center well the center of the

1484
01:07:55,449 --> 01:08:01,989
Milky Way is about 8.5 kiloparsecs from

1485
01:07:58,630 --> 01:08:03,820
where we are and you know we're in one

1486
01:08:01,989 --> 01:08:05,019
of the we're in one of the spiral arms

1487
01:08:03,820 --> 01:08:12,269
in Milky Way that's where we're located

1488
01:08:05,019 --> 01:08:17,199
I believe it's the the Orion we're in

1489
01:08:12,269 --> 01:08:19,449
we're inside that arm if we were so

1490
01:08:17,199 --> 01:08:21,880
we're I guess my best way of saying is

1491
01:08:19,449 --> 01:08:24,849
this we're just about if you imagine the

1492
01:08:21,880 --> 01:08:27,340
galaxy is just like a ball or a circle

1493
01:08:24,850 --> 01:08:29,680
right and here's the center where like

1494
01:08:27,340 --> 01:08:31,840
about 8.5 kiloparsecs away out of that

1495
01:08:29,680 --> 01:08:37,619
center inside one of the arms that's why

1496
01:08:31,840 --> 01:08:54,039
we are alright any other questions here

1497
01:08:37,619 --> 01:08:59,229
come on go ahead I'm silly undergrad I'm

1498
01:08:54,039 --> 01:09:01,000
still like everybody okay we have a

1499
01:08:59,229 --> 01:09:06,729
bunch of questions online but they all

1500
01:09:01,000 --> 01:09:08,800
deal with cosmological topics that they

1501
01:09:06,729 --> 01:09:11,279
go off topic a little bit too much I'll

1502
01:09:08,800 --> 01:09:15,579
I'll type in some some answers for them

1503
01:09:11,279 --> 01:09:17,949
next month January 16th third Tuesday

1504
01:09:15,579 --> 01:09:21,760
okay the James Webb Space Telescope in

1505
01:09:17,949 --> 01:09:23,500
three acts okay so third Tuesday let you

1506
01:09:21,760 --> 01:09:25,390
all have a great holiday

1507
01:09:23,500 --> 01:09:28,739
we'll see you see you next month and

1508
01:09:25,390 --> 01:09:28,740
let's give Kelsey one more big round

1509
01:09:34,359 --> 01:09:38,219
[Applause]

1510
01:09:45,350 --> 01:09:48,650
let's get baking